Chapter 4 – The Expert System

How to Use BIKESAFE

Selection Tool

Interactive Matrices

Countermeasures

Case Studies
The BIKESAFE expert system is provided on the enclosed CD-ROM and is available online at http://safety.fhwa.dot.gov/bikesafe and at http://www.bicyclinginfo.org/bikesafe. This chapter provides an overview of the application and specific instructions on how to access and use the tools available. The application is designed to:

- Provide information on the countermeasures available to prevent bicycle crashes and improve motorist and bicyclist behavior.
- Highlight the purpose, considerations and cost estimates associated with each countermeasure.
- Provide a decision process to select the most applicable countermeasures for a specific location.
- Provide links to case studies showing the various treatments and programs implemented in communities around the U.S.
- Provide easy access to resources such as statistics, implementation guidance, and reference materials.

The expert system combines the resources provided in this document with online tools (see home page below) to enable practitioners to effectively select engineering, education, or enforcement treatments to mitigate a known crash problem or achieve a specific performance objective.

The home page of the BIKESAFE Web application introduces the site and highlights the Resources and Tools sections.
The resource materials included in the Web/CD-ROM application are related to this document as follows:

**WEB/CD-ROM**

- **Background**: Chapter 1: The Big Picture
- **Crash Factors**: Chapter 2: Bicyclist Crash Factors
- **Crash Analysis**: Chapter 3: Selecting Improvements for Bicyclists
- **Objectives**: Selection for Bicyclists
- **Implementation and Publications**: Chapter 7: Implementation and Resources

*Chapters 5 and 6 include the countermeasures and case studies, which are available as Tools on the Web/CD-ROM application.

**HOW TO USE BIKESAFE**

The opening page gives a brief explanation of BIKESAFE and then highlights the “Resources” and “Tools” sections. The “Resources” section provides an overview of bicycling in today’s transportation system, information about bicycle crash statistics and analysis, and selecting and implementing bicycling improvements. “Tools” allows the user to select appropriate countermeasures or treatments to address specific objectives, such as the need to make intersections safer for bicyclists, or crash problems, such as overtaking motorists striking bicyclists from the rear on a busy corridor with inadequate space. This section also includes a large number of case studies to illustrate treatments implemented in communities throughout the United States.

The rest of this chapter focuses on the four tools available on the Web/CD-ROM application. Each can be used to enter the system, as described below:

- **Selection Tool** – This interactive tool allows the user to develop a list of possible countermeasures on the basis of site characteristics, such as geometric features and operating conditions, and the type of safety problem or desired behavioral change. The decision logic used to determine when specific treatments are and are not applicable is based on input from an expert panel of practitioners.
- **Interactive Matrices** – This tool shows the relationship between the countermeasures and the performance objectives or crash types and can be used to display applicable countermeasures.
- **Countermeasures** – Details of 50 engineering, education, enforcement, and other treatments or programs for improving bicycle safety and mobility are provided in the categories of shared roadway treatments; on-road bicycle facilities; intersection treatments; traffic calming applications; trails/shared-use paths; markings, signs, and signals; education and enforcement; and support facilities and programs.
- **Case Studies** – More than 50 real-world examples illustrate various treatments or programs as implemented in a state or municipality.

BIKESAFE is designed to allow the tools and information to be accessed from multiple points of entry. Links are provided to allow users to easily navigate between the tools and to quickly access the resource materials. Provided below are four examples of how a user may choose to enter the system and access the tools.
1) Selection Tool – The user may have information available about geometrics and operating conditions of a particular location and either has a specific type of crash problem or desires to change motorist/bicyclist behavior at the site. Known location information may be entered by answering a series of questions. The system will then display the countermeasure options to be considered.

2) Interactive Matrices – The user has a specific type of crash problem or desires to change motorist/bicyclist behavior but does not have specific information about the characteristics of the site. The matrices can be used to view and access the types of countermeasures available for further consideration.

3) Countermeasures – The user is interested in acquiring information about a particular treatment or program. The countermeasures page can be directly accessed and displays the nine categories of treatments included. Detailed descriptions of the 50 countermeasures can be accessed from this point. Links to relevant case studies can then be accessed from the description pages.

4) Case Studies – The user wishes to see specific examples of treatments that have been installed. The case studies page provides a list of all case studies assembled, as well as the option of selecting a specific implementation example by type of treatment or by location (state and municipality). From there, the user can access the countermeasure description pages that are relevant to a particular example.

