BCA.Net - Highway Project Benefit-Cost Analysis System

User's Manual

Federal Highway Administration

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Contents

Introduction

Purpose of the *User's Manual*

BCA.Net is the Federal Highway Administration's (FHWA) web-based system for highway benefit-cost analysis in support of the project-level decision-making process. This manual provides direction on how to use the *BCA.Net* system to set up and conduct a benefit-cost analysis, and incorporate the system's outputs in project-level decision support.

This *User's Manual* is directed to candidate users of the system, which includes: U.S. and State Department of Transportation employees; local government employees; economists, engineers, budget analysts and other consultants who support State and local authorities; and, anyone else involved in supporting decisions for highway development and maintenance.

Following this introduction, the manual contains instructions on getting started with *BCA.Net*, a description of the system, and directions on using it to perform benefit-cost analyses.

About *BCA.Net*

The growing requirements for highway investments and constrained fiscal resources point to the need for a tool to facilitate the benefit-cost analysis of highway investments. Surveys of available tools show the need for an easy-to-use tool that incorporates recent research findings, thereby enhancing the accessibility of highway project benefit-cost analysis to the practitioner. The challenges of deploying software in diverse information technology environments with increasing security requirements strongly suggest that a new benefit-cost analysis tool be an Internet-based application.

To meet this need, the FHWA developed *BCA.Net,* which is a web-based decision support tool that assists Federal, State and local authority decision-makers in evaluating the benefits and costs of highway projects. The *BCA.Net* system enables users to: manage the data for an analysis; select from a wide array of sample values; develop cases corresponding to alternative strategies for managing highway facilities; evaluate and compare the benefits and costs of improvements; and, provide summary indicators for informing resource allocation decisions.

A *BCA.Net* analysis evaluates the relative economic merits of pursuing alternative multi-year improvement and maintenance programs for highway projects. Based on the users-provided project information, *BCA.Net* forecasts the transportation and non-transportation effects of highway investments and maintenance strategies, and

estimates the economic value of these effects over the useful life of projects in dollar terms. The benefit-cost of an investment is calculated by comparing the time-stream of expected economic benefits with the time-stream of investment-related and other costs, while adjusting for the timing of the realization of costs and benefits. Known as "discounting", this adjustment enables decision makers to inspect future benefits and costs in terms of their *present-day* value. This is a standard way of giving appropriate weight to nearer-term versus distant (thus less valued) outcomes. By comparing the present values of net benefit (e.g., benefits less costs), the analyst can determine which alternative has greater economic worth.

The computational approach in *BCA.Net* allows the users to develop unitary, point estimates (e.g., single values) for the result metrics. Alternatively, the users can use the risk analysis features of *BCA.Net* to develop probabilistic inputs and results. The probabilistic method is a way of explicitly handling the uncertainty associated with some of the analysis inputs (e.g., forecast growth) and its impact on the analysis results. Probability functions describe the probabilistic inputs, which convey the range of likely inputs and the likelihood of their occurrence. Risk analysis allows for the simultaneous computation of differing assumptions for many different variables. The results of a risk analysis are presented as probability distributions, rather than point estimates. These risk analysis outcomes promote informed decision-making that accounts for both the downside risk and upside potential of candidate projects. *BCA.Net* includes an array of charts and reports that enable the users to interpret results, refine analyses, and develop risk-mitigating contingencies.

BCA.Net's underlying methodology is consistent with the current benefit-cost methodologies employed by the FHWA. The model is transparent in all of its assumptions and the model inputs are readily accessible to users who may want to adjust model inputs to reflect local circumstances. *BCA.Net* is designed to minimize the data needs and technical expertise required of the users while at the same time providing analytical flexibility and reliable benefit-cost results.

Technical Description

A Web-Based Application

BCA.Net runs over the Internet on a central server. This enables many users to access the system simultaneously. Any user with a minimally configured computer having a browser and an Internet connection can use the system and all its features. The system requires no local installation of special software. Web deployment addresses the following issues:

Figure 1 Overview Schema of BCA.Net
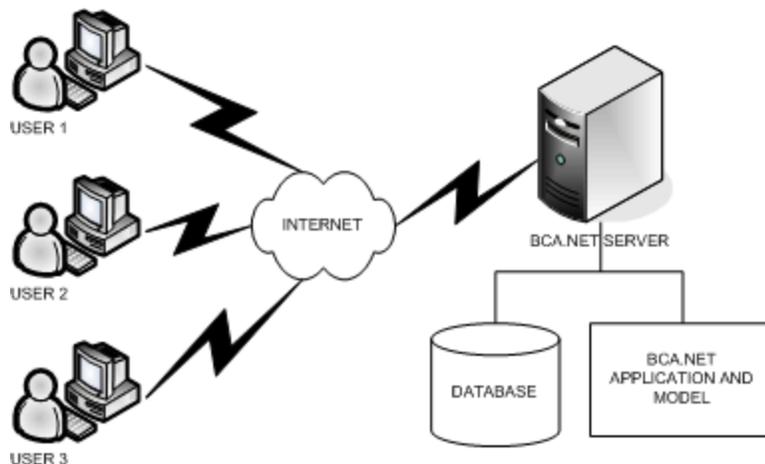
- *System Security* – State and local agencies are moving increasingly to secure systems and, in many cases, a requirement to install dedicated software is a barrier to adoption. *BCA.Net* does not require any special software and presents no security risk for system users.

- *Interoperability* - *BCA.Net* does not does require special hardware or even a special operating system (it will work on client computers running Windows, Linux, Unix or Mac operating systems).

- *Deployment of Upgrades and Modifications* -Modifications and improvements to the software are immediately deployed for all users.

- *Updates of Data Resources* - Most recent data are always available to the application.

Users analyses and data are run on a central database, thus minimizing the need for users to track and maintain their data on their local computer. Users have the option

of storing their data locally at the end of a session, deleting it from the central database, and then restoring their data for use when beginning a new session.

The technical description of the system that follows is presented in the form of "FAQs" (frequently asked questions).

Using *BCA.Net* – Frequently Asked Questions

How do I access BCA.Net?

Check the section below on "Software and Hardware Requirements" to verify that your computer is compliant.

You access *BCA.Net* from either FHWA's User Profile and Access Control System (UPACS) or from the URL (Internet address) of the system. See section "1. Login Page" below for more information.

How do I use BCA.Net?

After logging on, you can access all the features of *BCA.Net*. You navigate to the different functional areas of the system, each represented by a web page, by clicking on the Navigation Bar of the Main Menu (top of the page, below the banner and status bar).

You develop your data and conduct your analysis by selecting options on the web pages of *BCA.Net*. When you make entries and click on selections in the web browser, a request is sent over the Internet to the *BCA.Net* server. The server performs all the calculations and data transformations and then sends back to your browser an updated page that reflects your selections.

Where do my data reside?

During a *BCA.Net* session, your data resides on the *BCA.Net* server. You may choose to leave your data on the server between sessions, or, you can store it locally on your own computer and delete it from the *BCA.Net* server. If you opt to store your data locally and remove it from the server, you can restore your data to the *BCA.Net* server and continue your analysis at the start of your next *BCA.Net* session.

Are my data secure?

The FHWA will take significant and reasonable measures to ensure the security and integrity of your data when they reside on the FHWA's server. *BCA.Net* uses secure socket layer (SSL), 128-bit encrypted communication, so that your data are secure in transmission.

Software and Hardware Requirements

Computer, Operating System, and Web Browser

BCA.Net is designed for use with any computer and operating system running a "high level" browser (i.e., browsers that were released in the second half of 1999 or later). The system has been tested on the following web browsers: Microsoft Internet Explorer 5 and 6, Netscape Navigator 6 and 7, Mozilla Firefox 1.0, and Safari 1.3 for Mac OS X.

The required hardware is the same as that required to run the web browser on a specific platform (i.e., type of computer and operating system).

If for instance, you were running Internet Explorer 6.0 on an Intel-based computer and the Windows XP operating system, then your minimum hardware requirements would be as follows:

- A Pentium III 450 MHz processor, with 128 MB RAMS.

The application can be activated with a pointing device (i.e., mouse) or via the keyboard. It complies with all the accessibility requirements of Section 508 of the Workforce Rehabilitation Act of 1973.

Internet Connection

BCA.Net requires an Internet connection. With a dial-up connection, the speed should equal or exceed 56kbps (kilobits per second). The system will operate with lower speed connections, but the response times will be slower.

A faster, broadband connection (either through your local area network or from a cable or DSL connection) will enhance the user experience.

As a general guideline for what to expect, pages sent to your browser from the *BCA.Net* server are between 2KB (kilobytes) and 50KB (pages with graphical content are at the higher end of this range). With a 56kbps connection, the larger pages should download to your computer in less than 2 seconds. With a broadband connection, new pages should take a fraction of a second. Keep in mind that other factors, like traffic volume on the Internet, may cause slower response times.

Web Browser Settings

This section discusses several browser settings that you may need to adjust in order to use *BCA.Net*. Access these settings from your browser's main menu. In Internet Explorer use the menu option Tools>Internet Options. With Netscape, select Edit>Preferences.

Cookies

BCA.Net uses session cookies. Your browser should allow session cookies with most privacy settings with the exception of "Block all cookies". Session cookies promote the security of your session without compromising your privacy.

Security and Other Settings

The following security settings must be enabled in your browser in order to use *BCA.Net* and all of its features.

In Internet Explorer, under "Security" you must enable:

- "Active scripting"
- "Downloading of files"

With Netscape, you must check under Advanced>Scripts & Plug-Ins:

- "Enable JavaScript with Navigator"

Also with Netscape, under Navigator>Downloads> you must select one of the following options:

- "Open the download manager"
- "Open a progress dialog"

File Formats

Some of the optional features of *BCA.Net* involve the transfer of files between the *BCA.Net* server and your computer. The following are the file formats used in these transfers:

- Files with a BCA extension are used when downloading and uploading archived data for storage on a local computer between sessions. These files can only be used by the *BCA.Net* system.

- PDF or portable document files are used with *BCA.Net* reports. In order to view and print these files, you should have Adobe Acrobat© Reader or other compatible software installed on your computer in order to read and print these files. Free versions of Adobe Acrobat© Reader are available from many sources on the Internet.

Overview of this Manual

The remainder of this document describes how to conduct a *BCA.Net* analysis and use the pages that are encountered during an analysis. The manual concludes with a glossary of terms and an index.

In the text, the following conventions are used:

- Bold text is used to refer to a page in *BCA.Net* (e.g., **Manage** page). The same bold text will be used when referencing the links to these pages from the main navigation menu.

- Italics are used to designate menu options and selections in *BCA.Net* (e.g., *Create new dataset*)

- Choices in browser menu hierarchies are shown with the > symbol (e.g., "Edit>Paste" means "select menu option Edit then select from its submenu the option Paste".

Using *BCA.Net*

Introduction

This chapter gives general guidance on working with *BCA.Net*. The first section describes data management in *BCA.Net*. The section that follows presents the process for conducting a benefit-cost analysis with *BCA.Net*.

The subsequent chapter, "*BCA.Net* Page-by-Page", provides detailed descriptions of all the features of *BCA.Net*.

Managing Data in *BCA.Net*

In order to manage data and conduct analyses effectively in *BCA.Net* you should be familiar with its data hierarchy.

Every active session of *BCA.Net* has a data hierarchy that is populated with values at all times. These values correspond to the current selections of data that are viewable, editable and are used in *BCA.Net* model calculations. You navigate among different data collections by making selections on the **Manage** page, which sets the values in the data hierarchy.

The data hierarchy is shown in the figure below. A brief description of each of the nodes (boxes) in the figure follows at the end of this section.

Figure 2 Data Hierarchy in BCA.Net
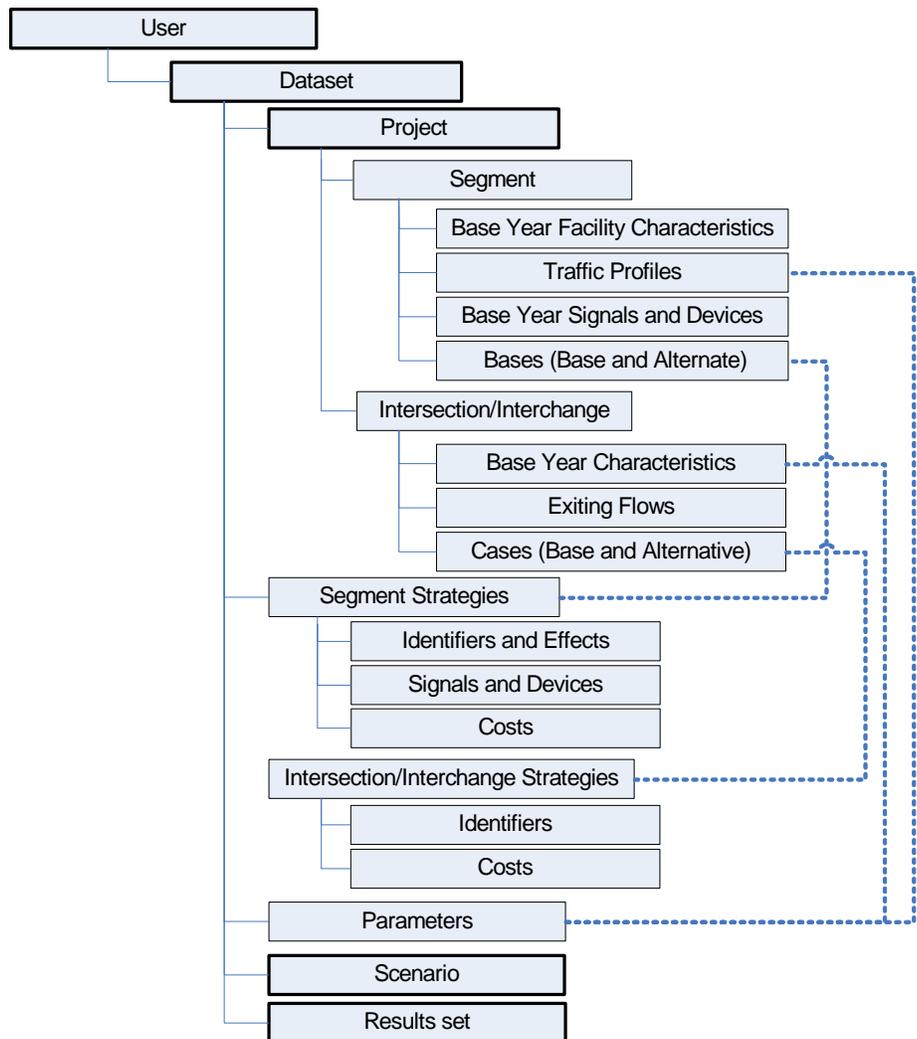
The solid connecting lines in the data hierarchy figure mean that the lower node to the right is a "child" of the parent node above and to its left and to which it is connected. The dotted lines indicate that the data objects to the right refer to objects contained in the collection to the left (i.e., a case contains a reference to one or more strategies; a traffic profile contains a reference to one or more traffic distributions).

When you change the value of a parent node (by making a selection in the **Manage** page), you are also re-populating the nodes in the hierarchy below the parent with values that represent data collections belonging to the newly selected parent node value.

The following are descriptions of the nodes in the data hierarchy.

User

When you log in to *BCA.Net*, a value representing your user account is set in the User node. This never changes during your session and ensures that users can only access their own data and not those of others.

Dataset

User data for analyses are organized in datasets in the *BCA.Net* database. Users may create and maintain up to 10 datasets at one time on the *BCA.Net* server. A dataset is a comprehensive container of data collections used in *BCA.Net* analyses. Note that data from different datasets cannot be combined in a single analysis. You can use datasets to preserve a baseline analysis, and then develop new analyses from renamed copies of the baseline dataset. You can download a dataset to your computer and restore it to the system later (thus allowing users to create and store as many datasets as desired). You can also share data with a colleague by sending your downloaded dataset to him or her, which your colleague can then upload during a session with *BCA.Net*.

Access the options for selecting, creating, deleting, downloading and uploading datasets from the Actions submenu of the **Manage** page.

Project

A project has a set of defining values (these can be viewed and modified in the data grid at the bottom of the **Manage** page – see Section 2. Manage Page below) and refers to a set of one or more highway segments. A segment is a specific highway facility with uniform physical and performance characteristics and traffic flows. It is common for a project to consist of only a single segment.

Create, delete and modify project segments (i.e., discrete components or sections of a project) and their associated data on the **Project Segment** page.

A project with multiple segments may also contain one or more intersection/interchanges. ISICs represent facilities that connect multiple segments. They can be as simple as a signaled intersection where four segments connect or as complex as a major clover leaf joining six roadway segments. The parameterization of ISICs is intended to capture the delay associated with vehicle traffic traversing the ISIC as it flows from one segment to the next. Create, delete and modify project ISICs and their associated data on the **Project ISICs** page. Enter the parameterization of an ISIC to represent traffic delay for a particular ISIC types on the **Parameters** page.

Create and delete projects, and modify their defining labels and values in the **Manage** page.

Scenario

A scenario has a set of defining values (a description, start year of the analysis period, last year of near term, and end year of the analysis period) and an associated collection of scenario data. A dataset will contain at least one scenario, and may contain as many as 30 scenarios.

Create and delete scenarios, and modify their defining values from the **Manage** page. After selecting a scenario, view and modify the scenario data from the **Scenario** page.

Segment Strategies

Although not defined through the **Manage** page, each dataset must have one or more segment strategies defined within it. The **Segment Strategy** page is used to describe the actions and costs of actions (e.g., resurfacing, adding lanes, adding or removing traffic signals, etc.) to be evaluated as part of the base cases and design alternatives

considered for one or more projects. Strategies can be combined and sequenced to make up any given base case or design alternative. (The combining and sequencing of strategies is done on the **Project Segments** page with the Base Case and Alternate Case view).

