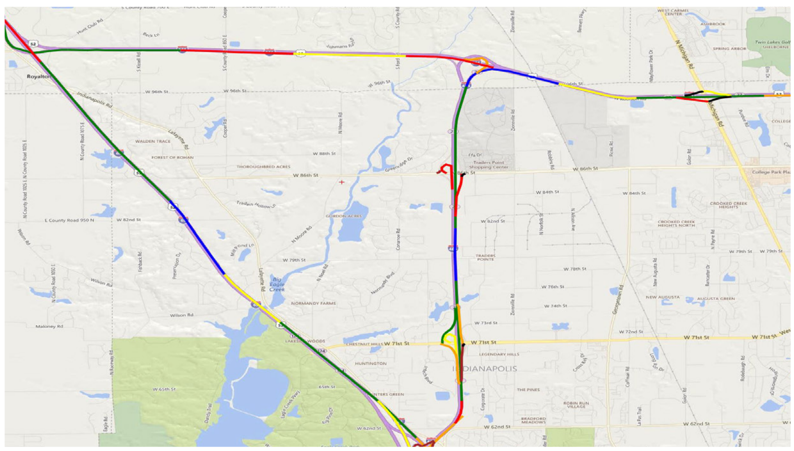
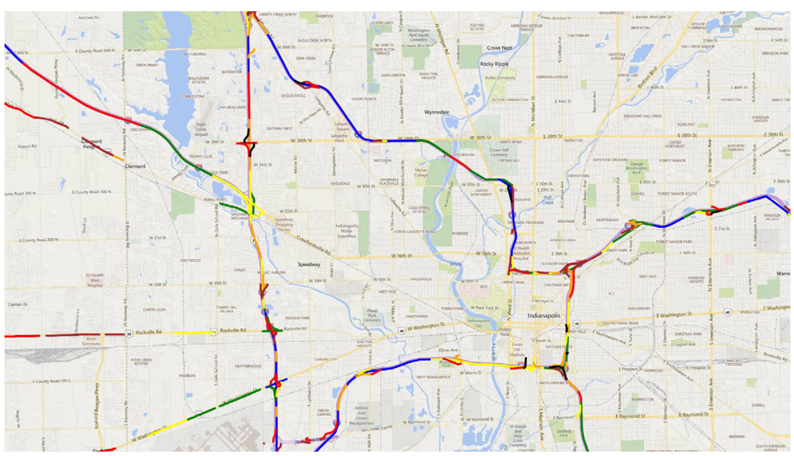
JOINT TRANSPORTATION RESEARCH PROGRAM

INDIANA DEPARTMENT OF TRANSPORTATION
AND PURDUE UNIVERSITY

SNIP Light User Manual





Andrew P. Tarko, Jose Thomaz, Mario Romero

SPR-4219 • Report Number: FHWA/IN/JTRP-2019/26 • DOI: 10.5703/1288284317136

RECOMMENDED CITATION

Tarko, A. P., Thomaz, J., & Romero, M. (2019). *SNIP light user manual* (Joint Transportation Research Program Publication No. FHWA/IN/JTRP-2019/26). West Lafayette, IN: Purdue University. https://doi.org/10.5703/1288284317136

AUTHORS

Andrew P. Tarko, PhD
Professor of Civil Engineering and Director of Center for Road Safety
Lyles School of Civil Engineering
(765) 494-5027
tarko@purdue.edu
Corresponding Author

Jose Thomaz, CRS Data Analyst
Mario Romero, PhD, Post Doctorate Research Associate
Lyles School of Civil Engineering
Purdue University

JOINT TRANSPORTATION RESEARCH PROGRAM

The Joint Transportation Research Program serves as a vehicle for INDOT collaboration with higher education institutions and industry in Indiana to facilitate innovation that results in continuous improvement in the planning, design, construction, operation, management and economic efficiency of the Indiana transportation infrastructure. https://engineering.purdue.edu/JTRP/index_html

Published reports of the Joint Transportation Research Program are available at http://docs.lib.purdue.edu/jtrp/.