Each of these tools is described in more detail in the remainder of the chapter.

**SELECTION TOOL**

The interactive selection tool allows the user to refine their selection of countermeasures on the basis of specific site characteristics and/or the type of safety problem or desired behavioral change. One begins by choosing selection tool from the Tools menu. A screen will appear with specific instructions on how to use the tool (see next page), and then allows the user to click on “Start the Selection Tool.” This leads to a simple three-step process:

Step 1: Choose the Location — A text box is provided for the user to describe the location of interest (e.g., “Route 1 between Spring Ave. and Summer Ave.” for a roadway segment, or “Intersection of Route 1 and Spring Ave.” for an intersection). This is entirely for the benefit of the user and allows other descriptive information to be entered as well. This information will be stored and displayed as typed with the results so the project can be identified. In the figure on the next page, a specific intersection location—Main Street and Broadway Avenue—has been entered.

Step 2: Select the Goal of the Treatment — The user must then choose a particular type of crash problem to be mitigated or a performance objective to be achieved. As shown in the figure on page 42, there are seven performance objectives and 13 crash groups. Only one can be selected. As the user proceeds through the steps, the previous input is shown on the right side of the screen (in this example, the roadway location from Step 1).

Step 3: Describe the Site — Finally, the user is asked to provide input about the characteristics of the site. As shown in the figure on page 43, there are nine questions that are asked in reference to the general location, geometric features, and operating conditions. The default value is “Not Applicable/Unknown” for each question. The answers to these questions are used to narrow the list of appropriate countermeasures for a specific goal or crash type. For example, if the location of interest was a roadway segment (midblock location), then the treatments associated with intersection improvements would not be applicable and would not be included in the results as applicable countermeasures.

The field investigation form included in Appendix A can be used for site visits to obtain the information asked for in this last step. For any question where the information is not known, an entry of “Not Applicable/Unknown” will simply retain all countermeasures relevant to the question, and the choice of treatments will not be reduced.

After completing these three steps, the user clicks Get Results. The information entered is used to develop a list of applicable countermeasures, which are presented as shown on page 44. The user can then read more about a specific countermeasure by selecting it, which takes the user to the countermeasure description page. The user is advised to carefully read the countermeasure description page, especially if some of the suggested treatments seem inappropriate. The description of the countermeasure, along with the “Considerations” section, hopefully will clear up questions. As an example, “Reduce Lane Width” is displayed for the crash type of motorist overtaking bicyclist on a shared roadway. While this may seem counter-intuitive, reducing lane width is one way to reduce motor vehicle speed. If speed is reduced, then some overtaking crashes may be averted (e.g., on curves with poor sight distance).
Selection Tool

How the Tool Works
The selection tool is designed to receive input on several variables from the user in three steps.

1. **Choose the Location**
   First, enter the location of the site in question. This allows the user to create reports for several different sites and keep the results separated by location. It is used for reporting purposes only and is not stored permanently by the operators of this web site.

2. **Select the Goal of the Treatment**
   Second, one must decide on the goal of the treatment. It may either be to achieve a specific performance objective, such as reduce traffic volumes, or to mitigate a specific type of bicyclist-motor vehicle collision.

3. **Describe the Site**
   Once a specific goal has been selected, the third step is to provide answers to a series of questions related to the geometric and operational characteristics of the site in question. The answers to these questions are used to narrow the list of appropriate countermeasures for a specific goal. For example, if the location of interest were a segment of roadway, or midblock location, then the treatments associated with intersection improvements would not be applicable and thus, would not be included in the results as possible countermeasures.

   For any question where the information is not known, an entry of “unknown” will simply retain the countermeasures relevant to the question, and the range of treatments will not be reduced.

   [Start the Selection Tool]

The Selection Tool includes three simple steps that are described on its opening page.

### Step One: Choose the Location

For the roadway location being addressed, please enter a description.