Intersection/Interchange Strategies

If a project contains an intersection/interchange, then the dataset must have one or more ISIC strategies defined within it. The **ISIC Strategy** page is used to describe the actions and costs of actions (e.g., modifying an intersection or interchange to facilitate more efficient traffic flow, by say, upgrading a signaled intersection to a diamond interchange). The strategies are to be evaluated as part of the base cases and design alternatives considered for one or more projects. Strategies can be combined and sequenced to make up any given base case or design alternative. (The combining and sequencing of ISIC strategies is done on the **Project ISICs** page with the Base Case and Alternate Case view).

Parameters

The **Parameters** page is used to hold information on 1) traffic flow distributions and, 2) intersection/interchange delay parameters.

The traffic distribution parameters represent traffic flows (e.g., peak hours, shoulder hours) for typical days (e.g., workday, weekend) over the course of a year. There is no limit on the number of traffic distributions you can define within a dataset. Data from the **Parameters** page can be applied to the traffic levels of any given project within a dataset.

For intersection/interchanges, each ISIC type is represented by three tables of data that characterize the delay for flows through an intersection.

Results

BCA.Net sets the defining values of a results set automatically when you run a simulation. You can set the description for a results set.

Create and delete results sets, and modify their descriptions from the **Manage** page. After selecting a results set and running a simulation, view results from the **Results** page.

The *BCA.Net* Analysis Process

The process for conducting a benefit-cost analysis with *BCA.Net* follows the steps shown in the workflow figure below. The boxes in the figure show the name of the step, an identifying number and the name of the *BCA.Net* system page where the step's operations are performed.

As the figure indicates, some steps are performed independently of others, while other steps require the prior completion of one or more predecessor steps. Each of the steps in the figure is explained in the following chapter, which includes a walkthrough and description of the model, its features and their use.

Figure 3 BCA.Net Analysis Workflows

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        ┌──────────────┬─────────────┼──────────────┬──────────────┐
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┌──────────────┐ ┌──────────────┐ ┌──────────────┐ ┌──────────────┐ ┌──────────────┐
│Select project│ │Select scenario│ │Select results│ │Enter data for│ │Enter data for│
│and           │ │and set        │ │set           │ │maintenance   │ │traffic       │
│set definitions│ │definitions,   │ │and set       │ │and           │ │distributions │
│              │ │including      │ │definitions   │ │improvement   │ │              │
│              │ │analysis years │ │              │ │strategies    │ │              │
│02    Manage  │ │03    Manage   │ │04    Manage  │ │05  Strategies│ │06 Parameters │
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│Create project│        │ Set scenario  │                   │                │
│segments      │        │ data          │◄──────────────────┘                │
│              │        │               │                                    │
│07    Segment │        │08   Scenario  │                                    │
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│Enter data││Enter data││Enter data││Set base  │                             │
│for base  ││for AADT  ││for base  ││and       │                             │
│year      ││and traffic││year     ││alternate │                             │
│facility  ││profiles in││signal and││cases    │                             │
│characteri││designated││traffic   ││          │                             │
│stics     ││years     ││devices   ││          │                             │
│09 Segment││10 Segment││11 Segment││12 Segment│                             │
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│Create and    │    │Create        │                                         │
│enter data    │───►│Intersection/ │                                         │
│for new ISIC  │    │Interchange   │                                         │
│type (if not  │    │              │                                         │
│already       │    │              │                                         │
│specified)    │    │              │                                         │
│13 Parameters │    │14    ISIC    │                                         │
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        │Enter     ││Enter data││Set base  │                                 │
        │segments  ││allocating││and       │                                 │
        │and       ││flows     ││alternate │                                 │
        │intersection││entering ││cases    │                                 │
        │type      ││ISIC to   ││          │                                 │
        │          ││segments  ││          │                                 │
        │15  ISIC  ││16  ISIC  ││17  ISIC  │                                 │
        └────┬─────┘└──────────┘└──────────┘                                 │
             ▼                                                               │
     ┌──────────────┐  ┌──────────────┐  ┌──────────────┐                   │
     │Set simulation│  │Run simulation│  │Review results│◄──────────────────┘
     │parameters    │─►│              │─►│              │
     │              │  │              │  │              │
     │18 Simulation │  │19 Simulation │  │20   Results  │
     └──────────────┘  └──────────────┘  └──────────────┘
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BCA.Net Page-by-Page

Introduction

The figure below shows the pages in *BCA.Net* and the means for accessing each page (pages directly connected to the main navigation menu are accessed from it. Access other pages from the connecting page to its left in the figure). The following descriptions of pages each contain an Overview and a Features section.

Figure 4 Key to Pages in BCA.Net
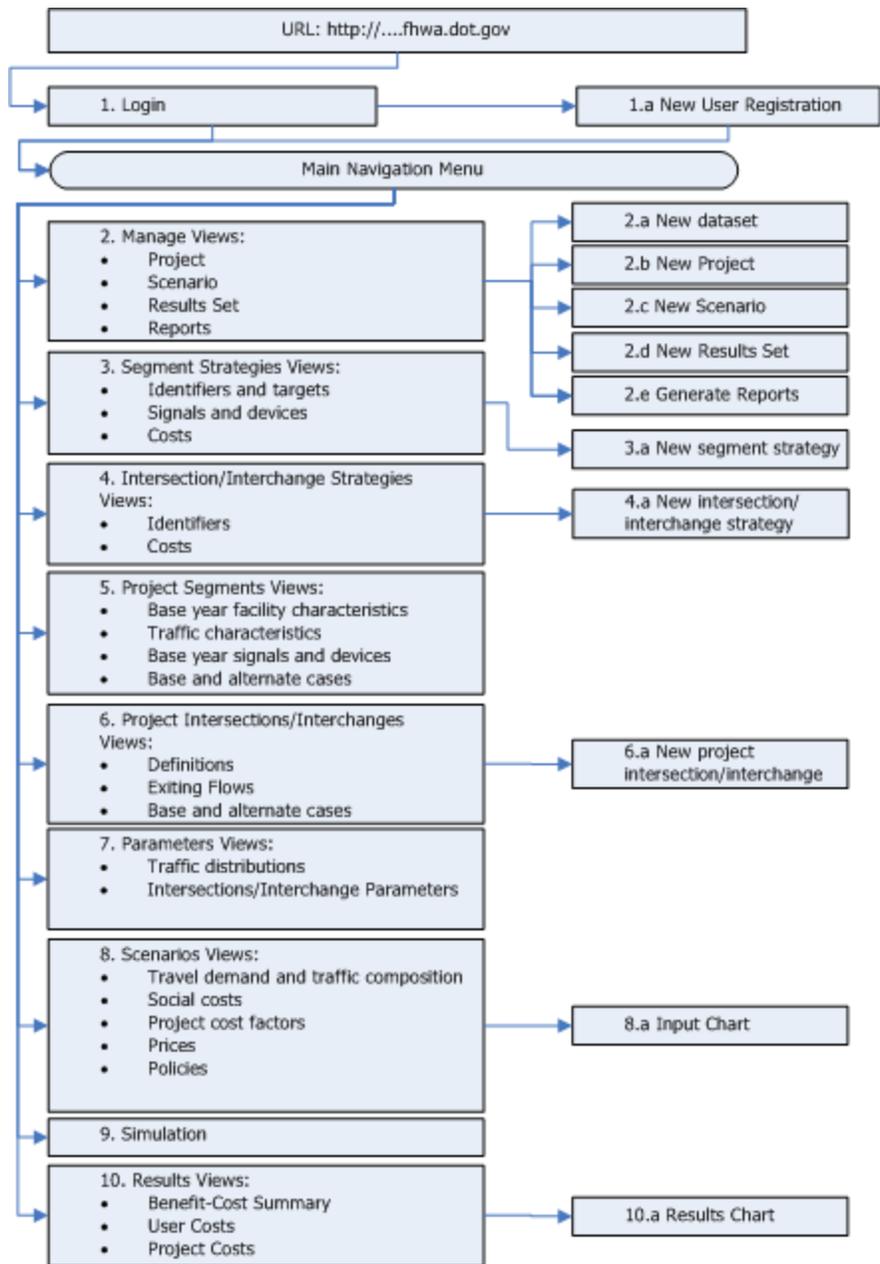
1. Login Page

Figure 5 View of Login Page

Login - Overview

BCA.Net can be accessed through one of two modes of access, each of which is the only access mode for a particular category of users. The modes of access and the user categories are:

- FHWA's User Profile and Access Control System (UPACS),

  Users that access *BCA.Net* with this access mode are FHWA employees or others that are registered users of FHWA information systems.

- The Login and Registration Pages of *BCA.Net*.

  Users that access *BCA.Net* with this access mode are non-FHWA employees and those who are not registered users of FHWA information systems.

Accessing BCA.Net through UPACS

Access *BCA.Net* by setting your browser to the UPACS login website. After you login through UPACS, a list of links will appear. Select the link that says *BCA.Net* System and your browser will be directed to the *BCA.Net* welcome page.

Accessing BCA.Net through the BCA.Net Login Page

Set your browser to the *BCA.Net* URL. The Login Page shown in Figure 5 will appear. If you have already registered as a *BCA.Net* user, then enter your user ID and password, and click submit to begin your session with *BCA.Net*.

1.a Registration Page

Figure 6 View of Registration Page

Registration - Overview

On this page, first-time users who are not FHWA employees and are not registered users of FHWA information systems register for *BCA.Net*. You arrive at this page by entering an e-mail address on the right side of the Login Page (Figure 5) and clicking submit.

Required information for registration includes: a User ID; a password; organization and type; address; and, a hint question and answer for login assistance.

After registering, you will be redirected to the welcome page.

2. Manage Page

Figure 7 Project View of Manage Page
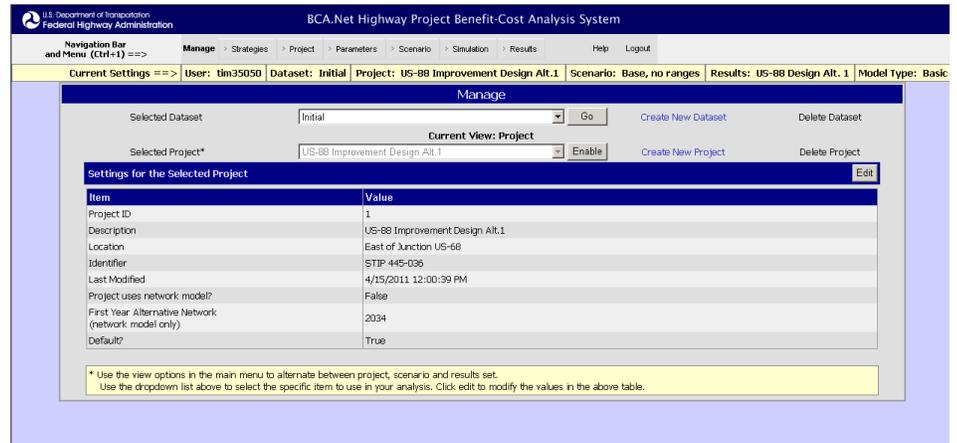
Manage - Overview

Use the controls on the Manage page to set and manage the data objects (e.g., datasets, projects, scenarios, result sets) for your analysis (see the section on "The Data Hierarchy in *BCA.Net*"). You can also modify the defining values for data objects, set or restore defaults, select the model type, and, launch the page to create new data objects or delete existing ones.

Use the Manage>View features in the main menu to toggle the page between the different views, which correspond to the three data, object types: project, scenario and results set.

Manage - Features

- Enable-Go toggle buttons – The two figures below show two rows from the Manage page, "Selected dataset" and "Selected Project" (note that "Selected Project" is specific to "Current View – Project"). In the first figure, the dataset selection dropdown list is active and the project selection dropdown list is inactive. Clicking the "Enable" button will cause the page to change so that the dropdown list to its left becomes active. When the dropdown list is active, the button to its right will display "Go". Clicking the "Go" button will change selected dataset (or project) to the one showing in the respective dropdown list.

Figure 8 Go-Enable Toggle Buttons - Dataset selection enabled
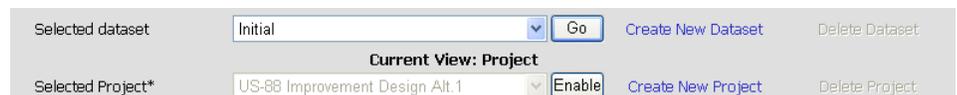
Figure 9 Go-Enable Toggle Buttons - Project selection enabled

- **Select dataset** dropdown list – if you have more than one dataset, select the one to use with this drop down list. After selecting, click the "Go" to the right of the dropdown list.

- **New dataset** link - Invoke the page for creating a new dataset.

- **Delete dataset** link – Delete the selected dataset. The link is enabled only if a non-default dataset is selected. If you wish to delete a default dataset, and then select a different dataset, set it as the default dataset, and then delete the former dataset.

- **Manage>Views** menu options: When you select one of the views, you change the current view to focus on one of the three data objects – project, scenario or results set. A fourth view on the page allows you to select and generate BCA.Net reports.

    The components on the page below the header "Current View" will change accordingly when you select one of the first three views:

    o Populate the drop down list for the data object selection (enabled after clicking on the "Enable" button below the "Current View" header).

    o Populate the grid at the bottom of the page with the defining values of the selected data object and enable editing of these values.

    o Enable the "Create New" link to navigate to the corresponding page when clicked for creating a new data object.

    o The "Delete" link is enabled (only if the selected data object is not the default data object.)

    The reports view on this allows you to select reports for printing and saving.

- **Manage>Views>Projects** menu options:

    o When you click the "Edit" button the grid changes to edit mode and the editable values will appear in text boxes. Click the "Update" button when you have completed editing, or, click the "Cancel" button to undo edits and return to non-edit mode.

    o Modify the defining values for the selected project in edit-mode.

    o Select the model type for the analysis by setting the *Project uses network model* parameter to "true" for a Network model type or "false" for a Basic model type. The *First year alternative network* parameter determines the first year the alternative network model is used in the analysis[1].

    o The *Default* parameter determines the default project settings for the selected dataset.

- **Manage>Actions** menu options:

    o **Reload defaults** – Some of your data collections are designated as "defaults", which are set as "selected" when you begin your

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[1] See Text Box at the end of the chapter for a description of the Network Model and how it differs from the Basic Model.

*BCA.Net* session. This action restores your default settings to be the current ones.

  o **Save current selections as defaults** – This action will replace your default selections with the ones that are current.

  o **Archive dataset to local disk** – When you download a dataset, you create a BCA file on your computer that contains a replica of all the data in your dataset. The downloaded dataset is for storage and sharing with other users. It is not in a suitable format for offline modification of data. After downloading your dataset, you can delete it from the *BCA.Net* server database.

  o **Restore archived dataset** – Select this action to upload and restore an archived dataset to the *BCA.Net* server.

  o **Generate report** – Selecting this option will generate a "Settings Report" in Adobe Acrobat (pdf file) for the project that is currently selected. This report summarizes all data included in the project, scenario, and result views on the Manage page.

- **Select project** drop down list (visible when the "Project" view is selected) – Select the project for your analysis.

- **Select scenario** drop down list (visible when the "Scenario" view is selected) – Select the scenario for your analysis.

- **Select results set** drop down list (visible when the "Results set" view is selected) – Select the results set for your analysis.

- **Create project, scenario, or results set** link - Invoke the page for creating a new data object (project, scenario or results set, depending upon the current view).

- **Delete project, scenario, or results** link – Delete the selected data object. Note that you cannot delete a default data collection – if the data collection you wish to delete is the default, then select a different data object and set that one as the default and then delete the originally selected data object.

- **Data object definitions** data grid – After selecting a data collection with the drop down lists above, its definitions will appear in the data grid at the bottom of the page.

  o Click the "Edit" button the grid changes to edit mode and the editable values will appear in text boxes.

  o Click the "Update" button when you have completed editing .

  o Click the "Cancel" button to undo edits and return to non-edit mode. Note that if you update changes to a default data set, these changes become part of the default data.

TEXT BOX – BASIC MODEL AND NETWORK MODEL

BCA.Net conducts benefit-cost analysis of improvements to specific roadways. BCA.Net's Basic Model assumes that the improvements to a roadway are largely restricted to the roadway itself and there is no fundamental shift in traffic patterns as a result of the improvement. With the Basic Model, BCA.Net always compares the base and alternate cases of an existing facility with no significant change in traffic flows on the improved segments or on adjacent roadways.

A large category of roadway improvements will, in fact, cause significant shifts in traffic patterns. For instance, a new connector that links between two facilities would typically result in major changes in traffic patterns. An example of one such project is a proposed connector road in Eagle County, Colorado (see figure below) that will add a new interchange to I-70 and build a new north-south connector road that flies over US 6 and connects to Cooley Mesa Road, which accesses the regional airport. When the connector road is added about one-third of the trips on parts of US 6 divert and use I-70 and the new connector road instead.