NOTICE

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/IN/JTRP-2019/26		

4. Title and Subtitle SNIP Light User Manual	**5. Report Date** October 2019 **6. Performing Organization Code**
7. Author(s) Andrew P. Tarko, Jose Thomaz, and Mario Romero	**8. Performing Organization Report No.** FHWA/IN/JTRP-2019/26
9. Performing Organization Name and Address Joint Transportation Research Program Hall for Discovery and Learning Research (DLR), Suite 204 207 S. Martin Jischke Drive West Lafayette, IN 47907	**10. Work Unit No.** **11. Contract or Grant No.** SPR-4219
12. Sponsoring Agency Name and Address Indiana Department of Transportation (SPR) State Office Building 100 North Senate Avenue Indianapolis, IN 46204	**13. Type of Report and Period Covered** Final Report **14. Sponsoring Agency Code**

15. Supplementary Notes

Conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

16. Abstract

A systemic approach to identifying road locations that exhibit safety problems was provided by the Safety Needs Identification Program (SNIP and SNIP2) developed by the Purdue University Center for Road Safety (CRS). The new version SNIP Light has been developed to provide other uses with planning level traffic safety analysis capability for a wider range of uses including Metropolitan Planning Agencies (MPOs) who want the tool for planning cost-effective safety programs in their metropolitan areas. The SNIP Light reduces the demand of computing and data storage resources and replaces the SQL server database system with an integrated module coded in-house which is considerably faster than the original component. Furthermore, certain proficiency required to install and use the old version is no longer needed thanks to the intuitive single-window interface and executing file operations in the background without the user's involvement. Some operations, such as optimizing funding of safety projects, are removed to simplify the tool.

17. Key Words	18. Distribution Statement
safety management, network screening, high-crash roads	No restrictions. This document is available through the National Technical Information Service, Springfield, VA 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	35	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

CONTENTS

PREFACE 1

SNIP LIGHT OVERVIEW 1
- Road Network Screening 1
- Results Visualization 1

INSTALLATION 2

RUNNING SNIP LIGHT 2
- SNIP Light Interface 2
- Folders and Files 4
- Typical Operations 6

SCREENING 6
- Study Folder 6
- Study Area, Roads, and Years 6
- Road Selection Criteria 7
- Crash Selection Criteria 7
- Saving and Retrieving Queries 9
- Screening Execution and Results 9

VISUALIZATION 11
- Visualization Settings 12
- Visualization Map 13
- Creating KML File 13

EXAMPLE: SCREENING 14
- Screening 14
- Visualization 16

REFERENCE 22

APPENDIX: SCREENING CONCEPTS
- Identification Method 23
- Statistical Evaluation 23
- Computations 27

LIST OF TABLES

Table	Page
Table 1 Example Exposure Measures for Different Road Elements (not all available in SNIP)	23
Table 2 Levels of Statistical Evidence	25
Table 3 Confidence F and Index I for the Three Screening Criteria	27

LIST OF FIGURES

Figure	Page
Figure 1 SNIP Light overall process	1
Figure 2 SNIP Light files	2
Figure 3 Proper location of *SNIPLight_Data* folder	2
Figure 4 Running the installation process for Snip Light	3
Figure 5 Initiation of the SNIP Light main interface	3
Figure 6 SNIP Light main interface	3
Figure 7 Components of the SNIP Light interface	4
Figure 8 *Screening* panel as floating window	5
Figure 9 Opening and closing the *Screening* panel	5
Figure 10 SNIP Light folder structure	5
Figure 11 Criteria options in menu bar	6
Figure 12 Create or open study folder	6
Figure 13 Selecting the scope and analysis period	7
Figure 14 Element selection criteria	7
Figure 15 *Study Crashes* selection criteria	8
Figure 16 *Reference Crashes* selection criteria	9
Figure 17 Options for saving, retrieving, or resetting criteria	9
Figure 18 Folder with *.qry* files	10
Figure 19 All branches collapsed, except for branches with selected options	10
Figure 20 Selecting the *Start Screening* option	10
Figure 21 Status of the screening process	11
Figure 22 Output from the *Results Table*	11
Figure 23 More output from the *Results Table*	12
Figure 24 SNIP Light *Visualization Map* and *Visualization Settings*	12
Figure 25 *Visualization Settings*	13
Figure 26 *Visualization Map*	13
Figure 27 Selecting a road segment in the *Visualization Map*	14
Figure 28 KML file displayed in Google Earth	14
Figure 29 Creating a new study folder	15
Figure 30 Selecting scope and analysis period for segments	15
Figure 31 Segment Type = Rural Two Lane and Shoulder Width $\leq$6 ft and with no curb present	16
Figure 32 Choosing the study crashes	16
Figure 33 Selection tree for the reference crashes	17
Figure 34 Final results table	17
Figure 35 Exporting results to current study criteria folder	18
Figure 36 Saving criteria definition to current study criteria folder	18
Figure 37 Visualization tool settings	19
Figure 38 High-crash rural two-lane segments with narrow shoulders in Indiana	20
Figure 39 High-crash rural two-lane segments with narrow shoulders in and around Spencer County	21