**Location:**
Main Street and Broadway Avenue

[Proceed to Step 2]

The user may enter any combination of text and numbers to describe the location of interest.
Step Two: Select the Goal of the Treatment

For the roadway location being addressed, the goal of the bicycling treatment is intended to improve bicyclist safety and access by either achieving one of the following performance objectives or mitigating one of the following crash types. Therefore, you must choose one of the following to begin:

### Performance Objectives
- Provide safe on-street facilities/space for bicyclists
- Provide off-road paths or trails for bicyclists
- Provide and maintain quality surfaces for bicyclists
- Provide safe intersections for bicyclists
- Improve motorist behavior/compliance with traffic laws
- Improve bicyclist behavior/compliance with traffic laws
- Encourage and promote bicycling

### Crash Types
- Motorist failed to yield-signalized intersection
- Motorist failed to yield-non-signalized intersection
- Bicyclist failed to yield-signalized intersection
- Bicyclist failed to yield-non-signalized intersection
- Motorist drove out - midblock
- Bicyclist rode out - midblock
- Motorist turned or merged left into path of bicyclist
- Motorist turned or merged right into path of bicyclist
- Bicyclist turned or merged left into path of motorist
- Bicyclist turned or merged right into path of motorist
- Motorist overtaking bicyclist
- Bicyclist overtaking motorist
- Non-motor vehicle crashes

A specific performance objective or crash type to be mitigated must be selected in step two.
Selection Tool

Step Three: Describe the Site

Please answer the following questions.

1. Is the problem location on an off-road multi-use path (not at an intersection with a roadway) or on a roadway (or roadway/path intersection)?
   - Roadway
   - Path
   - Not Applicable/Unknown

2. In what type of area is the roadway located?
   - Urban CBD
   - Urban - Other
   - Suburban
   - Rural
   - Not Applicable/Unknown

3. What is the functional class of the roadway?
   - Local
   - Collector & Minor Arterial
   - Principal Arterial
   - Not Applicable/Unknown

4. Is the problem location at an intersection or midblock?
   - Intersection
   - Midblock
   - Not Applicable/Unknown

5. Is vehicle volume low, medium, or high?
   - Low (<10,000 ADT)
   - Medium (10 - 25,000 ADT)
   - High (>25,000 ADT)
   - Not Applicable/Unknown

6. Is vehicle prevailing speed low, medium, or high?
   - Low (<= 30 mph)
   - Med (31 - 44 mph)
   - High (>45 mph)
   - Not Applicable/Unknown

7. What is the number of through lanes?
   - <=2
   - 3 or 4
   - 5 or more
   - Not Applicable/Unknown

8. Is a traffic signal present, being considered, or not an option?
   - Present (removal not an option)
   - Present (removal could be an option)
   - Not present (installation is not an option)
   - Not present (installation possible)
   - Not Applicable/Unknown

9. What are the existing on-road bicycle facilities?
   - Bike Lane
   - Wide Curb Lane
   - Paved Shoulder
   - None or Other
   - Not Applicable/Unknown

The characteristics of the location are provided in step three by answering nine questions.
In addition to the applicable countermeasures, the results page also provides the user with a list of the inputs made in the three steps. Options are provided for changing these inputs for the location of interest, exporting the results to Microsoft Excel, or starting over with a new location.

**Applicable Countermeasures**

Based upon your input, the following countermeasures were found:

- **Shared Roadway**
  - Roadway Surface Improvements
  - Bridge and Overpass Access
  - Tunnel and Underpass Access
  - Lighting Improvements
  - Parking Treatments
  - Median/Crossing Island
  - Driveway Improvements
  - Access Management
  - Reduce Lane Number
  - Reduce Lane Width

- **On-Road Bike Facilities**
  - Bike Lanes
  - Wide Curb Lanes
  - Paved Shoulders
  - Combination Lanes
  - Contralflow Bike Lanes

- **Maintenance**
  - Repetitive/Short-Term Maintenance
  - Major Maintenance
  - Hazard Identification Program

- **Traffic Calming**
  - Speed Tables/Humps/Cushions
  - Visual Narrowing

- **Markings, Signs, Signals**
  - Sign Improvements
  - Pavement Marking Improvements
  - School Zone Improvements

- **Education and Enforcement**
  - Practitioner Education

- **Support Facilities and Programs**
  - Wayfinding
  - Aesthetics/Landscaping

The results produced from the Selection Tool provide a list of applicable countermeasures and present the user with options to edit the responses, save the results, or start over.
Also included in the Web/CD-ROM application are two matrices that may be accessed by selecting “interactive matrices” from the Tools menu. The objectives matrix (shown below) provides the user with a quick view of the relationship between the seven performance objectives and the nine countermeasure groups. The crash analysis matrix (shown on the following page) allows the user to see the relationship between the 13 crash type groups and the nine countermeasure groups. In either matrix, a filled cell indicates that there is a specific countermeasure within the countermeasure group (shown in the columns) that is applicable to the crash group or performance objective listed in each row. The user can click on the bullet in any filled cell to obtain a drop-down list of the specific applicable countermeasures. From there, the user can select a countermeasure and be linked to the countermeasure description page or select another cell within the matrix.