Figure 10 Example Connector Road Project
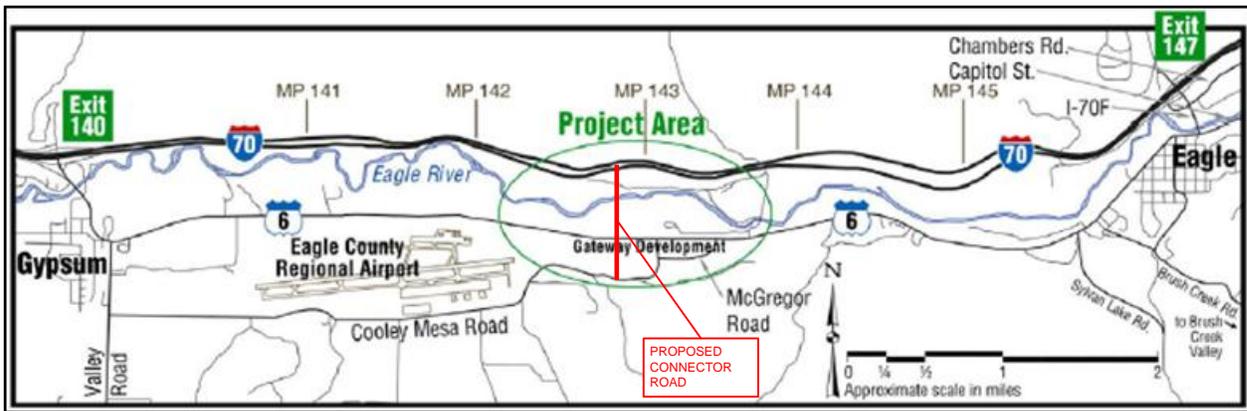
The Network Model permits the comparison of a base case roadway network having base case traffic flows with an alternate case network with different, alternate case traffic flows. BCA.Net performs all of the required calculations on each of the networks. Just as BCA.Net assumes that traffic analysis has been conducted on roads that are considered for improvement, projects with connector roads would likewise have suitable traffic planning with forecast traffic on road links in a network for the period of analysis. So the required set of inputs remains largely the same for the Basic Model that compares a base and alternate case for the same segments with the same traffic in the base and alternate cases.

To use the Network Model the user selects the model type on the Manage Page (Project View), selecting Network Model, for comparing base and alternate road networks. When selecting the Network Model, the user also selects the first year in which the alternate network is operational in the alternate case. The selected year divides the analysis into two periods and compares the alternate case (with the base network and traffic flows in the first period and the alternate network and traffic flows in the second period) with the base case (base network and traffic flows in both periods).

Table 1 Network Model and Effective Networks in Each Case

	BASE CASE	**ALTERNATE CASE**
PERIOD 1	Base Network and Traffic Flows	Base Network and Traffic Flows
PERIOD 2	Base Network and Traffic Flows	Alternate Network and Traffic Flows

With the Network Model the user prepares project segments that represent the base case network and its traffic flows. The user also specifies for the base case segments the traffic flows for the alternate network. The user then adds to the project new segments that are present in alternate case network including their forecast traffic flows. On all project segments the user assigns strategies of maintenance or improvements for the base and alternate case.

With both model types, the user runs simulation in exactly the same way. With the Network Model, however, the forecast traffic flows are assumed to already account for induced demand while the Basic Model calculates induced demand and its effects on user costs and benefits.

2.a to 2.d New Data Object (Dataset, Project, Scenario, Results set) Page

*Figure 11 View of Create New Project Page*

New Data Object - Overview

Invoke this page from the **Manage** page and use it to create a new data object. Depending on the data object, the required actions will vary (see the table below). Note that if you invoke this page and then change your mind, you can return to the Manage page by selecting from the Main Menu Manage>Go to Manage Page.

Table 2 Required Actions for Creating New Data Objects

Data object	Required Actions for Creating New Object
Dataset	Select "new from sample data" or "copy a dataset". If you select "copy" then you must select the dataset to copy from a dropdown list. Provide a name for the new dataset.
Project	Select "create a new, empty project" or "copy an existing project". If you select "copy" then you must select the project to copy from a dropdown list. Provide a name for the new project.
Scenario	Select "create new scenario with default values" or "copy an existing scenario". If you select "copy" then you must select the scenario to copy from a dropdown list. Provide a name for the new scenario.
Results Set	Provide a name for the new results set.

2.e Generate Multiple Reports Page

Figure 12 A section of the Generate Multiple Reports View with a Network model type
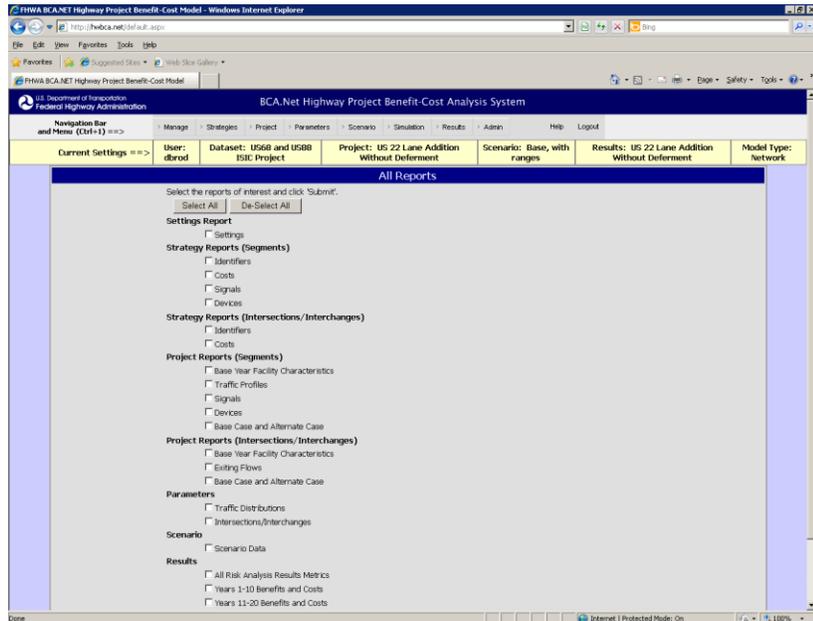
Generate Multiple Reports - Overview

Invoke this page from the **Manage** page and the menu selection Mange>Actions>Generate Multiple Reports. This page allows you to generate all BCA.Net reports or any subset of them. Select the reports you wish to generate then click "Submit". The reports listed will vary according to the network model type selected for the analysis.

Note that the Results reports require running a simulation prior to report generation. Failure to do so will cause an error notice to be displayed. Each report generated will pop in up a new browser with the report displayed as a portable document file (pdf). The report can be printed or saved to your local computer.

After generating your reports you can move to any other page with the navigation menu.

3. Segment Strategies Page

Figure 13 View of Segment Strategies Page (Identifiers and Targets View)
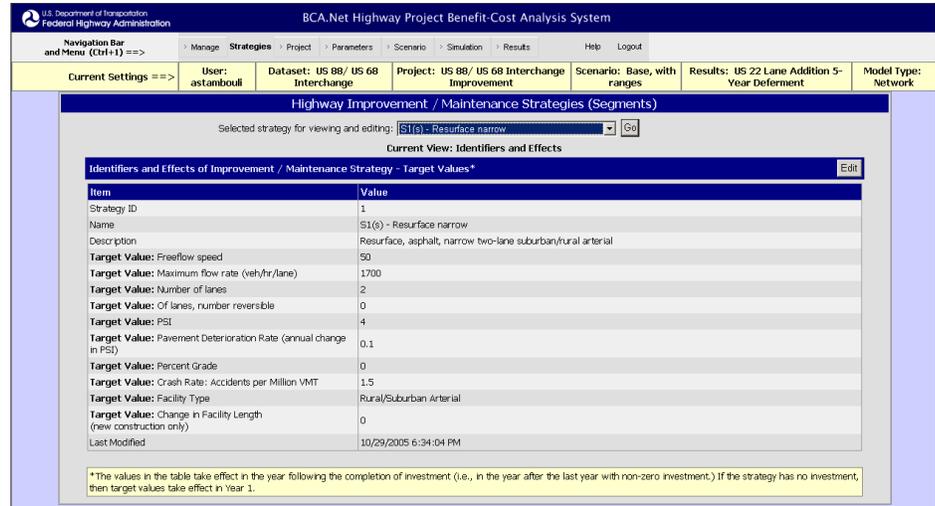
Segment Strategies - Overview

Use the **Segment Strategies** page to develop strategies for highway segments, which are improvement and maintenance actions. You specify segment strategies to use in the benefit-cost analysis when you set the base and alternate cases for the segments of a project (at **Project Segments>Views>Cases**).

The **Segment Strategies** page has three views: 1) Identifiers and Effects, 2) Signals and Devices, and, 3) Costs. To specify the effects of a strategy you set target values for the facility characteristics that are the result of the strategy (either improvement or maintenance). The following table for the Identifiers and Effects View lists the variables targeted by the strategy and their definitions:

Table 3 Definitions of Strategy Target Variables in the Identifiers and Effects View

Variable	Definition
Freeflow speed	The average speed "that a driver would like to attain in absence of any impedance due to other vehicles or control devices".
Maximum flow rate (veh/hr/lane)	The maximum flow rate of a facility, a measure of its capacity, is the flow rate ("equivalent hourly rate at which vehicles pass over a given point…during a given time interval") where speed and density are optimal (i.e., more traffic results in greater density, lower speeds and less flow)
Number of lanes	Number of lanes of the facility after implementation of the strategy. For

Variable	Definition
	instance, if the strategy is to add lanes, the number of lanes should equal the total lanes (new and existing) that would be available after strategy implementation.
Of lanes, number reversible	Number of lanes whose direction is reversible to accommodate unbalanced directional flows of traffic at different times of day.
Pavement Serviceability Index (PSI)	The AASHTO Pavement Serviceability Index, a zero to five rating scale, where a user considers a roadway with rating 5 to be perfect and a roadway with rating 0 to be impassable.
Pavement Deterioration Rate (annual change in PSI)	After improvement and with a designated maintenance program, this is the value by which PSI is expected to decrease annually (i.e., if PSI is 4.2 in 2010 and the Pavement Deterioration Rate is .1, then in 2011 the PSI will be 4.1).
Percent Grade	The change in elevation between the beginning and end of a segment, divided by the length of the segment times 100.
Crash Rate: Accidents per Million VMT	Number of crashes per million vehicle-miles traveled on the segment.
Facility Type	Use the dropdown list to select one of eight facility types: Freeway, expressway, arterial or collector - in an urban or rural/suburban environment
Change in Facility Length	If the strategy involves construction which alters the roadway alignment, enter the change in facility length between the new and old alignments (i.e., if a 5.5 mile facility is shortened to 4.7 miles, enter here - 0.8 miles).

In the "Signals and Devices" view of the **Strategies page** (see Figure 12), you specify any changes in the traffic signals or traffic control devices that are associated with a strategy. In effect, this page supplements the "Identifiers and Effects" view with data specifically pertaining to intersection traffic control. If the strategy does not cause any change in traffic control, you must indicate this by checking the "No changes..." check box that appears in this view. (When the "No changes…" check box is checked traffic control in a particular year of the analysis is determined by either: 1) the base year traffic control set in the **Project** page, or, 2) the last strategy implemented that affects traffic control). If a change in traffic signals or devices is intended as part of the strategy, the "No changes…" check box(es) should be

unchecked and activated by clicking the corresponding "Go" button (see Figure 13). Once the signals view is invoked, signals and devices for the strategy under consideration can be entered, modified or eliminated using the appropriate buttons (e.g., "Add New", "Edit"). After modifying signal or device data, click the "Update" button to save your changes. **Note that the signal and device data must be specified separately for peak, shoulder and non-peak traffic periods.** Also, see the base year "Signals and devices" discussion in the **Project** section of this manual below.

Figure 14 Signals and Devices View of the Strategy Page with No Changes to Signals or Devices
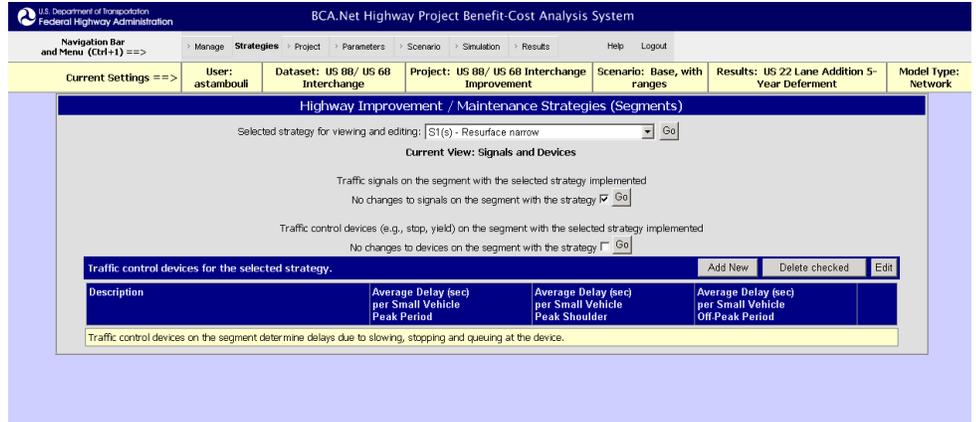
Figure 15 Signals and Devices View of the Strategy Page with Changes to Signals or Devices
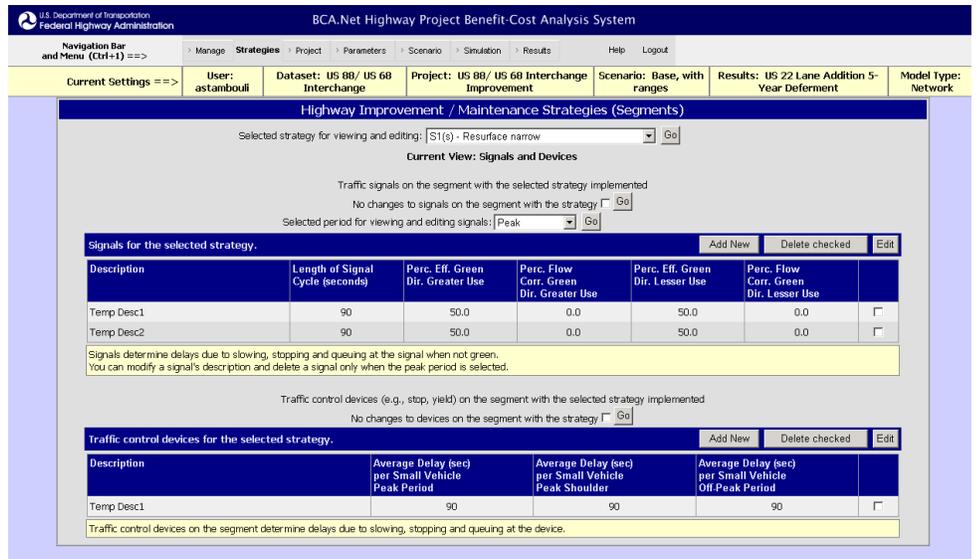
Table 4 Definitions of Strategy Target Variables in the Signals and Devices View

Variable	Definition
Length of Signal Cycle(seconds)	The total time in seconds to complete a complete signal cycle (i.e., the time from the beginning of a red signal to the beginning of the next red signal).
Perc. Eff. Green Dir. Greater Use	The percent of the total signal cycle during which the light is green in the on the segment in the direction with the greater traffic flow.
Perc. Flow Corr. Green Dir. Greater Use	The correlation of traffic flow (in the direction of greater use) with the green signal. This variable allows you to capture the effect of synchronized traffic signals. A zero correlation means that the percent of traffic not experiencing delay due to the signal equals the percent effective green.
Perc. Eff. Green Dir. Lesser Use	The percent of the total signal cycle during which the light is green in the on the segment in the direction with the lesser traffic flow.
Perc. Flow Corr. Green Dir. Lesser Use	The correlation of traffic flow (in the direction of lesser use) with the green signal. This variable allows you to capture the effect of synchronized traffic signals. A zero correlation means that the percent of traffic not experiencing delay due to the signal equals the percent effective green.
Average Delay (sec) per Small Vehicle Peak Period	This variable applies to stop signs and other non-signal traffic devices, including traffic circles, and reflects the average delay in seconds per small vehicle due to the slowing, stopping, and return to the uninterrupted flow speed on the segment from the traffic device. In the case of a traffic circle, it represents the time to slow, merge with circulating traffic, and return to the uninterrupted flow speed on the segment.
Average Delay (sec) per Small Vehicle Peak Shoulder	This variable has the same meaning as the previous one, except that it applies to peak shoulder traffic periods.
Average Delay (sec) per Small Vehicle Off-Peak Period	This variable has the same meaning as the previous except that it applies to off-peak traffic periods.

Note that is the "No Changes…" boxes are unchecked for a particular strategy, and if that strategy is used in the "Cases" view of the **Project** page, then the signal and device information specified for that strategy will be used by *BCA.Net* in the benefit-cost analysis. If no traffic or signal services are specified for the strategy, then *BCA.Net* assumes that all such devices have been eliminated by the strategy (as would occur if a traffic signal were replaced by an interchange). If an interchange is part of the strategy, then the cost of the interchange must be included in the strategy costs (see immediately below).