Figure 40 High-crash rural two-lane segments with narrow shoulders on SR 66 and SR 545 near Troy, Indiana 21

Figure 41 Relationship between the index of frequency I and the significance of level F 25

Figure 42 Dependence between crash counts 26

Figure 43 Case 1—Simulated (blue) versus calculated (red) distributions of m estimates 26

Figure 44 Case 2—Simulated (blue) versus calculated (green) distributions of m estimates 26

PREFACE

The Safety Needs Identification Program, Light version (SNIP Light) is a tool developed by the Center for Road Safety at the request of the Indiana Department of Transportation. Its development was supported through the Joint Transportation Research Program of Purdue University and the Indiana Department of Transportation. SNIP Light is an abridged version of its predecessors, SNIP and SNIP2, and it provides an intuitive and user-friendly tool for identifying roads and areas that may require special attention due to an excessive number of crashes of types defined by the user.

This user manual describes SNIP Light and presents examples that illustrate its features. SNIP Light runs in the MS Windows environment with a 64-bit operating system. In order to render the maps that are part of the tool, the software requires an Internet connection.

SNIP LIGHT OVERVIEW

SNIP Light is a computer application that supports the following operations:

1. Identification of road segments and intersections that exhibit excessive number of crashes, cost of crashes or proportions of crashes of a type defined by the user.
2. Visualization of the individual road elements on digital maps.

Road Network Screening

The SNIP Light facilitates defining screening criteria and performing screening tasks that identify crashes and road intersections and segments that meet the screening criteria (Figure 1). For example, the user may need a list of rural road segments with narrow shoulders that are experiencing a considerable number of severe single-vehicle crashes in order to identify locations where widening shoulders might be justified. The screening criteria and the results of screening execution are saved in a study folder for later project continuation. The user also has an option of saving the screening criteria to libraries for future use. The screening module executes the screening task by accessing the SNIP Light database and searching for crashes and roads that meet the criteria currently in use. The user has an option to save the screening results in a csv file. The screening results are immediately displayed on a visualization map. The screening is described in detail in the Appendix.

Results Visualization

The Road Network *Screening* component saves the results of a query in a tabular format convenient for additional processing as needed. The final results are also displayed on a map to visualize the spatial distribution of the identified roads. Such visualization is beneficial in presenting the results to decision-makers and to identify spatial patterns not detectable otherwise. Since the identified road components are geo-coded with their respective latitudes and longitudes, they can be visualized using the embedded *Visualization Map* component in SNIP Light or exported as a KML file and displayed using Google Earth or ArcGIS.

The Road Network Screening and Results Visualization components are described in more detail in the Tarko et al. (2014) SNIP-2 research report. The remainder of this manual focuses on the features of the User Interface and their use.