### Objectives Matrix

Select an Objective and Countermeasure Group from the matrix below by clicking on one of the dots, or view the text-only version.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Countermeasure Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Provide safe on-street facilities/pace for bicyclists.</td>
<td>•</td>
</tr>
<tr>
<td>2. Provide off-road paths or trails for bicyclists.</td>
<td>•</td>
</tr>
<tr>
<td>3. Provide and maintain quality surfaces for bicyclists.</td>
<td>•</td>
</tr>
<tr>
<td>4. Provide safe intersections for bicyclists.</td>
<td>•</td>
</tr>
<tr>
<td>5. Improve motorist behavior/compliance with traffic laws.</td>
<td>•</td>
</tr>
<tr>
<td>6. Improve bicyclist behavior/compliance with traffic laws.</td>
<td>•</td>
</tr>
<tr>
<td>7. Encourage and promote bicycling.</td>
<td>•</td>
</tr>
</tbody>
</table>

Cells with a bullet indicate there are one or more countermeasures within a countermeasure group that are applicable to a specific performance objective.
Crash Matrix

Select a Crash Group and Countermeasure Group from the matrix below by clicking on one of the dots, or view the text-only version.

<table>
<thead>
<tr>
<th>Crash Group</th>
<th>Countermeasure Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Motorist failed to yield – signalized intersection</td>
<td>•</td>
</tr>
<tr>
<td>2. Motorist failed to yield – non-signalized intersection</td>
<td>•</td>
</tr>
<tr>
<td>3. Bicyclist failed to yield – signalized intersection</td>
<td>•</td>
</tr>
<tr>
<td>4. Bicyclist failed to yield – non-signalized intersection</td>
<td>•</td>
</tr>
<tr>
<td>5. Motorist drove out – midblock</td>
<td>•</td>
</tr>
<tr>
<td>6. Bicyclist rode out – midblock</td>
<td>•</td>
</tr>
<tr>
<td>7. Motorist turned or merged left into path of bicyclist</td>
<td>•</td>
</tr>
<tr>
<td>8. Motorist turned or merged right into path of bicyclist</td>
<td>•</td>
</tr>
<tr>
<td>9. Bicyclist turned or merged left into path of motorist</td>
<td>•</td>
</tr>
<tr>
<td>10. Bicyclist turned or merged right into path of motorist</td>
<td>•</td>
</tr>
<tr>
<td>11. Motorist overtaking bicyclist</td>
<td>•</td>
</tr>
<tr>
<td>12. Bicyclist overtaking motorist</td>
<td>•</td>
</tr>
<tr>
<td>13. Non-motor vehicle crashes</td>
<td>•</td>
</tr>
</tbody>
</table>

Cells with a bullet indicate there are one or more countermeasures within a countermeasure group that are applicable to a specific crash group.
Each of the 50 engineering, education, and enforcement countermeasures described in Chapter 5 are included in the Web/CD-ROM application. After selecting “countermeasures” within the Tools menu, the user may select one of the following nine categories of treatments:

- Shared Roadway
- On-Road Bike Facilities
- Intersection Treatments
- Maintenance
- Traffic Calming
- Trails/Shared-Use Paths
- Markings, Signs, Signals
- Education and Enforcement
- Support Facilities and Programs

A specific countermeasure may then be selected from those listed for each category. Each countermeasure includes a description of the treatment or program, purpose(s), considerations of which one should be aware, and cost estimates. Finally, there are links to specific case studies (if available) where the particular countermeasure has been implemented. An example countermeasure description page is shown on the following page for Bike Lanes.

**Countermeasures**

A total of 50 engineering, education, and enforcement countermeasures are discussed in this section. The treatments and programs selected for inclusion in this application are those that have been in place for an extended period of time and/or have been proven effective at the time the material for this product was being compiled. Since that time, new countermeasures continue to be developed, implemented, and evaluated. Thus, practitioners should not necessarily limit their choices to those included here; this material is a starting point. More information on the latest treatments and programs can be found through many of the Web sites and resources included in this section and the More Info section.

**Shared Roadway:** The goal of an appropriately designed roadway should be to safely and efficiently accommodate all modes of travel, from bicyclists to pedestrians to motorists.