Figure 16 Costs View of Strategy Page with the Work Zone Calculator Disabled
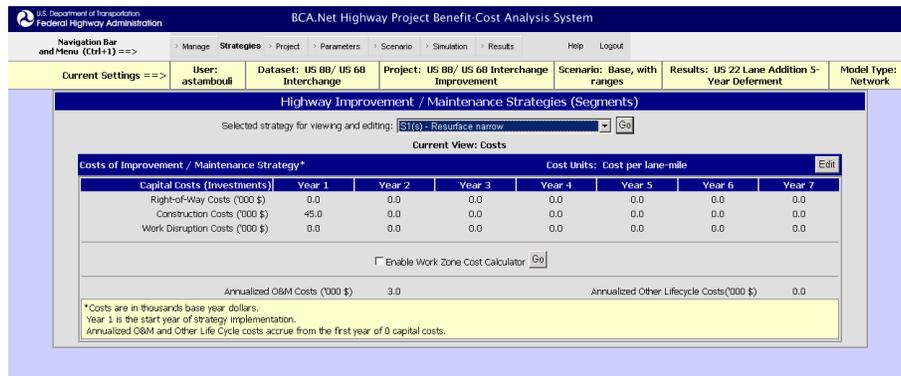
Figure 17 Costs View of Strategy Page with the Work Zone Calculator Enabled
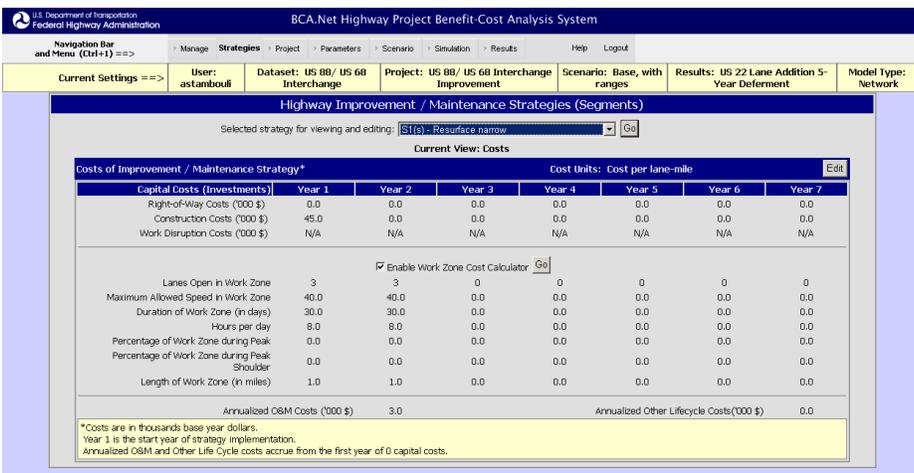
In the Costs view of the **Segment Strategies** page, you specify the costs associated with the strategy. Select the units (total, per facility-mile, or per lane-mile) and enter the capital expenditures for up to seven years of a construction program, with separate costs for right-of-way, construction and anticipated user costs (i.e., delay) due to construction activities such as work zones.

Anticipated user costs due to construction can be calculated using the Work Zone Cost Calculator. To enable the use of the calculator, check the "Enable Work Zone Calculator" checkbox in the Costs view of the **Segment Strategies** page, and click "Go". This will disable manual entry for work disruption costs and enable the user to enter parameters for the work zone calculator in all seven years of the strategy.

Table 5 Definitions of Work Zone Calculator Variables in the Costs View

Variable	Definition
Lanes Open in Work Zone	The total number of operational lanes in a work zone.
Maximum Allowed Speed in Work Zone (in miles-per-hour)	The maximum posted speed for the operational lanes in a work zone, in miles-per-hour.
Maximum Duration of Work Zone (in days)	The maximum duration of a work zone disruption, in days.
Hours per Day	The total daily number of hours during which the work zone lane closures are active.
Percentage of Work Zone During Peak	The percentage of daily work zone disruptions that take place during the peak period.
Percentage of Work Zone During Peak Shoulder	The percentage of daily work zone disruptions that take place during the peak shoulder period.
Length of Work Zone (in miles)	The total length of work zone, in miles.

If changes to signals or traffic devices are included in the strategy, these costs must be included as part of the strategy's cost in this view. Note that the capital costs of a strategy only begin in the year in which you specify the strategy to be implemented in the Cases view of the **Project** page. You must also specify the annual Operating and Maintenance (O&M) and Other Lifecycle (OLC) costs (if any) associated with the strategy. Note that theses recurring annual costs take effect in the year following the last year of capital expenditures. Likewise, the target effects of a strategy (specified in the Identifiers and Effects view of the **Segment Strategies** page) take effect in the year following the last year of capital expenditures. For instance, if a strategy is implemented, say, in the alternate case in year 2010 and has three years of capital expenditures, there will be associated capital expenditures in years 2010, 2011 and 2012. In year 2013, the strategy target effects will apply and the strategy O&M and OLC costs begin to accrue in each year.

Segment Strategies - Features

- **Select strategy** dropdown list – Select the strategy to edit with this drop down list. After selecting, click the "Go" to the right of the dropdown list.

- **Segment Strategy>Views** menu options – Use this option to toggle between the pages' three views: 1) Identifiers and Effects, 2) Signals and Devices, and 3) Costs. The components on the page below the header "Current View" will change accordingly. Each view will show a suitable data grid control for editing its variable values.

- **Segment Strategy>Actions** menu options:

  o **Create new strategy** – Selecting this option will bring you to the New Strategy page. See the description of its use and features in the following section.

  o **Create copy of selected strategy** – This option will create a copy of the currently selected strategy. The newly created strategy will

have a temporary name, which can be edited in the Identifiers and Effects view of the page. The new copy will be set as the current strategy.

- o **Delete selected strategy** – Selecting this option will cause the selected strategy to be deleted. The selected strategy can only be deleted if it is "orphaned", that is, it is not referenced by any case (as specified in the Cases view of the **Project** page) belonging to any project segment in the dataset. If you attempt to delete a strategy that is referenced by a case, then the page will show an error message. Following a successful deletion, the first strategy in the list is set as current.

- o **Generate report –** Selecting this option will generate a "Segment Strategy Report" in Adobe Acrobat (pdf file) for the strategy that is currently selected. This report includes all data in the identifiers, target effects and costs views on the Segment Strategy page.

- **Strategy values data grid** – On the page below the line "Current View" is a data grid corresponding to the selected view of the page ("Identifiers and Effects", "Signals and Devices" or "Costs"). When you click the "Edit" button the grid changes to edit mode and the editable values will appear in text boxes. Click the "Update" button when you have completed editing, or, click the "Cancel" button to undo edits and return to non-edit mode. If you try to update, but one or more of the text boxes contains invalid values (i.e., non-numeric characters in a numeric field, or, values outside a permissible range for the variable), the page will show an error message.

- On the "Signals and Devices" view of the page, there are additional buttons that allow you to add or delete signals or devices. Two checkboxes indicate whether the strategy effects no changes to existing signals or devices, respectively. If the checkboxes are checked, then the associated table of signals or devices will not be displayed.

3.a New Segment Strategy Page

Figure 18 View of New Strategy Page
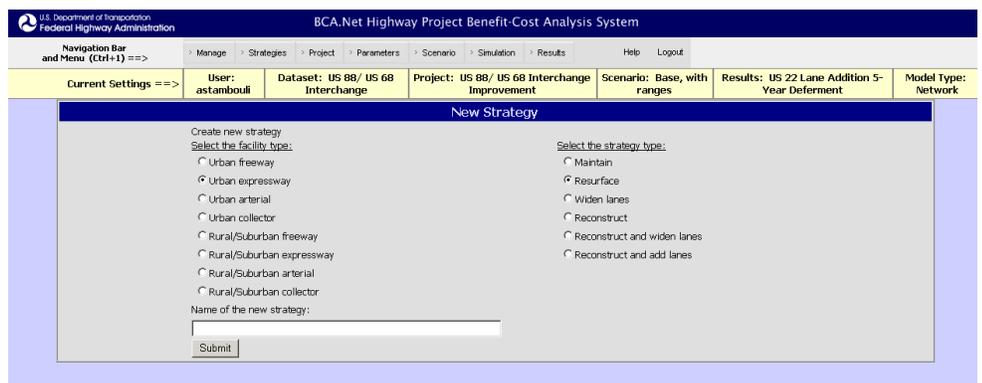
New Segment Strategy - Overview

This page is accessed from the menu option **Segment Strategy>Actions>Create new strategy**. To create a new strategy: 1) select one of the eight facility types (Freeway, expressway, arterial, collector – urban or rural), 2) select one of the

strategy types (maintain, resurface, widen lanes, add lanes, reconstruct, reconstruct and widen lanes, reconstruct and add lanes), 3) enter a name for the new strategy and click "Submit".

After clicking "Submit", the **Segment Strategies** page will appear and the new strategy will be set as the current strategy and can be modified as needed.

4. Intersections/Interchanges (ISIC) Strategy Page

Figure 19 View of Segment Intersection / Interchanges Page (Identifiers)

ISIC Strategies - Overview

Use the **Intersections/Interchanges (ISIC) Strategies** page to develop strategies for highway intersections/interchanges. The strategies are improvement and maintenance actions. You specify ISIC strategies to use in the benefit-cost analysis when you set the base and alternate cases for the ISIC of a project (at **Project ISIC>Views>Cases**).

The **ISIC Strategies** page has two views: 1) Identifiers and 2) Costs. To specify the effects of a strategy you set the target ISIC type in the Identifiers view, which is the result of the strategy (either improvement or maintenance). The ISIC types are defined on the **Parameters Page**, **ISIC Parameters View**. A set of parameters defines the travel time of vehicles traversing the ISIC as a function of the volume of traffic.

Figure 20 Intersection/Interchanges Strategies Page (Costs View)

In the Costs view of the **ISIC Strategies** page, you specify the costs associated with the strategy. Enter the capital expenditures for up to seven years of a construction program, with separate costs for right-of-way, construction and anticipated user costs (i.e., delay) due to construction activities such as work zones. Note that the capital costs of an ISIC strategy only begin in the year in which you specify the strategy to be implemented in the Cases view of the **Project ISIC** page. You must also specify the annual Operating and Maintenance (O&M) and Other Lifecycle (OLC) costs (if any) associated with the strategy. Note that theses recurring annual costs take effect in the year following the last year of capital expenditures. Likewise, the effect of a strategy (e.g., the new ISIC type that is specified in the Identifiers view of the **ISIC Strategies** page) takes effect in the year following the last year of capital expenditures. For instance, if a strategy is implemented, say, in the alternate case in year 2010 and has three years of capital expenditures, there will be associated capital expenditures in years 2010, 2011 and 2012. In year 2013, the strategy target effects will apply and the strategy O&M and OLC costs begin to accrue in each year.

ISIC Strategies - Features

- **Select strategy** dropdown list – Select the strategy to edit with this drop down list. After selecting, click the "Go" to the right of the dropdown list.

- **ISIC Strategy>Views** menu options – Use this option to toggle between the pages' two views: 1) Identifiers and 2) Costs. The components on the page below the header "Current View" will change accordingly. Each view will show a suitable data grid control for editing its variable values.

- **ISIC Strategy>Actions** menu options:
    - **Create new strategy** – Selecting this option will bring you to the New ISIC Strategy page. See the description of its use and features in the following section.

    - **Create copy of selected strategy** – This option will create a copy of the currently selected strategy. The newly created strategy will have a temporary name, which can be edited in the Identifiers and Effects view of the page. The new copy will be set as the current strategy.

    - **Delete selected strategy** – Selecting this option will cause the selected strategy to be deleted. The selected strategy can only be deleted if it is "orphaned", that is, it is not referenced by any case (as specified in the Cases view of the **Project ISIC** page) belonging to any project segment in the dataset. If you attempt to delete a strategy that is referenced by a case, then the page will show an error message. Following a successful deletion, the first strategy in the list is set as current.

    - **Generate report** – Selecting this option will generate an "Intersection and Interchanges Strategy Report" in Adobe Acrobat (pdf file) for the strategy that is currently selected. This report will include all data from the identifiers, target effects and costs views on the ISIC Strategy page.

- **Strategy values data grid** – On the page below the line "Current View" is a data grid corresponding to the selected view of the page ("Identifiers" or "Costs"). When you click the "Edit" button the grid changes to edit mode and the editable values will appear in text boxes. Click the "Update" button when you have completed editing, or, click the "Cancel" button to undo edits and return to non-edit

mode. If you try to update, but one or more of the text boxes contains invalid values (i.e., non-numeric characters in a numeric field, or, values outside a permissible range for the variable), the page will show an error message.

4.a New Intersection/Interchanges (ISIC) Strategy Page

Figure 21 New Intersection/Interchange Strategy Page

New ISIC Strategy - Overview

This page is accessed from the menu option **ISIC Strategy>Actions>Create new strategy**. To create a new strategy: 1) Select and Intersection/Interchange type from the dropdown list, 2) Enter the name of the new strategy, and 3) click "Submit". Note the definitions of the ISIC types are found on the **Parameters Page**.

After clicking "Submit", the **ISIC Strategies** page will appear and the new strategy will be set as the current strategy and can be modified as needed.

5. Project Segments Page
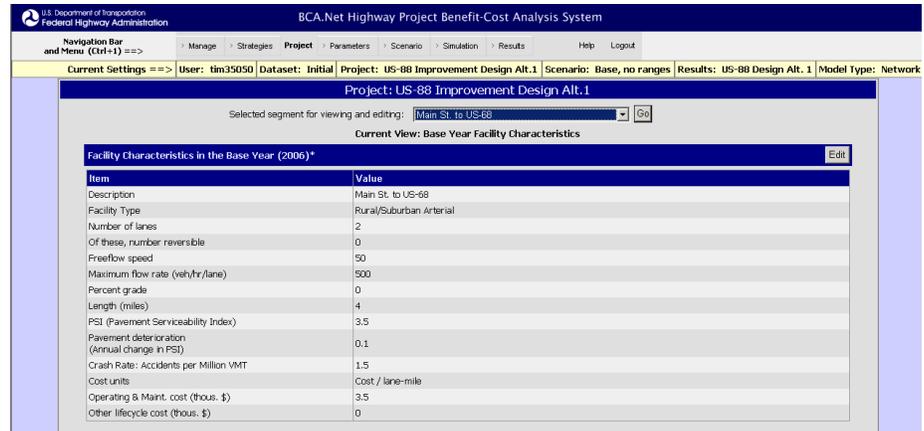
Project Segments - Overview

From the **Project Segments** page, you can edit the data for project segments, create new project segments, and delete existing segments. The Project Segments page has differing views for the Basic and Network model types. The model type is determined in the Project View of the **Manage Page**. The Basic model type is used if a Network model is not enabled for the analysis.

The **Project Segments** page has four views if a Basic model type is selected. These four views apply to the selected project segment:

- Base Year Facility Characteristics

  The facility characteristics in the base year include the variables that are targeted by strategies (see Section 3 above). In this section, you also specify the Operating and Maintenance and Other Lifecycle costs that are associated with the facility in the base year. The base year is the year that precedes the period of analysis and the conditions specified for the base year will prevail in subsequent years (for either the base or alternate cases, or both) until superseded by a strategy.

- Traffic Characteristics

  In traffic characteristics there are two components: 1) Forecast Average Annual Daily Traffic (AADT) for the segment in each of the three designated forecast years: start year, last year near term and end year (set these years on the **Manage** page in the scenario view). The second component is the traffic profiles, which describe the distribution of traffic in representative days.

- Base Year Signals and Devices

  In this view, the analyst sets the number and characteristics of the traffic signals and devices in the facility's base year. In constructing the base and alternate cases of the project (see next bullet on "Cases"), the analyst can select strategies that add, modify, or eliminate the base year signals or devices (see **Strategies** page discussion of Signals and Devices above).

- Cases

  For each segment in a project you specify a base and alternate case. The base case represents the "do minimal" scenario that is needed to maintain serviceable operation of the facility over the analysis period. The alternate case represents a possible improvement to the roadway that typically involves a significant investment of funds or resources relative to the "do minimal" base case. Each case is built of one or more strategies along a specification of the year(s) in which the strategies would be implemented. For more information on base and alternate cases, see the glossary.

The **Project Segments** page has five views if a Network model type is used. These five views apply to the selected project segment:

- Base Year Facility Characteristics

  The facility characteristics in the base year include the variables that are targeted by strategies (see Section 3 above). In this section, you also specify the Operating and Maintenance and Other Lifecycle costs that are associated with the facility in the base year. The base year is the year that precedes the period of analysis and the conditions specified for the base year will prevail in subsequent years (for either the base or alternate cases, or both) until superseded by a strategy.

- Base Network Traffic Characteristics

  In the base network traffic characteristics there are two components: 1) Forecast Average Annual Daily Traffic (AADT) for the segment in each of the three designated forecast years: start year, last year near term and end year (set these years on the **Manage** page in the scenario view). The second component is the traffic profiles, which describe the distribution of traffic in representative days. These values only apply to the base network.

- Alternate Network Traffic Characteristics

  In the alternate network traffic characteristics there are two components: 1) Forecast Average Annual Daily Traffic (AADT) for the segment in each of the three designated forecast years: start year, last year near term and end year (set these years on the **Manage** page in the scenario view). The second component is the traffic profiles, which describe the distribution of traffic in representative days. These values only apply to the alternate network.

- Signals and Devices

  In this view, the analyst sets the number and characteristics of the traffic signals and devices in the facility's base year. In constructing the base and alternate cases of the project (see next bullet on "Cases"), the analyst can select strategies that add, modify, or eliminate the base year signals or devices (see **Strategies** page discussion of Signals and Devices above).

- Base Case and Alternate Case

  For each segment in a project you specify a base and alternate case. The base case represents the "do minimal" scenario that is needed to maintain

serviceable operation of the facility over the analysis period. The alternate case represents a possible improvement to the roadway that typically involves a significant investment of funds or resources relative to the "do minimal" base case. Each case is built of one or more strategies along a specification of the year(s) in which the strategies would be implemented. For more information on base and alternate cases, see the glossary.

Project Segments - Features

- **Select segment** dropdown list – Select the segment to edit with this drop down list. After selecting, click the "Go" to the right of the dropdown list. Note that segments can be added or deleted in the **Project>Actions** options (see below).

- **Project Segments>Views** menu options – Use this option to toggle between the page's multiple views:

  - For a Basic model type: 1) base year facility characteristics, 2) traffic characteristics, 3) signals and devices, and 4) base and alternate cases.

  - For a Network model type: 1) base year facility characteristics, 2) base network traffic characteristics, 3) alternate network traffic characteristics, 4) signals and devices, and 5) base case and alternate case.

  The components on the page below the header "Current View" will change accordingly. Each view will show a suitable data grid control for editing its variable values.