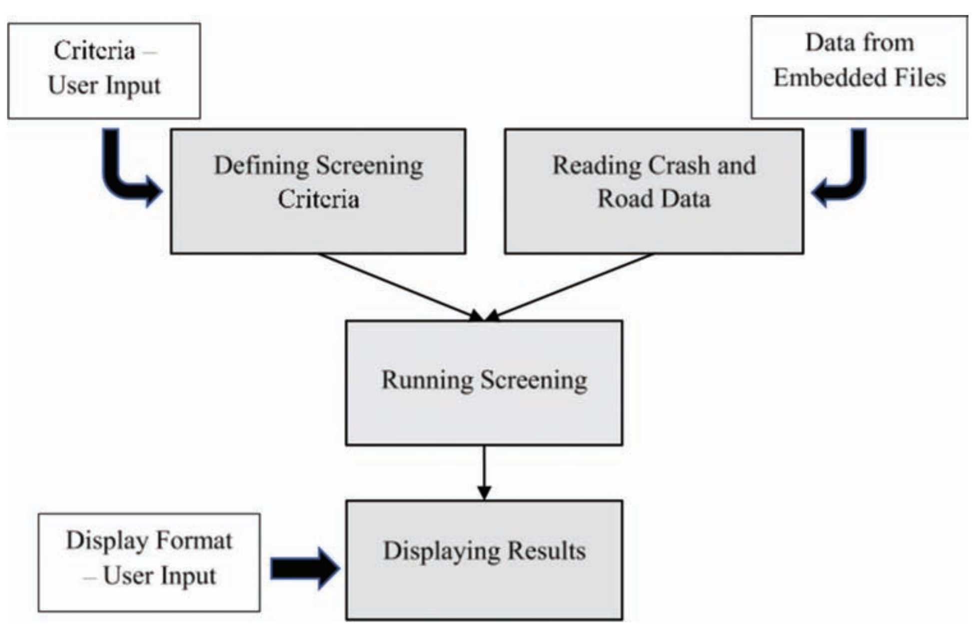


Figure 1 SNIP Light overall process.

INSTALLATION

SNIP Light is compatible with MS Windows 64-bit operating systems. The SNIP Light files for installation are compressed and the user must unzip them in the folder of his or her choice prior to installing the software. The unzipped files are shown in Figure 2.

The unzipped *Readme.txt* file (Figure 2) provides installation instructions for the tool. These steps are also discussed below. The user should retain the zipped/compressed file to reinstall the program in the future if necessary.

First, the *SNIPLight_Data* folder containing the SNIP Light database must be copied into the PC's *c:\Users\Public* folder (Figure 3). This step must precede installing the software.

To continue installation of the SNIP Light, the user should return to the folder where the content of the zip file was extracted and click on the *setup.exe* file (Figure 4). The SNIP Light interface should appear (Figure 5).

The user must **not delete** the *Documents/SNIPLight_Data* folder ***or*** the files in the folder. Also, the files in the folder where the program was installed **must not be deleted.**

RUNNING SNIP LIGHT

SNIP Light can be executed from the Windows start menu, where the program should appear if already installed. As noted in the Installation section of this manual, the *SNIPLight_Data* folder containing the SNIP Light database must be located in the PC's *Documents* folder prior to the installation of the software interface. Otherwise, the user will receive an error message at the attempt of running the software.

When executed, the SNIP Light interface window appears within several seconds (Figure 6). Any temporary tables remaining open from the previous run are closed.

SNIP Light Interface

SNIP Light includes a menu bar that executes the SNIP Light features and facilitates operations on study folders and SNIP Light settings. Moreover, SNIP Light

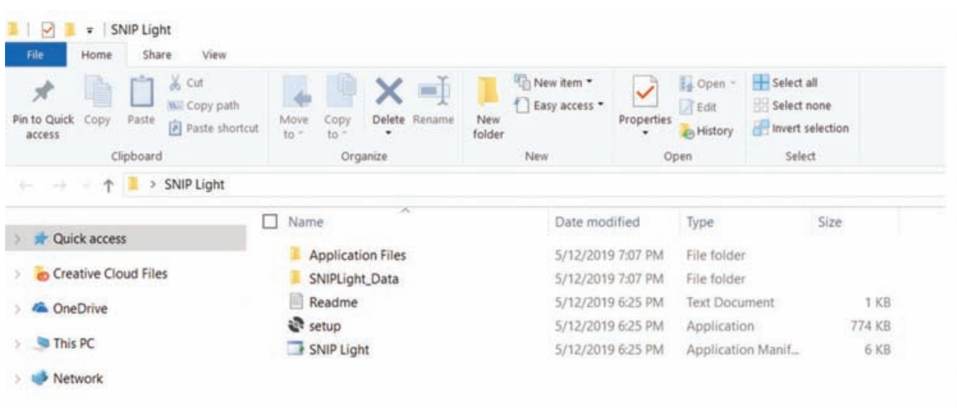


Figure 2 SNIP Light files.