**On-Road Bike Facilities:** Various kinds of on-road facilities, such as bike lanes, paved shoulders, and wide curb lanes, make bicyclists more comfortable.

**Intersection Treatments:** Nearly half of all bicycle-motor vehicle crashes occur at intersections or other junctions.

**Maintenance:** Maintenance of all kinds of bicycle facilities must be planned for and done routinely.

**Traffic Calming:** Traffic calming is a way to design streets, using physical measures, to encourage people to drive more slowly.

**Trails/Shared Use Paths:** Bike paths or shared-use trails are complementary to the road network and serve recreational, child, and even commuter bicyclists.

**Markings, Signs, Signals:** Traffic engineers have an arsenal of pavement markings, signs, and signals that can be used to inform, regulate, and warn both motorists and bicyclists.

**Education and Enforcement:** Education and enforcement are key strategies in increasing bicyclist and motorist awareness and behavior.

**Support Facilities and Programs:** The simple promotion of bicycling is a way to increase the amount of riding in a community.

The 50 countermeasures are divided among the nine categories of improvements shown here.
The case studies described in Chapter 6 are included in the Web/CD-ROM application. The user can access the implementation examples by selecting “case studies” within the Tools menu. As shown on the following page, the user then has the option of selecting a case study on the basis of location or type of countermeasure. The figure on the following page provides an example of selection by countermeasure. The selection of the On-Road Bike Facilities countermeasure group produces a list of the five treatments included in the application. The selection of Bike Lanes produces a list of 16 case studies in which a bike lane was a component of the treatments implemented. Accessing each of these case studies provides information about the specific problem that was addressed, the solution implemented, and the results achieved.

Each countermeasure includes a description, purpose, considerations, estimated cost, and links to case studies where the treatment or program has been implemented.
Choose a Case Study

The 50 engineering, education, enforcement and promotional countermeasures are described in the Countermeasures section. Included in this section are case studies that illustrate these treatments or programs as implemented in a state or municipality. Examples are included from many States.

Each case study includes a description of the problem that was addressed, relevant background information, a description of the implemented solution, and any quantitative results from evaluation studies or qualitative assessments.

Many communities find it difficult to conduct formal evaluations of projects due to staff and budget limitations, but assessing whether a treatment has helped toward the intended objectives and not caused unexpected adverse impacts is critical to long-term improvement. We tend to think that some evaluation is better than none but occasionally may be misled by short-term or single-event types of assessments. In these cases, the judgment of experienced practitioners may help to fill in the gaps in knowledge or interpret results that seem "too good to be true." By far, longer-term evaluations (bicycle traffic counts, speed studies, etc.) are preferable to short-term project assessments. Multiple short-term studies of the same types of facilities do, however, build on each other and help to provide a more complete picture of the effectiveness of bicycling countermeasures. These cautions should be borne in mind when reviewing the case studies that follow.

Included for each study is a point of contact in the event that further information is desired. Please note that in some cases the specific individual listed may have left the position or agency. There should still be someone at the municipal or state agency who is familiar with the project and can provide any supplemental information.

Not all traffic control devices (TCDs) in the case studies comply with the Manual Uniform Traffic Control Devices (MUTCD). The Federal Highway Administration (FHWA) does not endorse the use of non-compliant TCDs except under experimentation, which must be approved by the FHWA Office of Transportation Operations.

All Case Studies

- #1 - Minimizing Roadway Surface Hazards for Bikes, Seattle, Washington
- #2 - A Tale of Portland Bridges, Portland, Oregon
- #3 - Lighting and Advance Warning of Bicyclists in the Knapp Hill Tunnel, State of Washington
- #4 - Back-in Diagonal Parking with Bike Lanes, Vancouver, Washington
- #5 - Valencia Street Road Diet — Creating Space for Cyclists, By Location

By Location

- □ Inside the United States
- □ Outside the United States

By Countermeasure Group

- □ Shared Roadway
- □ On-Road Bike Facilities
- □ Bike Lanes
- □ Wide Curb Lanes
- □ Paved Shoulders
- □ Combination Lanes
- □ Contraflow Bike Lanes
- □ Intersection Treatments
- □ Maintenance
- □ Traffic Calming
- □ Trails/Shared-Use Paths
- □ Markings, Signs, Signals
- □ Education and Enforcement
- □ Support Facilities and Programs

The case studies may be selected by location or countermeasure. Opening a countermeasure group folder reveals the list of countermeasures included. Selecting a specific countermeasure reveals the case studies in which that treatment/program was a component.