- **Project>Actions** menu options:

  - **Create new segment** – Selecting this option will invoke a submenu of eight segment types. The selection of a segment type under this submenu will generate a new segment, populated with default data that can be edited to reflect the specific characteristics of the segment under consideration. These characteristics are described below under the "Segment valued datagrid" discussion.

  - **Copy selected segment** – This option will create a copy of the currently selected segment that can be modified to new specifications. The system gives a temporary name to the newly created segment, which you can edit in the Base Year Facility Characteristics view of the segment.

  - **Delete selected segment** – Selecting this option will cause the selected segment to be deleted. Note that it is very important that you delete any segment that is not an intended component of a project. Otherwise, the model will include the segment in the benefit-cost analysis.

  - **Copy base network traffic characteristics to alternate network traffic characteristics for selected segment** (Network model type only) – Selecting this option will copy the base network traffic characteristics to the alternate network traffic characteristics for a selected segment.

  - **Copy base network traffic characteristics to alternate network traffic characteristics for all segments** (Network model type only) – Selecting this option will copy the base network traffic

characteristics to the alternate network traffic characteristics for all segments

o **Delete traffic profiles and set AADT to 0 in base network for selected segment** (Network model type only) – Selecting this option will delete all traffic profiles in the Base Network Traffic Characteristics view of the Project Segments page and set the AADT for the selected segment to 0 in all years of the base network analysis.

o **Delete traffic profiles and set AADT to 0 in alternate network for selected segment** (Network model type only) – Selecting this option will delete all traffic profiles in the Alternate Network Traffic Characteristics view of the Project Segments page and set the AADT for the selected segment to 0 in all years of the alternate network analysis.

o **Generate report** – Selecting this option will invoke a submenu of project reports to generate. Users can generate project reports for each view in the Project Segments page. For a Basic model type, these reports include "Base Year Facilities Characteristics", "Annual Traffic Data", "Traffic Profiles", "Signals", "Devices", and "Segment Base and Alternate Cases". Reports are generated as Adobe Acrobat PDF files. For a Network model type, these reports include "Base Year Facilities Characteristics", "Base Network Traffic Data", "Alternate Network Traffic Data", "Base Network Traffic Profiles", "Alternate Network Traffic Profiles", "Signals", "Devices", and "Segment Base and Alternate Cases". Reports are generated as Adobe Acrobat PDF files.

Segment values data grid – On the page below the line "Current View" is a data grid corresponding to the selected view of the page ("Facility characteristics in the base year", "Traffic characteristics", "Base year signals and devices", "Cases").

- **View: Facility Characteristics in the Base Year**

When you click the "Edit" button the grid changes to edit mode and the editable values will appear in text boxes. Click the "Update" button when you have completed editing, or, click the "Cancel" button to undo edits and return to non-edit mode. If you try to update and one or more of the text boxes contains invalid values (i.e., non-numeric characters in a numeric field, or, values outside a permissible range for the variable) the page will show an error message.

- **Views: Traffic Characteristics, Base Network Traffic Characteristics, and Alternate Network Traffic Characteristics**

This view contains three components:

o **Annual traffic data for selected years** data grid

Specify here the Average Annual Daily Traffic (AADT) for each of the three designated forecast years (these years are part of the selected scenario definition – set these on the **Manage** page with the scenario view). For each of these tables, the "Edit", "Update", "Cancel" buttons work the same as other data grid controls in *BCA.Net*. In "Edit" mode set the values for AADT in the text boxes. After clicking "Update", the data grid displays the imputed average annual rates of growth in AADT.

o **Selected Year** dropdown list

Use this dropdown list to select the year (start year, last year near term, end year) whose traffic profiles you wish to edit. After selecting, click the "Go" button.

o **Traffic profile for the selected segment and year data grid**

Figure 23 Year Selector and Traffic Profile Data Grid

The data grid contains traffic profiles for the selected year and segment. A traffic profile is a representative traffic day on the segment in the selected year. The traffic profile specifies:

o **Duration Periods** - the duration of the periods of the day (peak, peak shoulder and off-peak). You specify the peak and peak shoulder durations in hours. The off-peak is calculated as the remaining hours in the day. The peak and peak shoulder period together cannot exceed 24. The periods should represent the sum total of such hours during a day (e.g., morning and afternoon peak hours should be added together).

o **Percent of Year** - the percent of days in the year represented by the traffic profile. The "Percent of Year" values for all the traffic profiles for the segment and year must sum to 100.

o **Percent of Annual Traffic -** the percent of annual traffic that flows on the segment in the days of the year represented by the traffic profile. The "Percent of Annual Traffic" for all the traffic profiles for the segment and year must sum to 100.

o **Percent Vehicle Type** – *BCA.Net* calculates user costs for three vehicle types – auto, truck and bus. You specify the percentage of vehicles in the traffic flow for types "truck" and "bus". The percentage of type auto is calculated as the remaining share.

o **Traffic Distributions by Vehicle Type** – For each of the three vehicle types you specify its traffic distribution from the dropdown list that appears when the data grid is in edit mode. For more on traffic distributions (how to edit them or add new ones), see the glossary and "5. Parameters Page"

In addition to the "Edit", "Update" and "Cancel" buttons for editing, the traffic profiles data grid has buttons "Add New" and "Delete Checked". These buttons appear only when the start year is the selected year. The "Add New" button will add a new traffic profile to the list. After adding a new traffic profile you will need to edit it to reflect your data and projections. In order to delete a traffic profile you must first edit the traffic profiles so that those to be deleted have the value zero in the columns "Percent of Day" and "Percent of Annual Traffic" while the remaining traffic profiles sum to 100 in each of the two columns. You must repeat this for each of the three years in order to delete the traffic profiles.

After editing, select the start year, and check the check boxes of the traffic profiles to delete. Click the button "Delete Checked" to complete the deletion.

- **View: Signals and Devices**

Figure 24 Base Year Traffic Signals and Control Devices View of the Project Page


Specify the base year facility traffic signals and devices for each project segment in this page. For instance, if a section of arterial highway has two traffic signals in the base year, these signals would be recorded here. The view consists of two sections. The top section is for traffic signals. You can add signals by using the "Add New" button, and then click the "Edit" button to modify the default data profile to provide an appropriate description of the signal, beginning with a name (e.g., location description) and the length of the signal's cycle (the time in seconds between the starts of the red signal). The data variables are identical to those described in Table 4 above in the Strategies section of this manual. Once the data has been modified and you wish to save the changes, click the "Update" button. **Please note that signal data must be specified separately for peak, peak shoulder and off-peak traffic periods.**

If you wish to study the impact of a signal or device on the intersecting road at the intersection, you must include a segment that reflects the data pertaining to the signal's impact on that segment (e.g., effective green time, etc.)

Base year signal and device information can be modified by the strategies selected for the base and alternate cases in the Cases view of the **Project** page (see Strategies section above and View: Cases below).

- **View: Base Case and Alternate Case**

Figure 25 Cases View
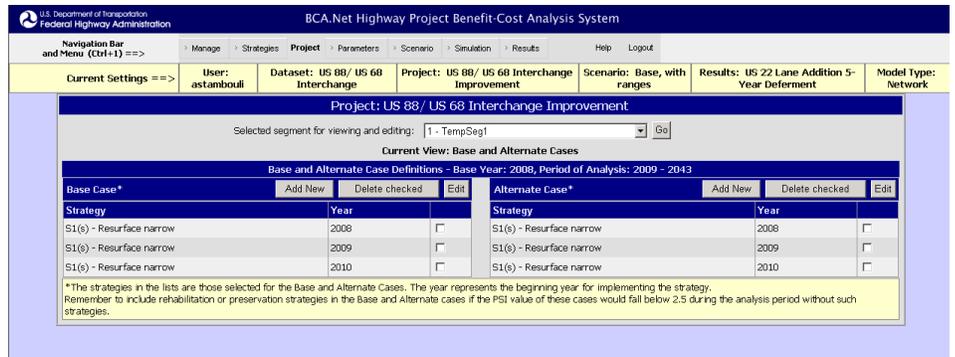
This view presents the base case and alternative case side-by-side. *These are the two cases that will be compared to each other during the BCA simulation*. The analyst is able, for each segment of the project, to specify the strategies and year of each strategy's implementation. For instance, for a project consisting of a single segment, the analyst could specify periodic resurfacing in the base case versus a reconstruction with less frequent resurfacing in the alternative case. The periodic resurfacing in the base case could be specified to take place in year 0, 10, 20, and 30; whereas the reconstruction could be specified for year 0 with one resurfacing at year 25. After running the BCA, the analyst could then build another alternative and compare that to the base case in a second BCA simulation.

Please note that the base case should reflect logical management of the asset. It is not a "do nothing" case. For instance, if the "Base Year Facility Characteristics" indicate that the Pavement Serviceability Index is 3.5 in 2005 and the pavement is deteriorating at the rate of .1 PSI per year, then within ten years the pavement condition would fall to 2.5. At this point, vehicles operating on the pavement would begin to incur significant operating cost due to the rough pavement – costs that would worsen dramatically thereafter. If the base case is specified with no strategies to maintain basic pavement quality at a level above a 2.5 PSI, almost any alternate case that does maintain pavement quality at serviceable levels during the analysis period, at whatever cost, will likely compare favorably to the base case. Thus, an expensive capacity addition could appear cost-beneficial purely on the basis of its effect on pavement, even if the new capacity adds little time saving benefit. However, nearly the same benefit could be achieved with a much less costly resurfacing of the road. The point is to select judiciously the base and alternate cases, where the base case includes "fallback" management measures (i.e., resurfacing to maintain pavement surface quality) that are likely to be implemented in lieu of major investments. Likewise, the alternate case should also include all relevant elements of sound asset management to avoid inadvertently undercutting benefits that should rightly be associated with an improvement.

6. Project Intersections/Interchanges (ISIC) Page

Figure 26 Project Intersection/Interchanges Page, Definitions View
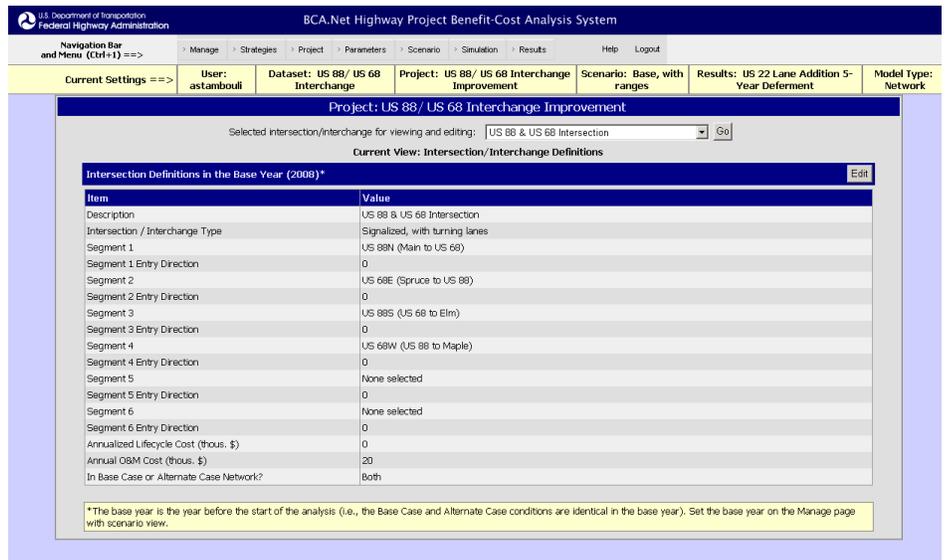

Project ISIC - Overview

From the **Project ISIC** page, you can edit the data for project ISICs, create new project ISICs, and delete existing ISICs. The **Project ISICs** page has three views, which apply to the selected project ISIC:

- ISIC Definitions in the base year

  The definition of an ISIC, specified in this view, includes: the intersection segments, the entry direction for each segment and the ISIC type (defined on the **Parameters Page**).

  In order to create an ISIC, you must have already defined the highway segments that join at the ISIC. When editing the table in the Definitions view, a dropdown list will include all the defined segments in the project.

  For clarity, the segments should be listed in order of adjacency moving in a clockwise direction. For instance, if your project segments correspond to the following diagram, list the segments as shown below.
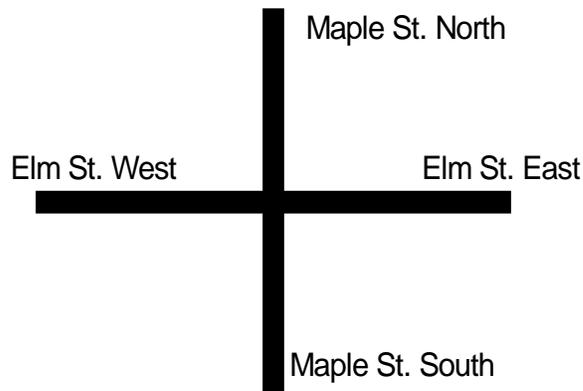
Segment 1 Maple St. North
Segment 2 Elm St. East
Segment 3 Maple St. South

Segment 4 Elm St. West
(Note: Leave segments 5 and 6 as "none selected")

The "entry direction" specifies the direction from which traffic enters the ISIC from the segment. The two directions are 0 are or 1, where 0 is the direction of major flow during the peak period.

In this view, you also specify the Operating and Maintenance and Other Lifecycle costs that are associated with the facility in the base year. The base year is the year that precedes the period of analysis and the conditions specified for the base year will prevail in subsequent years (for either the base or alternate cases, or both) until superseded by a strategy.

This view also allows you to enable a selected intersection in either the base or alternate networks, or both. This parameter is only available if a network model type is used for the analysis.

- Exiting Flows

  The exiting flows view contains a table in which the user specifies how traffic flows originating from each segment are allocated to the other segments when exiting the ISIC. The user can specify that some of the flow from a segment exits to no segment, that is, it exits to a roadway that is not under evaluation.

- Cases

  For each ISIC in a project you specify a base and alternate case. The base case represents the "do minimal" scenario that is needed to maintain serviceable operation of the facility over the analysis period. The alternate case represents a possible improvement to the ISIC that typically involves a significant investment of funds or resources relative to the "do minimal" base case. Each case is built of one or more strategies along a specification of the year(s) in which the strategies would be implemented. For more information on base and alternate cases, see the glossary.

Project ISICs - Features

- **Select ISIC** dropdown list – Select the ISIC to edit with this drop down list. After selecting, click the "Go" to the right of the dropdown list. Note that ISICs can be added or deleted in the **Project ISICs>Actions** options (see below).

- **Project ISICs>Views** menu options – Use this option to toggle between the page's three views: 1) Base year definitions, 2) exiting flows, and 3) base and alternate cases. The components on the page below the header "Current View" will change accordingly. Each view will show a suitable data grid control for editing its variable values.

- **Project ISICs>Actions** menu options:

    o **Create new ISIC** – Selecting this option will invoke the new ISIC page. On this page the user specifies the name of the new ISIC, the segments and the ISIC type.

    o **Copy selected ISIC** – This option will create a copy of the currently selected ISIC that can be modified to new specifications. The system gives a temporary name to the newly created segment, which you can edit in the Definitions view of the ISIC.

o **Delete selected ISIC** – Selecting this option will cause the selected ISIC to be deleted.

o **Generate report** – Selecting this option will invoke a submenu of Project Intersection/Interchange reports to generate in Adobe Acrobat (pdf file). Users can generate project reports for each view in the Project ISIC page. These reports include "Intersections/Interchanges Base Facilities Characteristics", "Exit Flows", and "Intersections /Interchanges Base and Alternate Cases".

ISIC values data grid – On the page below the line "Current View" is a data grid corresponding to the selected view of the page ("Definitions", "Exiting flows", "Cases").

Figure 27 Project Intersections/Interchanges Exiting Flows View
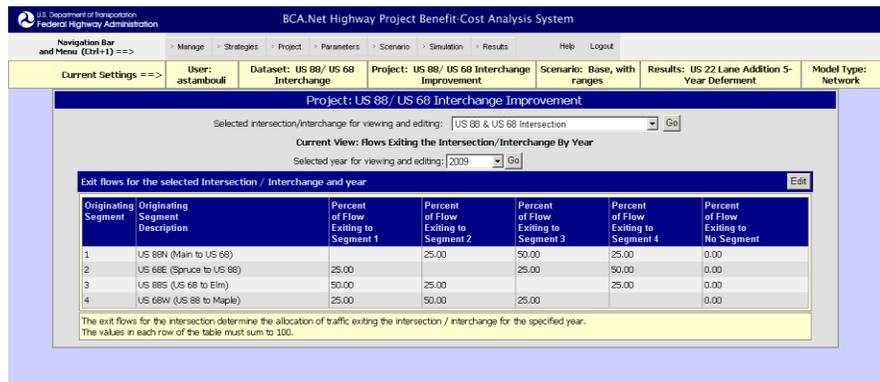
Figure 28Project Intersections/Interchanges Cases View
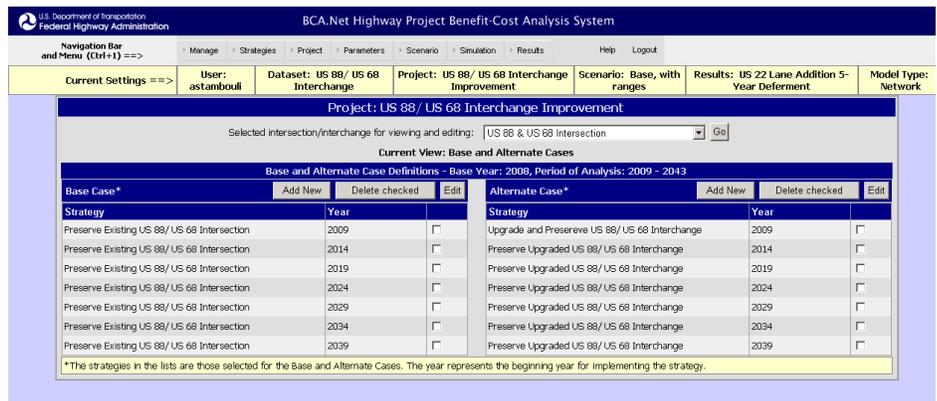
6.a New Project Intersection/Interchanges (ISIC) Page

Figure 29 New Project Intersection/Interchange Page

New Project ISIC - Overview

This page is accessed from the menu option **ISIC Project>Actions>Create new interchange/intersection**. To create a new interchange/intersection: 1) Enter the name of the new ISIC, 1) select segments to include in the ISIC from the dropdown list, 3) select the ISIC type, and 4) click "Submit". Note the definitions of the ISIC types are found on the **Parameters Page**.