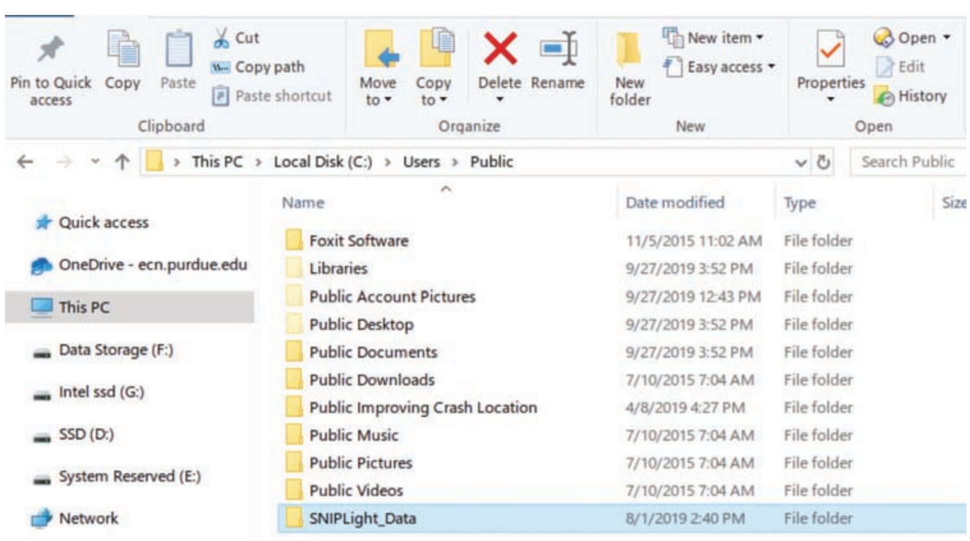


Figure 3 Proper location of *SNIPLight_Data* folder.

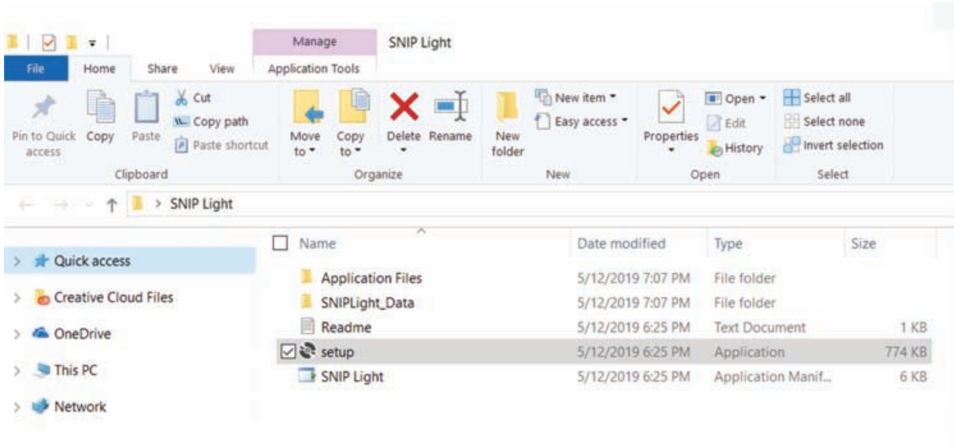


Figure 4 Running the installation process for Snip Light.

Figure 5 Initiation of the SNIP Light main interface.

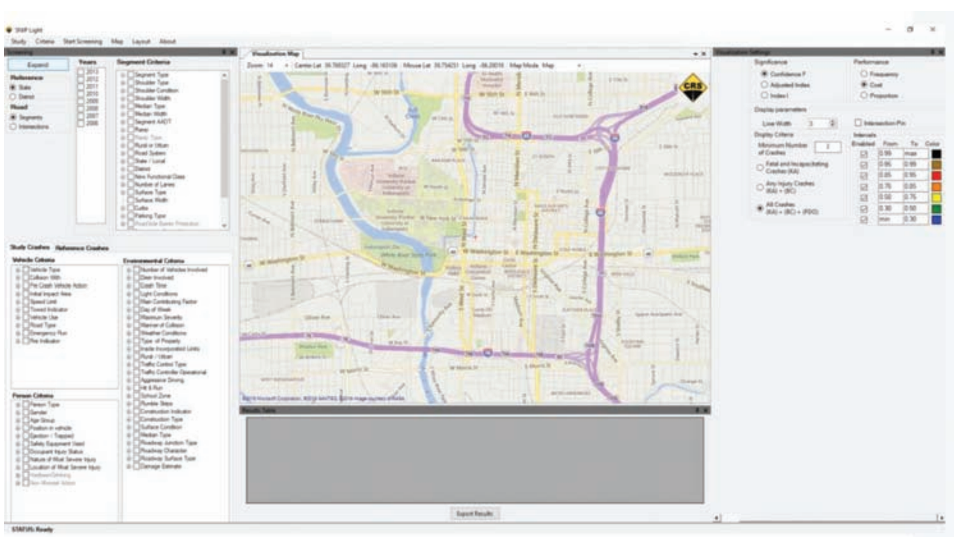


Figure 6 SNIP Light main interface.

includes four main interactive components: *Screening*, *Visualization Settings*, *Visualization Map*, and *Results Table* (Figure 7). Each of these four components is described below.

Screening

The *Screening* component allows to define the screening criteria (i.e., years of crash data, types of road elements, and types of crashes) used in searching for high-crash roads. Once defined, these screening criteria can be used in the current screening task and can be saved for future use. The user can reset the screening criteria to start all over. The Screening chapter explains how to use the *Screening* component.

Visualization Settings and *Visualization Map*

The *Visualization Settings* allow to specify various options for results visualization (crash types, performance and significance measures, and display options). The execution of these settings can be viewed in the embedded *Visualization Map*. Moreover, the *Visualization Map* allows the user to navigate across the map by panning with the mouse and adjusting the zoom settings. The user also has the option to export the map to a KML file that may be viewed in Google Earth or ArcGIS Explorer. The Visualization chapter explains the visualization tools in further detail.

Results Table

The *Results Table* displays in tabular form the road segments or intersections identified through the screening process. By clicking on a row in the *Results Table*, the corresponding road is automatically displayed on the *Visualization Map*.

The interface window is filled with interactive panels. The layout of the interface window can be changed by resizing and moving the panels. For instance, double clicking on the top bar of a panel, that panel becomes a floating object. To dock a panel, click and hold a panel's title bar while dragging it, and the interface will show where it can be docked (Figure 8).

Clicking on the vertical pin in the upper right corner of a panel closes the panel (Figure 9). The closed panel is represented with a tab placed along the vertical border of the interface window. Hovering the cursor above the tab opens the panel as long as the cursor is placed over the tab. Moving the cursor over the horizontal pin in the upper right corner of the open panel and clicking on the pin make the panel open permanently.

Folders and Files

The *SNIPLight_Data* folder has two subfolders: *Studies* and *QueryLibrary*. The *Studies* subfolder is used to store new study files, while the *QueryLibrary* folder is for storing screening criteria for future studies. The screening criteria saved in this library may be later opened, used, modified, and saved under different names with SNIP Light.

The basic SNIP Light folder structure for studies is shown in Figure 10 with an example study folder *Manual Examples*. It should be noted that although the *Studies* folder is automatically created by SNIP Light inside the *Documents/SNIPLight_Data/* folder, the user may place study folders anywhere on the PC. Regardless of where a study folder is placed by the user, it always contains a *Criteria* folder to store the files. Once an existing study folder is selected for use, SNIP Light will create and save its files properly in the default or user-selected folder.