After clicking "Submit", the **Project ISIC** page will display and the new ISIC will be set as the current ISIC and can be modified as needed.

7. Parameters Page

Figure 30 View of Parameters Page –Traffic Distributions View

Parameters - Overview

The **Parameters** page is where you can view and modify model parameters and other data values in *BCA.Net*. The page contains two views, traffic distributions and intersection/interchange parameters.

- **Traffic Distributions**

Traffic distributions are data objects in the dataset that can be applied to any project segment in the dataset through the traffic profile (see the Glossary and "4. Project Page" above.

Traffic distributions describe the intensity of traffic, in terms of the average percent of daily traffic per hour, in two of the periods of the day: Peak and peak shoulder. You also specify whether there is a directional imbalance in the traffic flow by specifying the percentage of traffic in the direction of greater flow (which will be a value between 50 and 100).

- **Intersection/Interchange Parameters**

The ISIC parameters define an ISIC type. The parameters for an ISIC comprise three tables:

- Minimum average delay per vehicle in intersection (sec),

- Saturation rates in ISIC (veh/hr), and

- Variable delay coefficient

Each of these tables has n rows and n columns, where n is the number of segments connecting to an ISIC. The value for n may be less than or equal to 2 and may not exceed 6. An element in the ith row and jth column of a table corresponds to the flow originating in the ith segment and exiting the ISIC in the jth segment. For each of the flows, the general expression for the delay (i.e., travel time) per vehicle in the intersection is:

$$D = \begin{cases} \min D, \text{ for } aht \leq sat \\ \min D + A(aht - sat)^2, \text{ for } aht > sat \end{cases}$$

Where *minD* is the value from the first table, *sat* is the value from the second table, and *A* is the value from the third table. The value for *aht* is calculated in the model based on the specification of traffic profiles of the segments and the allocation of exiting flows from the ISIC to segments.

Figure 31 Parameter Page Intersection/Interchanges Parameters View (top section)

- **Action: Generate report**
- Action: Generate report

Selecting this option will generate two parameters reports in Adobe Acrobat (pdf file) for each view in the Parameters page. These reports include "Traffic Distribution Parameters" and "Intersections/Interchanges Parameters". This information can be an important addition to the Results report (see Results page discussion) as it enables decision-makers to review the specific project parameters used in the BCA.

Using the buttons on the page, you can copy an existing traffic distribution or create a new one, which can than be edited. You can delete a traffic distribution. Prior to deleting a traffic distribution, you must ensure that the traffic distribution is not referenced by any segment's traffic profile in the dataset. Attempting to delete a referenced traffic distribution will fail and an error message will be displayed.

8. Scenario Page

Figure 32 View of Scenario Page

Scenario - Overview

The Scenario page is where you view and edit scenario data for an analysis. Scenario data for a model input variable can be either a fixed value, or several values that describe a probability distribution.

This page possesses a number of features that let you easily visualize data and quickly develop probability distributions that best reflect available information and judgments on operations, future developments and social costs. These features include:

- Ease of navigation among variables;
- Instant viewing of statistics and charts
- Instant validation and saving of ranges

Please note that the *BCA.Net* tool can store many different scenarios for analysis (e.g., high traffic growth; high cost uncertainty; baseline assumptions, etc.). Scenarios are initially defined and selected in the **Manage** page (change to the Scenario view using the **Manage>Views** submenu). Modifications made to scenario data in the **Scenario** page apply only to the scenario selected in the **Manage** page, and will not affect other scenarios no selected. Also, remember that the data in the selected scenario are the data that will be used by the *BCA.Net* model to conduct the benefit-cost analysis on the strategies and cases defined elsewhere in the model. If you wish to work with data from another scenario and use that data in the analysis, that scenario must be selected from the **Manage** page (see section above on the **Manage** page).

Scenario - Features

The **Scenario** page is shown above. The scenario input variables in *BCA.Net* are organized into data groups according to a functional classification. The data groups are:

- Travel demand and traffic composition
- Social costs
- Project cost factors
- Prices
- Policies
- Non-Transportation Benefits

When you link to the **Scenario** page, the "Travel demand and traffic composition" data are loaded.

The remainder of this section describes the features of the **Scenario** page and their functions.

Data Group Pull Down List

Use this drop down list at the top of the page to select the data group to view and edit.

The data groups accessible from the **Scenario** page offer the analyst great flexibility in specifying the present and future travel, cost, and policy environment that will affect a project. The content of the major groups are summarized below. Note that each data group allows the analyst to specify a range of uncertainty around any of the values entered for that group (see the Variable Data Grid below).

- "Travel demand and traffic composition" data on this page (see Figure 21) impact other traffic data that are input on the **Project** page with Traffic Characteristics view, and on the **Parameters** page (traffic distributions). Inputs on the **Scenario** page that impact traffic levels include: traffic level uncertainty, average vehicle occupancy, annualization factor (that converts daily traffic flows into annual values), minimum speed in peak period, mph (the lowest speed allowed in the peak period before peak traffic is reallocated to the shoulder period), and effective price elasticity of demand (the response of traffic to changes in the cost of driving).

  Note that the Effective Elasticity of Demand coefficient (located on the second page of the "Travel demand and traffic composition" data group is currently the only variable that influences the potential response of road users to changes in the roadway environment (i.e., congestion level, pavement surface and roadway capacity)). The selection of a price elasticity factor (always a negative value) will cause traffic to increase if a road project leads to lower travel costs (e.g., reduced travel time). The specification of an elasticity of -1 means that a 1 percent reduction in the generalized cost of travel (i.e., out-of-pocket user costs plus the imputed values of travel time and safety) would result in a 1 percent increase in traffic. An elasticity value of -0.1 means that for a 1 percent reduction in travel cost would lead to a one-tenth percent increase in traffic. Long run, total trip elasticities of -1 or higher (in absolute value terms) are well documented in the economic literature. It is recommended, however,

that such elasticity values be adjusted to fractional levels based on the ratio of project length to the average total trip length of drivers using the project facilities. For instance, if project affects 2 miles of an average 20-mile trip, then a -1 whole trip elasticity should be adjusted by a factor of 2/20, or -0.1 for use in *BCA.Net*.

- "Social costs" data are entered in this **Scenario** page view. Most of the cost items (including discount rate, value of travel time, value of statistical life and injury, etc.) are self-explanatory and are set to default values taken from FHWA sources. The analyst can specify, of course, alternate values for these items in accordance with his or her agency's policies.

  Please note that *BCA.Net* works in terms of constant dollars (i.e., dollars that have the purchasing power of a specified year. In *BCA.Net*, dollars are base year constant dollars). Inflation is assumed to affect all prices equally and is not tracked in *BCA.Net*. The only exception to this is that users can choose to set a real oil price index (i.e., the change in oil prices net of general price inflation). The change in oil prices will be reflected in the analysis in the user costs of fuel and oil consumption. As the model uses constant dollars, the discount rate for converting multi-year streams to present value equivalents must be a constant dollar discount rate (i.e., has no component for deflating future nominal dollars).

  The model uses the "depreciation rate" to calculate the residual value (if any) of a project's non-land assets at the end of the analysis period, and to adjust the construction disruption costs realized in the analysis period if an analysis period ends before the end of the useful life of an asset. *BCA.Net* does not depreciate the value of the land in its residual value calculations. Fuel prices are before taxes (taxes are added in the "Policies" view of the Scenario page – see below). *BCA.Net* does not assign default cost values to emissions. Emission costs should reflect region-specific values developed by the regional planning agency for each emission type (e.g., tons of carbon monoxide).

- The "Project cost factors" data of the **Scenario** page are used to adjust project cost data specified elsewhere in *BCA.Net* (i.e., the **Strategies** page Costs view for individual strategies, which are in turn assembled into projects and project costs in the **Project** page Cases view. In particularly, the "Project cost factors" view of the **Scenario** page is used to specify overall project cost uncertainty.

- The "Prices" view in the **Scenario** page allows you to specify future increases in the real price of fuels and motor oil (net of general price inflation). This feature is helpful if you wish to study the effects of increases in fuel prices that exceed the rate of general inflation. If the index value for fuel on this screen is set at 100 for each year, this means that the real cost of fuel (relative to other goods and services in the economy) is expect to remain constant.

- The "Policies" view allows the analyst to specify changes in the tax on fuel over time.

- The "Non-Transportation Benefits" view allows you to include anticipated benefits (or costs) of a project that are not captured in the categories already measures by *BCA.Net*. Values must be input by year and should, as with other inputs of the model, are in constant dollar

amounts. For instance, a State DOT may wish to add an anticipated economic development value that it believes is not redundant with measured transportation benefits. Alternately, a State may wish to include the value of land purchased for a project as a residual value.

Variable data grid

The variable data grid enables a quick overview of the variables and data in the selected data group. The data grid displays the scenario variables, one per row. Some of the data groups have more than one page, which is evident by the presence of numbered links at the bottom right of the data grid.

The left most column of the data grid contains links that say "View". Clicking this link will cause a page to pop up with the chart and table of the input variable (see 6.a Input Chart below).

Each scenario variable can be a fixed value, or a probability distribution and a risk analysis input. To the right of the variable description is a column called "Distribution", which specifies the selected probability distribution (of which, "Fixed Value" is one of the options). By clicking the "Edit Distributions" button, you enable the selection of distributions for each variable on the page through dropdown lists. Depending upon the choice of probability distribution, the display of the variable changes accordingly. The following table shows the displayed values for each probability distribution.

Table 6 Probability Distributions and their Displays on the Scenario Page

Probability Distribution	First Data Value	Second Data Value	Third Data Value
Fixed Value	Fixed value	None	None
Uniform	Minimum value	Maximum value	None
Skewed Normal	Lower 10%	Median	Upper 10%
Normal	Mean	Standard Deviation	None
Triangle	Minimum value	Most Likely	Maximum value

The following are descriptions of the available probability distributions:

Fixed Value (single value required)

When you choose fixed value, there is no distribution and the variable assumes a unitary, fixed value in a simulation. For a fixed value, no statistics are shown and only the middle percentile box is enabled for data entry. No chart is shown for a fixed value.

Uniform (two values required – maximum and minimum value)

With the uniform distribution, every point on an interval is equally likely. When you select this distribution type, the 0 percentile (minimum value) and 100 percentile (maximum value) are enabled for data entry.

Skewed Normal (three values required – Lower 10 %, median and upper 10%)

The skewed normal distribution is derived from three points: the 10% lower value (10th percentile), the 50% value (or, median) and the 10% upper value (90th percentile). For non-skewed values this distribution is normal.

This distribution is useful when the exact form of the distribution is not known yet good estimates on the median and boundary values are available.

When this distribution type is selected, the 10% lower value, median, and 10 percent upper value boxes in the data grid are enabled for data entry.

Normal (two values required – mean and standard deviation)

For this distribution, enter data in the statistical summary frame. The mean and standard deviation are available for data entry when this distribution type is selected.

Use this distribution type when you have data indicating the variable is non-skewed and normally distributed.

Triangle (three values required – maximum, minimum and mode)

For the triangle distribution, you enter data for the maximum value, the minimum value and the most likely value (the mode of the distribution). All values for this distribution lie between the minimum and the maximum and its density function forms a triangle with its peak at the mode. Use this distribution when the variable and data indicate firm bounds on the maximum and minimum values and a most likely value.

After setting the distributions, click on "Edit Values" to edit the values for each variable.

8.a Scenario Input Variable Chart

Figure 33 View of Scenario Input Variable Chart
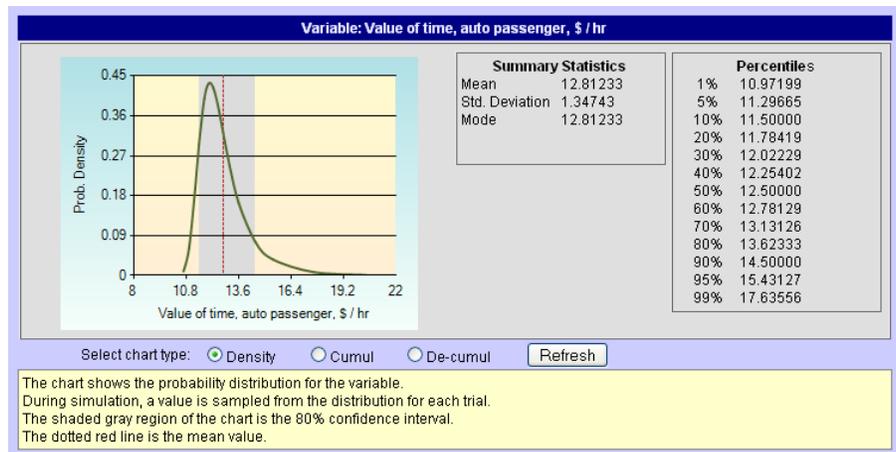
Scenario Chart - Overview

Clicking on "View" for a variable on the Scenario page will cause the scenario input variable chart to pop up, showing a chart and data for the variable. The page contains a chart, a summary statistics table, a percentiles table and option buttons for selecting alternative chart types.

For a fixed value, the chart will display the message "No Chart for Fixed Value" and the tables will reflect the information for the single, fixed value.

There are three chart types and each shows a shaded region that represents the 80% confidence interval. A dotted red line marks the mean value of the distribution.

The x-axis on all the charts ranges between the values whose probabilities are 0.1 and 99.9 percent, respectively. The different chart types are selected using the option buttons below the chart (click "Go" after making a selection).

Density/Cumul/De-Cumul option buttons

The selected option determines which of the three chart formats:

- Probability density
- Cumulative probability
- De-cumulative probability

are displayed for the selected variable (see the Glossary for definitions).

Summary statistics table

The summary statistics frame displays the mean, mode, and standard deviation of the distribution. See the glossary for the definitions.

Percentiles

The percentiles frame displays the percentiles of the input distribution. A percentile indicates the probability that the value of the input variable would fall below the given value of the x-axis. For instance, in Figure 22, the chance that the sampled input value of time for trucks (average all types) would fall below $20/hour is 90 percent, given the distribution specified by the users.

9. Simulation Page

Figure 34 View of Simulation Page
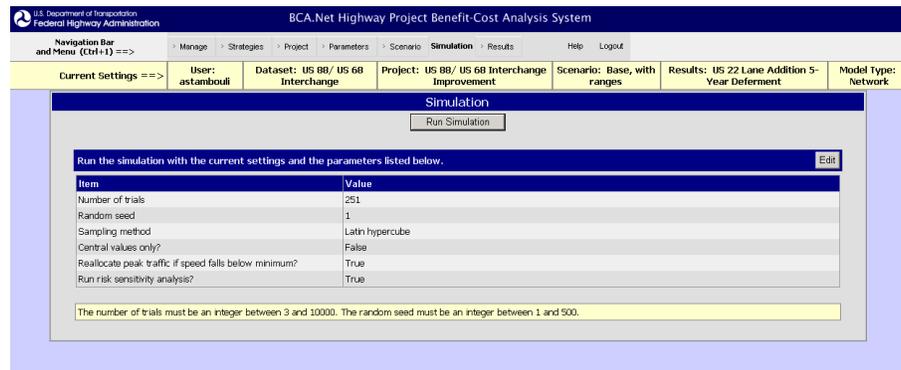
Simulation - Overview

Use the **Simulation** page to set the simulation parameters and run a simulation (i.e., generate the BCA results). You should browse to this page only when you are ready to conduct a simulation, that is, after having made all required modifications to data, and after having selected the project, scenario and results file for the analysis.

Simulation - Features

Set the simulation parameters by clicking "Edit", and click "Update" when finished editing. The parameters that you set will be saved in the results set. If you run subsequent simulations, the parameters you set will be saved and used as long as you continue to use the same results set for your analysis.

About Simulation

BCA.Net uses simulation, or risk analysis, to generate BCA results and the uncertainties associated with them. By specifying probability distributions for scenario inputs (which is performed in the **Scenario** page), the users quantify their variability and uncertainty. The impact of this uncertainty on the outcomes, as reflected in the *BCA.Net* analytic model, is quantified using simulation.

With simulation, rather than solving the model once using "best guess" values for inputs, *BCA.Net* solves the model for many independent trials. In each trial, a random sample is taken from the distribution of each scenario input. Each trial produces an outcome (e.g., a set of values for the result variables) based on the sampled values from the input distributions. By applying statistical analysis to a set of outcomes, *BCA.Net* derives descriptive statistics for each result variable. Thus, for instance, *BCA.Net* will tell us not only "the answer is 50", but also that "with 90% probability the answer lies between 30 and 75". As opposed to point estimates or sensitivity analysis (where one variable is arbitrarily varied), risk analysis supports better decisions by explicitly reporting the probability distributions of the results.

Also, see the section "About *BCA.Net* "in the Introduction.

The simulation parameters are discussed below.

Trials Box

Enter the number of trials for the simulation. The number of trials is the number of times that the program will sample from the scenario input distributions, solve the model and generate results. More trials will yield more stable results and will take more time to run. While a number of factors will determine the minimum number of trials needed to achieve stable results, 500 trials will usually be adequate. You must use at least three trials to run a simulation.

Recommended Practice: To save time, when testing your data and assumptions, use a small number of trials (50 or less). After you are satisfied that you will make no more changes to the data, and then run a simulation with a large number of trials to arrive at your result.

If you wish to learn more on this subject, a good technical reference is "Latin Hypercube sampling (A Program Users Guide)", by R.L. Iman J.M. Davenport and D.K. Zeigler, Technical Report SAND79-1473, Sandia Laboratories, Albuquerque (1980).

Random Seed Box (Note: this is an expert option)

The random seed determines the sequence of pseudo-random numbers that are generated by the simulation engine. Any positive integer value will generate a unique sequence of pseudo-random numbers for the simulation. Two simulations with identical data, number of trials and random seed will generate identical results.

Changing the random seed is an expert option. You may want to change the random seed to test the effects of the randomness of the sampling on the result distributions.

Sampling Method (Note: this is an expert option)

You can select from two sampling methods for the simulation: Latin hypercube and Monte Carlo simulation. Latin hypercube is a stratified sampling method that ensures that a relatively small number of trials will yield results that are widely distributed, and not clustered, in the input variable sample space. This method is the default and, in general, unless you have a special need for a "purely random" sampling of inputs you should use this method.

"Run Central Values Only" Check Box

Check this box to run your model using only the central values. The reported results will be point values without probability ranges. When this box is checked, the trials box and random seed box are disabled. Note that, if the box is checked, the term "True" will be displayed once the page is updated. If unchecked, the term "False" is displayed.

Reallocate Peak Traffic If Speed Falls Below Minimum Check Box

Check this box to direct *BCA.Net* to automatically reallocate traffic from the peak traffic period to the shoulder traffic period if it determines that travel speed during the peak period would drop below the minimum speed threshold that is specified in the "Travel demand and traffic composition" data group of the **Scenario** page, which was 10 MPH. If this box is not checked, *BCA.Net* will assume that all traffic in the peak period gets through, but at an average speed that may be too low to represent practical usage of the facility- thus possibly overstating delay.

Risk Sensitivity Analysis Check Box

The risk sensitivity analysis, which is executed after the simulation, runs the *BCA.Net* model with all the input variables except one set to their mean values. The exception input variable is set to its 10 percent lower value and the model is solved. This input variable is then set to its 10 percent upper value and the model is solved again. This process is repeated for all input variables. The results of the sensitivity analysis are displayed in the tornado chart, which is invoked from the **Results** page.

By leaving this box unchecked (the term "False" will show on the page when the data grid is not in edit mode), your results file will not contain values for the tornado chart.

10. Results Page

Figure 35 View of Simulation Page

Results - Overview

The results of a simulation are viewed in the **Results** page. When you browse to the page, it displays the first results group. Note that the model will put the simulation results in the particular Results file selected under the **Manage** page (Manage>Views>Results). You can also create new results files and delete old files under the **Manage** page.

When a simulation completes, the browser automatically redirects to this page.

The purpose of this page is to navigate, view, and print results and their associated tables and graphics.

Results - Features

The Results page contains an extensive assortment of data on the findings of the simulation, including summary data and graphics. These data and graphs provide important data to decision-makers.

Result Group Pull Down List

Use this drop down list at the top of the page to select the results group to view. The groups include the benefit-cost summary and breakouts by benefits and cost category showing the base case, alternate case and net result for each project segment.

BCA.Net presents the simulation results in a highly detailed format. This presentation format can be very useful to the analyst because it allows the ready identification of those aspects of a project that are or are not successful, and especially those aspects of the project that are most subject to risks from real price increases or future traffic growth. These data can be presented in report format and used to inform decision-makers. Note that all dollar values in the Results page are presented in terms of thousands of dollars of present value.

The following is a description of the major benefit categories summarized in the Benefit-Cost Summary view of the Results page:

- "Travel time savings" represents the difference in the value of travel time incurred between the base and alternate cases. If the alternative case saves travel time relative to the base case, the time saving value shown in this view will be positive (meaning it is a benefit of the alternate case). *BCA.Net* calculates travel time saving by comparing the speed and volume of the traffic flow of the alternate case to that of the base case, factoring in future traffic growth, design speeds, congestion levels, vehicle occupancy, traffic peaks, and other data specified in the Strategies, Project, Scenario, and Parameters pages.

- "Vehicle operating cost savings" consist of the non-travel time cost changes incurred by vehicle operators when traveling at higher or lower speeds; and due to wear and tear on vehicles associated with different pavement conditions. Pavement condition and deterioration rates are entered in the Strategies>Views>Identifiers and Effects view. Although it is often expected that a road improvement (as represented by the alternate case relative to the base case) that saves travel time will also reduce vehicle operating costs, this will not always be the case. For instance, a capacity improvement that enables faster travel speeds on a road may reduce travel time costs but lead to higher vehicle operating costs due to greater fuel consumption and maintenance costs. In other cases, the improvement may reduce these costs while also saving travel time if it relieves severe congestion that results in inefficient vehicle operating speeds.

Note that the value of the time saving for a capacity project on an existing congested roadway should generally exceed the absolute change in vehicle operating cost by a significant margin. Particularly if the vehicle operating cost savings are very large in absolute terms, the base and alternate cases should be studied carefully. Such investigation may reveal that either the base case or the alternate case does not include appropriate pavement maintenance strategies, leading to very low PSI values for one or the other cases in out years and thus unrealistically high vehicle operating costs.

- *BCA.Net* calculates "Safety benefits" from estimated traffic volumes and the "Crash Rate: Accidents per Million VMT" values provided for each strategy under the Strategies>Views>Identifiers and Effects view. The model currently uses hard-coded lookup values by which crash rates are categorized into property damage only; minor injury; serious injury; and fatal injury crashes. The model assigns severities based on accident type categorizations (fatal, injury and property damage only). You specify the valuation for each type of crash in the "Social Costs" dropdown view of the Scenarios page.

- *BCA.Net* calculates "Environmental benefits" based on traffic volumes, emission rates, and speeds. It applies speed-based emission rates (grams of emission per mile) to segment average speeds and traffic volumes, adjusts the emissions for time spent at traffic signals and devices, sums these amounts for periods and days, and then multiplies the tonnage weight of

each emission type by the per ton cost value specified in the second screen of the "Social Costs" view of the Scenario page. Please note that the default per ton cost values in the Scenario view are set to zero, so no value will show up under "Environmental benefits" unless you change the zero default values.

- "Project residual value" represents the total remaining value of non-land assets of the alternate case at the end of the analysis period. You specify the analysis period in the Manage>Views>Scenarios page for each scenario. You specify the rate at which non-land assets are used up each year through the "Rate of asset depreciation" variable of the "Social Costs" view in the Scenario page.

- "Disbenefit of traffic disruption from construction" shows the net "work disruption costs" of all strategies assumed in the alternate case relative to those assumed for the base case. In the case of disruption costs that are incurred in the analysis period, but which are associated with strategies that remain in effect (i.e., have a residual value) after the analysis period ends, *BCA.Net* assigns only a partial share of these disruption costs to the analysis period. This partial assignment of costs is necessary to avoid biasing the model results based purely on changing the length of the analysis period (due to the lump sum nature of work disruption costs caused by strategies that are implemented near the end of analysis periods). The work disruption costs for each strategy can be manually entered or independently calculated by the BCA.Net models in the Strategies>Views>Costs view.

- "Total benefits" is the total present value of the transportation benefits of the alternate case that are additional to the transportation benefits of the base case. Transportation benefits are the collective savings in travel time, vehicle operating costs, crash costs, environmental costs, residual values, and user disruption costs. Note that some or all of the benefits in these categories may be negative (i.e., disbenefits), and that the "Total Benefits" could also be negative for some projects where the alternate case is clearly inferior to the base case.

- The category called "Of this, Benefits to new users" requires some explanation. It will have a value only if you assigned a value to the "Effective Elasticity of Demand" variable in the Scenario>Views>Travel demand and traffic composition view. The "Effective Elasticity of Demand" variable measures the percentage increase of traffic caused by each one percent reduction in transportation costs caused by a project. In particular, if a project reduces net travel costs (e.g., by reducing travel time), then it is likely that more drivers will use the road than would have had it not been improved by the project. The new users receive benefits in the form of reduced transportation costs that are additional to benefits realized by pre-existing users of the road. "Benefits to new users" indicates the amount of "Total Benefits" (e.g., the line above "Benefits to new users") that are realized by new users. It is not additional to the "Total Benefits" but rather is a subset of the total benefits of the project.

- "Total costs" is the total present value of the resource expenditures to build and operate the alternate case that are additional to the expenditures made for the base case.

- "Net benefits" is the difference between "Total Benefits" and "Total Costs," representing the net present value of the alternate case relative to the base case (see the glossary for more information on net present value). Note that

this value can be either positive or negative. A positive value indicates that the alternate case is economically efficient relative to the base case.

- The "Benefit-cost ratio" is the ratio of "Total benefits" to "Total Costs." Ratios that exceed one indicate that the alternate case is economically efficient relative to the base case. See the glossary for more information on the benefit-cost ratio.

- "Rate of return" is the estimated rate of return, or discount rate, that would equate the present value of "Total benefits" to "Total costs." Multiple "Rate of return" values are possible if, during the analysis period, costs exceed benefits in more than one year. The *BCA.Net* model, however, will only display one of these values. Accordingly, rate of return data should be used with caution.

In the dropdown menu in the Results page you will note that a number of cost categories beneath the overall category of "Benefit-Cost Summary." The categories, which are subsets of the Summary, include the following:

- User costs: travel time

- User costs: fuel consumption

- User costs: oil consumption

- User costs: tire wear

- User costs: maintenance and repair

- User costs: depreciation (i.e., vehicle mileage-based depreciation)

- User costs: safety

- User costs: environmental (note that this includes costs to non-users as well)

- Project costs.

Each of these cost subsets provides data on that cost category for both the base case and alternate case, and well as the net difference between the cases.

"View" Link

Clicking on the "View" link for a variable causes the results chart page to pop up. See Results Chart section below.

Results>Action>Generate and show reports

This action will generate two reports of the simulation results in Adobe Acrobat (pdf file).

• The "Highway Benefit-Cost Analysis Results" report presents the distribution and summary statistics for all cost and benefit categories in the base and alternate cases.

• The "Annual Benefits and Costs" reports present relevant cost and benefit categories in the base and alternate cases for each ten-year period of the analysis.

This report can only be generated when simulating with central values only and disabling risk sensitivity analysis. This can be done by accessing the Simulation page and checking the "Central values only box", and leaving the "Run risk sensitivity analysis" box unchecked.

10.a Results Chart

Figure 36 View of Results Chart
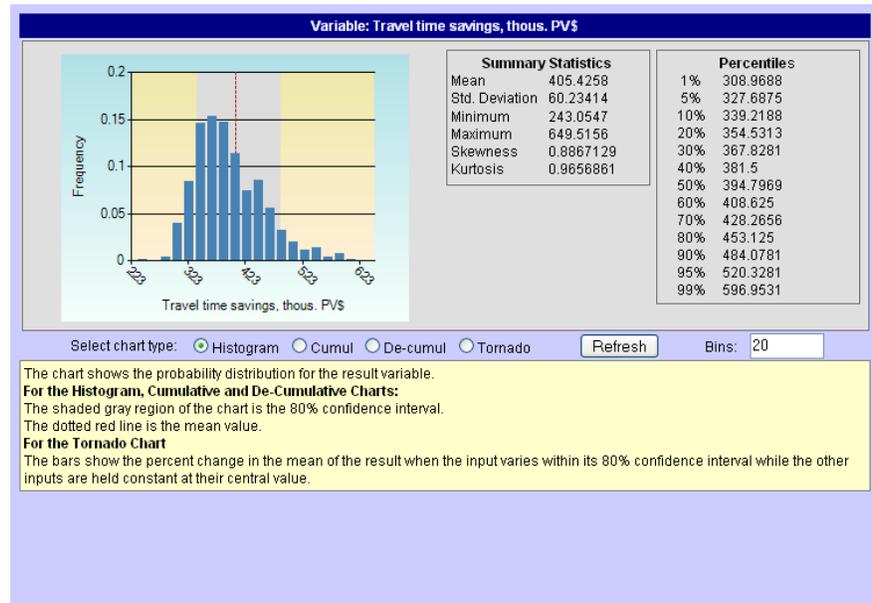
Results Chart - Overview

When you click a "View" link on the results page, the results for the selected variable are displayed in the **Results Chart** that pops up.

The variable's risk analysis statistics are shown in the tables on the page as well as a chart of the table values. Using the option buttons you can choose to display the summary chart as a cumulative, de-cumulative, or histogram format. If in your simulation you selected to run a risk sensitivity analysis, then you can also view a tornado chart, which shows a ranking of input variables that were the most significant contributors to the variance of the result.

Results Chart - Features

The analyst is accorded a high degree of choice in the type and appearance of charts showing the results of probability and sensitivity analyses. The options available to the analyst are described immediately below.

Number of Bins

The "Results Chart" displays probability outcome in the default form of a histogram chart. Each vertical bar of the histogram chart is defined by the number of trial outcomes that fall within a given range of values, called a "bin". The default number of bins is 20, but you may select any number of bins between 10 and 100 for the histogram chart. Click "Refresh" after changing the number of bins (also see the Glossary of this document for more information about bins).

Histogram/Cumul/De-Cumul/Tornado option buttons

As noted, when the "Results Chart" page opens it displays a histogram chart of the selected variable with its values distributed into 20 probability bins. In the "Select

chart type" feature of the "Results Chart", you have the choice of chart formats other than the histogram. You can toggle between the following four chart formats:

- Histogram

- Cumulative probability

- De-cumulative probability

- Tornado (option available only if the risk sensitivity option on the **Simulation** page was selected when the simulation was run)

Each chart is displayed for the selected result variable (see the Glossary for definitions).

Histogram

When you first click the "View" link, the histogram chart is displayed. Clicking the Histogram option will display the chart again after you have browsed to another chart type on the page.

Cumulative Probability Chart

The cumulative probability chart is displayed when you press the "Cumulative" option button on the form.

De-cumulative Probability Chart

Choose the "De-cumul" option button to view the de-cumulative probability chart. This chart shows the full range of values for the selected result and the probability of exceeding each value in its range. More information about these chart formats in included in the Glossary.

Tornado chart

An input variable contributes to risk by means of: a) its own variance, and, b) its structural role in the *BCA.Net* model. For instance, an input variable with large variance may not be a significant contributor to the risk of a result while an input variable with small variance may cause the result to be very uncertain and risky. Without the analysis of risk sensitivity, it is not easy to determine which factors are the significant contributors to the risk associated with a particular result.

The tornado chart shows the impact of each random variable input factor when all the other input factors are set to their mean values and the single input factor is allowed to vary within its 80% confidence interval. The tornado chart displays in order the ten input variables that are the major contributors to the risk of a result.

This analysis of sensitivity can guide the analyst to focus on refining the estimates on the range of input variables that truly matter and help decisions-makers plan for mitigating risks.

Click "Refresh" after making a selection.

Glossary of Terms

Base Year

The base year is the year that precedes the start year of the period of analysis selected for the project.

Benefit-Cost Ratio

The benefit-cost ratio is a measure of economic worth. It is the present value of the project benefits divided by the present value of the project costs. The costs in the denominator include only the net resource expenditures required to build or maintain the highway infrastructure or otherwise provide highway services. All other effects (i.e., user costs, environmental costs, disruption costs of construction) are captured in the numerator of the benefit-cost ratio. If the benefit-cost ratio exceeds 1, then the project passes the benefit-cost test.

The benefit-cost ratio is a good measure of "bang for the buck", that is, benefits received for public dollar expended. However, its use to prioritize projects for funding should be undertaken carefully. In the case of projects or alternatives that are mutually exclusive, a project with a lower benefit-cost ratio may yield greater net benefit (i.e., higher NPV) and may be generally preferable than a project with a higher benefit-cost ratio. More information on this is available in the FHWA's Economic Analysis Primer.

Bins

(This pertains to the risk analysis features of *BCA.Net*.) The range for a simulation result variable, i.e., the values bounded by its minimum and maximum values, is divided into equal portions called bins. The result value from each trial "falls" into one of these bins. Charting the result value's range on the horizontal axis and the probability of a result value falling in each of the bins yields the histogram chart.

Case (Base and Alternate)

A case is a set of assumptions regarding the decision variables of an agency affecting the provision of highway-related services. These decision variables will, in general, include options of whether, what, and when to build. However, a case could consider non-build management measures, like redirection of traffic or policies of taxing or tolling.

A benefit-cost analysis calculates the total present value of the transportation benefits and costs of the alternate case that are additional to the transportation benefits and

costs of the base case. A well-specified "base case" will, in most circumstances, represent the set of maintenance and minor improvements that would most likely be undertaken in lieu of a major investment. The "alternate case" will typically represent an improvement involving a significant construction component.

In *BCA.Net* cases, base and alternate, are developed for each project segment in the **Project** page (Project>View>Base case and alternative case) by selecting a strategy and its year of implementation. A case may have more than one strategy. For instance, an alternate case for a segment may involve rehabilitating the facility in 2007 and adding lanes in 2015.

Cumulative Probability Distribution

(This pertains to the risk analysis features of *BCA.Net*.) A cumulative probability distribution is constructed by adding (or cumulating) the frequency of the probability density function. A cumulative probability distribution is an "upwardly sloping" curve, where each point on the curve gives the probability that the variable will be equal to or less than the value on the x-axis. The y-axis of the cumulative probability distribution ranges between 0 and 1. The cumulative probability distribution equals zero for a variable's minimum value and rises to 1 at a variable's maximum value.

De-Cumulative Probability Distribution

(This pertains to the risk analysis features of *BCA.Net*.) A de-cumulative probability distribution is constructed by subtracting (or de-cumulating) a variable's probability frequency starting with a probability of 1. A de-cumulative probability distribution is a "downward sloping" curve, where the curve gives the probability of the variable exceeding the value along the x-axis. The de-cumulative probability is 1 for a variable's minimum value and is 0 for its maximum value (i.e., the y-axis ranges between 1 and 0).

Deterministic

The term deterministic indicates that there is no uncertainty attributed to a given value, variable or model. Models that include random variables are called probabilistic or stochastic.

Dollar Values

Dollar values in the model are constant, base year dollars (also called "real dollars"). Present value dollars in the model are discounted to the end of the base year.

End Year

The end year is the last year of an analysis period. This is one of three years that the user must set in the Scenario view of the **Manage** page.

For example, suppose the analysis period of a benefit-cost analysis was twenty-five years and the near-term planning horizon was five years. If the start year is 2008, then the respective years of the analysis in this example would be:

Start Year	Last Year Near Term	End Year
2008	2012	2032

For each segment of a project, the user sets the forecast levels of traffic and traffic profiles for representative days in each of the three years. The base year for this analysis would be 2007, the year before the start year of the period of analysis.

In the benefit-cost analysis with *BCA.Net* the effects of improvements and their respective costs and benefits are measured in each year from the start year to the end year, inclusive. Benefits and costs in the analysis are discounted to the beginning of the start year (i.e., the end of the base year). The residual value of the project – which is the depreciated value of capital improvements at the end of the end year – is added to the benefit-cost summary as a benefit.

Histogram

(This pertains to the risk analysis features of *BCA.Net*.) A histogram shows the frequency of a discrete random variable and is used to display the frequency distribution of Monte Carlo simulation result variables. In a histogram, the result values are gathered in bins and the height of the bars correspond to the frequency with which values fall in the respective bins.

Kurtosis

(This pertains to the risk analysis features of *BCA.Net*.) Kurtosis is a statistical measure of a distribution's peakedness. Flatter distributions (with thin tails) are called platykurtic and peaked distributions (with fat tails) are called leptokurtic. The formula for kurtosis is:

$$\left(\frac{n(n+1)}{(n-1)(n-2)(n-3)} \frac{\sum_i (x_i - \bar{x})^4}{s^4} \right) - \frac{3(n-1)^2}{(n-2)(n-3)}$$

where $\bar{x}$ is the mean of the observations, s is the standard deviation, and n is the number of observations.

Last Year Near-Term

The last year near-term is the last year of near-term planning. This is one of three years that the user must set in the Scenario view of the **Manage** page.

For example, suppose the time horizon of a benefit-cost analysis was twenty-five years and the near-term planning horizon was five years. If the start year is 2008, then the respective years of the analysis in this example would be:

Start Year	Last Year Near Term	End Year
2008	2012	2032

In the benefit-cost analysis with *BCA.Net* the effects of improvements and their respective costs and benefits are measured in each year from the start year to the end year, inclusive. Benefits and costs in the analysis are discounted to the beginning of the start year (i.e., the end of the base year).

For each segment of a project the user sets the forecast levels of traffic and traffic profiles for representative days in each of the three years.

Latin Hypercube

(This pertains to the risk analysis features of *BCA.Net*.) Latin Hypercube is an alternative statistical sampling method to the Monte Carlo method. This is a stratified sampling method, which means that the range for each input variable is divided into strata and one random sample is taken from each stratum. This method ensures that low probability events are sampled in the simulation. It enables faster convergence to the result distribution than with the Monte Carlo sampling method.

Lower 10% Value

(This pertains to the risk analysis features of *BCA.Net*.) The lower 10% value is the 10th percentile value and is the lower limit of an 80% confidence interval as input by the user.

Mean Value

(This pertains to the risk analysis features of *BCA.Net*.) The mean value for a collection of observations of a random variable is its expected value and equals the sum of the observations divided by the number of observations. For skewed distributions, the mean value is off the median value and is located in the direction of the distribution's skew.

Median Value

(This pertains to the risk analysis features of *BCA.Net*.) The median value is the 50th percentile: there is equal probability that the value for a random variable will lie above or below the median.

Mode

(This pertains to the risk analysis features of *BCA.Net*.) The mode of a probability distribution is the value for which the probability density function is at a maximum. The value has the highest probability (and is sometimes called "the most likely value", not to be confused with the mean or expected value).

Monte Carlo

(This pertains to the risk analysis features of *BCA.Net*.) Monte Carlo is the method of sampling from random variables by taking a random number on the 0-1 interval , call it "a", and finding the value of the random variable whose cumulative probability equals a. Repeated Monte Carlo sampling on a number of random variables that are inputs to a model and repeatedly solving the model to arrive at probability distributions for the result variables is called Monte Carlo simulation.

Net Present Value

The net present value, NPV, of a project is the present value sum of benefits less the present value sum of costs over the period of analysis. The net present value is the

principal measure of economic worth of a project. When NPV>0, the project passes the benefit-cost test.

Period of Analysis

(This is also called the time horizon or analysis period in the documentation). The period of analysis is the period during which the benefits and costs due to the effects of changes to the road infrastructure or traffic flowing on it are measured and compared. The period of analysis begins with the start year and ends with the end year. There may also be construction during the base year (the year that immediately precedes the start year) and these costs are included in the benefit-cost summary.

Present Value

The present value is a single number that expresses a future cost or benefit stream in terms of an equivalent value realized in the present. The formula for the present value is given as:

$$PV = \sum_{i=1}^{n} \frac{v_i}{(1+dr)^i}$$

where v_i is a value in the ith year of the analysis, dr is the discount rate and n is the number of years in the period of analysis.

Probability

(This pertains to the risk analysis features of *BCA.Net*.) Probability is the likelihood of the occurrence of a value or event.

Probability Density Function

This is the same as probability distribution.

Probability Distribution

(This pertains to the risk analysis features of *BCA.Net*.) A probability distribution or probability density function shows a continuous random variable's frequency of occurrence over its range.

Project

A project is a collection of one or more segments that are to be improved. The benefit-cost results summary aggregates the results from the segments in a project.

Random seed

(This pertains to the risk analysis features of *BCA.Net*.) The random seed is a number that initializes the generation of random numbers used in a Monte Carlo (or Latin Hypercube) simulation. For the same random seed and the same number of trials given no change in the model or inputs, the results of two Monte Carlo simulations will be identical.

Rate of Return

The project rate of return is an indicator of economic worth. The rate of return is equal to the discount rate that if applied to the stream of net benefits, would yield a net present value of 0. If the rate of return exceeds the discount rate, then the project passes the benefit-cost test. The rate of return is useful in communicating benefit-cost results to laymen, because the metric somewhat resembles the return on a financial asset.

Some care is required in interpreting the rate of return, because in cases where the stream of net benefits changes sign more than once (e.g., goes from negative to positive and then back to negative), multiple rates of return may exist. This can occur, for instance, if there are multi-phased investments in the period of analysis.

Risk

(This pertains to the risk analysis features of *BCA.Net*.) The term refers to measured uncertainty in a forecast outcome. Colloquially, risk is often associated with undesirable or downside outcomes (as in "hedging against risk"). In a risk analysis, risk is reflected in the probability distributions of result variables.

Risk Analysis

Risk analysis is a term applied to several methods for quantifying uncertainty in forecasts. The risk analysis methods used in *BCA.Net* are called Monte Carlo simulation.

Scenario

A scenario is a collection of general data for use in the benefit-cost analysis. The scenario variables are organized into several groups: travel demand and traffic composition; social costs; project cost factors; prices; policy variables; and, non-transportation benefits. Users can assign fixed values or probabilistic ranges to each variable from the **Scenario** page. Probabilistic ranges are used as risk analysis inputs in the benefit-cost analysis. The scenario definition, which is set on the **Manage** page, includes the three analysis years: start year, last year near term and last year.

Segment

A segment is a specific highway facility that is uniform with regard to: 1) its physical and performance characteristics, and 2) traffic flowing on it. The data for a segment include: base year characteristics (i.e., length, number of lanes, maximum flow, grade, etc.); traffic profiles for each of three years (start year, last year near term, last year); and, a base and alternate case, each of which is a collection of improvement/maintenance strategies and their respective years of implementation. A project may consist of one or more segments.

Simulation

(This pertains to the risk analysis features of *BCA.Net*.) Simulation is a numeric method for finding solutions to analytically complex problems by "simulating" repeated, real world occurrences.

Skewness

(This pertains to the risk analysis features of *BCA.Net*.) Skewness is a measure of the asymmetry of a distribution. The probability density function of a skewed distribution has a longer tail on its skewed side. A right skewed distribution has skewness greater than 0 and a left skewed distribution has skewness less than 0. The formula for skewness is:

$$\frac{n}{(n-1)(n-2)} \frac{\sum_i (x_i - \overline{x})^3}{s^3}$$

where $\overline{x}$ is the mean of the observations, s is the standard deviation and n is the number of observations.

Standard deviation

(This pertains to the risk analysis features of *BCA.Net*.) The standard deviation, which is the square root of the variance, is the principal descriptive statistic after the mean value. Knowing only a distribution's mean value and standard deviation, an upper bound can be found on the probability of any value in a variable's range. The standard deviation reported for the results is the sample standard deviation, given by the formula:

$$\sqrt{\frac{n\sum x^2 - \left(\sum x\right)^2}{n(n-1)}}$$

where n is the number of trials.

Start Year

The start year is the first year of an analysis. This is one of three years that the user must set in the Scenario view of the **Manage** page.

For example, suppose the time horizon of a benefit-cost analysis was twenty-five years and the near-term planning horizon was five years. If the start year is 2008, then the respective years of the analysis in this example would be:

Start Year	Last Year Near Term	End Year
2008	2012	2032

For each segment of a project the user sets the forecast levels of traffic and traffic profiles for representative days in each of the three years.

The start year is the first year in which an analysis may register differences between the base and the alternate cases. The start year is the year following the base year for the analysis. In the benefit-cost analysis with *BCA.Net* the effects of improvements and their respective costs and benefits are measured in each year from the start year to the end year, inclusive. Benefits and costs in the analysis are discounted to the beginning of the start year (which is equivalent to the end of the base year).

Strategy

A strategy is an improvement or maintenance program. Strategies are referenced in the base and alternate cases of project segments. In *BCA.Net*, a strategy is

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independent of a project and can be deployed in more than one project or project segment.

There are three components to a strategy: effects; traffic signals and devices; and, costs. The effects of a strategy are the target facility characteristics (i.e., maximum flow, number of lanes, improved pavement condition, etc.) that result from an improvement (or, represent the presumed facility status under a specified maintenance regime).

The costs of a strategy include a multi-year cost schedule that specifies: right-of-way (ROW) costs; capital improvement costs; and, anticipated costs of disruption due to construction. The multi-year cost schedule begins at Year 1 and can extend up to Year 7. Year 1 of the multi-year schedule is the year of implementation that is specified in the project segment case that deploys the strategy. Strategy costs also include an annual "O&M" cost and "other lifecycle" cost.

Strategy costs (ROW, Capital, Disruption, O&M and Other Lifecycle) are in thousands of constant base year dollars. When specifying costs, the user can specify the cost units as one of the following: total costs for the segment, costs per facility-mile, or costs per lane-mile.

An investment strategy is one that has non-zero capital costs in at least one year. The effects of an investment strategy are realized in the year following the last year of non-zero investment. From the year in which strategy effects are realized, "O&M Costs" and "Other Lifecyle Costs" recur in each year. These costs replace the costs from the base year facility characteristics or from strategies implemented in the case in previous years. Care should be taken to assure that the base year facility characteristics data are compatible with the data specified for O&M Costs and Other Lifecycle Costs" in the strategies.

The effects associated with a non-investment strategy are immediate in the year of implementation. "O&M Costs" and "Other Lifecycle Costs" recur in each year from the year of implementation. These costs replace the costs from the base year facility characteristics or from strategies implemented in previous years.

Traffic Distribution

The traffic distribution describes the intensity of traffic during three different periods of the day: Peak, peak shoulder and off-peak. The traffic distribution specifies the percent of daily traffic per hour in each period (the user specifies the peak and peak shoulder while the off-peak is calculated as the remaining traffic). Additionally, the traffic distribution includes a specification of the percent of traffic in the direction of greater flow – a value between 50 and 100. The traffic distributions are specified in the **Parameters** page of *BCA.Net*.

Traffic Profile

A traffic profile describes a representative day of traffic on a segment for each of the three years – start year, last year near-term and end year. A segment may have one or several traffic profiles, depending on whether traffic varies by time of week (e.g., weekday vs. weekend) or time of year (e.g., tourist season).

For each year, the traffic profile includes a percent of total days in the year and, a percent of annual traffic. If there is only one traffic profile for the segment, then these values must equal 100 for that profile. If there are several traffic profiles in a segment, then the sum of the percent of total days and the percent of annual traffic must each sum to 100. Traffic profiles are specified in the **Project** page of *BCA.Net*.

The traffic profile also specifies the duration of each of the travel periods, peak and peak shoulder, in hours. For each of the three vehicle types (auto, truck, bus) the user specifies the traffic distribution for each.

Note that daily traffic profiles are converted to annual traffic levels in the by means of the "Annualization Factor", which is specified in the "Travel demand and travel composition" data group on the **Scenario** page.

Trial

(This pertains to the risk analysis features of *BCA.Net*.) A trial is one solution of a model in a simulation. A simulation consists of many trials. In each trial, every input variable is populated with a data value sampled from the variable's probability distribution.

Upper 10% Value

(This pertains to the risk analysis features of *BCA.Net*.) The upper 10% value is the 90th percentile of a probability distribution and the upper limit of an 80% confidence interval.

Variable

(This pertains to the risk analysis features of *BCA.Net*.) A variable is a model element that can be assigned more than one value. A fixed-value input variable can assume only one value. A random variable can assume a range of values according to its probability distribution.

Variance

(This pertains to the risk analysis features of *BCA.Net*.) The variance is a measure of the dispersion of values in a probability distribution, and is a measure of risk. The variance is the average of the squared deviations about the mean. The variance gives disproportionate weight to "outliers," values that are far away from the mean. The variance is the square of the standard deviation.

Index

percentile 49, 50, 51
period of analysis 33, 34, 41
  base year 24, 33, 34, 36, 38, 40, 41, 42, 48
  end year 9, 33, 34, 37
  last year 9, 28, 31, 33, 34, 37
  last year near term 33, 34, 37
  start year 9, 33, 34, 37, 38
profiles 5, 8, 9, 10, 23, 24, 26, 27, 28, 33, 34, 35, 36, 37, 38, 43, 44, 45, 46, 47, 53, 55, 56
project 1, 9, 10, 17, 18, 19, 21, 23, 29, 30, 31, 33, 34, 35, 38, 39, 40, 41, 44, 47, 48, 52, 54, 55, 56
project costs 48
  capital costs 28, 31
  disruption costs 48, 56
Project ISICs Page
  Cases 1, 3, 9, 10, 23, 30, 33, 34, 35, 38, 39, 41, 46, 55, 57
  Identifiers 23, 24, 28, 29, 30, 31, 55
Project Page
  cases 1, 3, 34, 35, 39, 41, 46, 55, 57
  signals and devices 25, 34, 35, 36, 38, 55
  traffic characteristics 33, 34, 35, 41
Project Segments Page
  cases 1, 3, 9, 10, 23, 30, 33, 34, 35, 38, 39, 41, 46, 55, 57
  signals and devices 25, 34, 35, 36, 38, 55
  traffic characteristics 33, 34, 35
PSI 24, 39, 55

R

random seed 53
rate of return 57
registration 16
residual value 48, 49, 56
results set 10, 17, 18, 19, 21, 52
reversible 24
right-of-way 27, 31
risk analysis 2, 49, 52, 58
  Latin Hypercube 53
  Monte Carlo 53
  simulation 10, 39, 49, 52, 53, 54, 55, 58, 59
  trial 52, 58

S

safety 47, 57
scenario 9, 17, 18, 19, 21, 33, 34, 36, 41, 46, 47, 49, 51, 52, 53, 56
Scenario Page
  data group 47, 49, 53
  social costs 46
segment 9, 23, 24, 26, 29, 31, 33, 34, 35, 37, 38, 39, 40, 41, 42, 44, 45, 54, 55
Segment Strategy Page

costs 1, 2, 9, 10, 27, 31, 33, 34, 37, 39, 41, 46, 47, 48, 55, 56, 57
  signals and devices 25, 34, 35, 36, 38, 55
signal 25, 26, 27, 38
simulation 10, 39, 49, 52, 53, 54, 55, 58, 59
social costs 46
strategy 23, 24, 27, 28, 29, 30, 31, 32, 33, 34, 39, 41, 43, 55, 56
Strategy Page
  costs 1, 2, 9, 10, 27, 31, 33, 34, 37, 39, 41, 47, 48, 55, 56, 57
  signals and devices 25, 34, 35, 36, 38, 55
summary 1, 50, 51, 54, 58

T

tax 48
traffic
  traffic characteristics 33, 34, 35, 41
  traffic distributions 8, 10, 37, 43, 47
  traffic profiles 33, 34, 37, 38, 44
traffic characteristics 33, 34, 35, 41
traffic distributions 8, 10, 37, 43, 47
traffic profiles 33, 34, 37, 38
trial 52, 58
triangle 50
Triangle 50

U

uniform 9, 49
Uniform 9, 49
user costs 27, 31, 37, 47, 48
  emissions 48, 55
  safety 47, 57
  travel time 30, 44, 47, 48, 55, 56, 57
  vehicle operating costs 55, 56