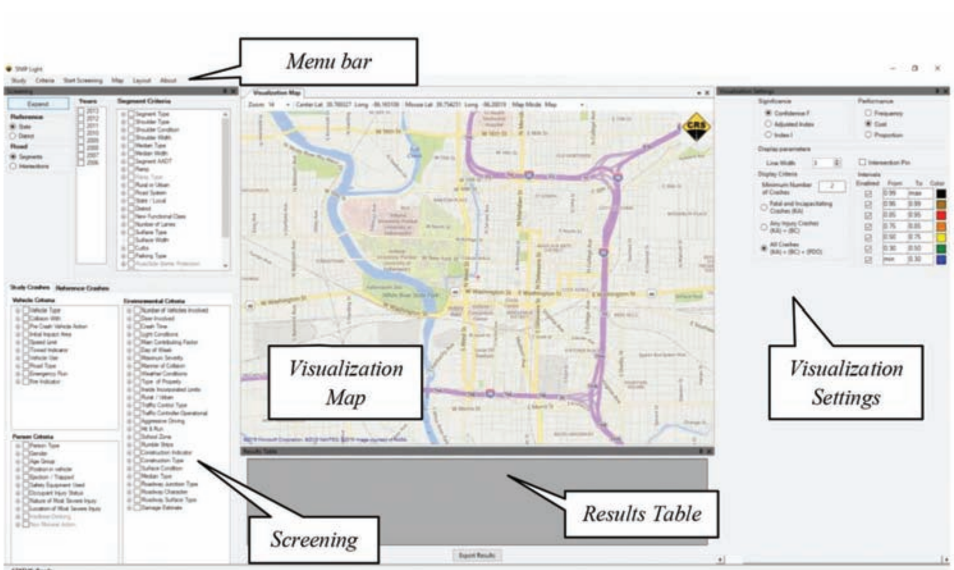


Figure 7 Components of the SNIP Light interface.

Figure 8 *Screening* panel as floating window.

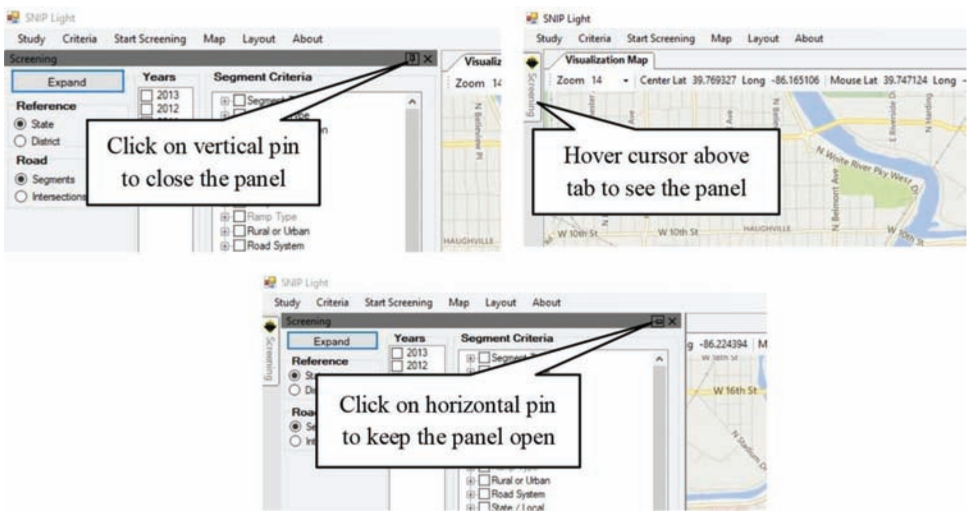


Figure 9 Opening and closing the *Screening* panel.

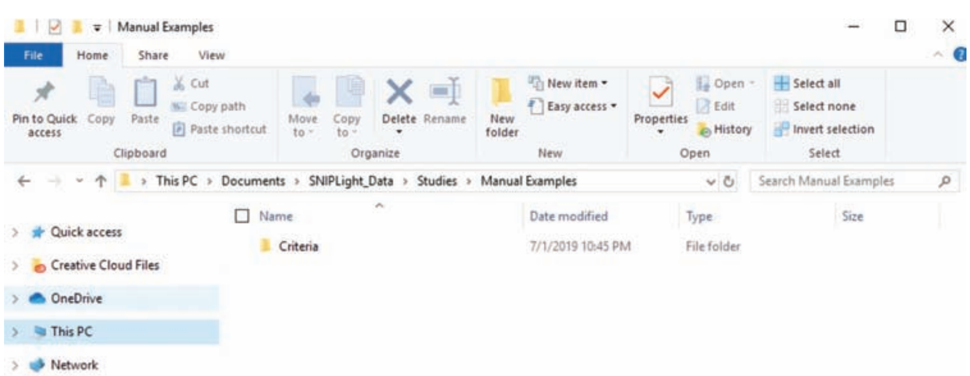


Figure 10 SNIP Light folder structure.

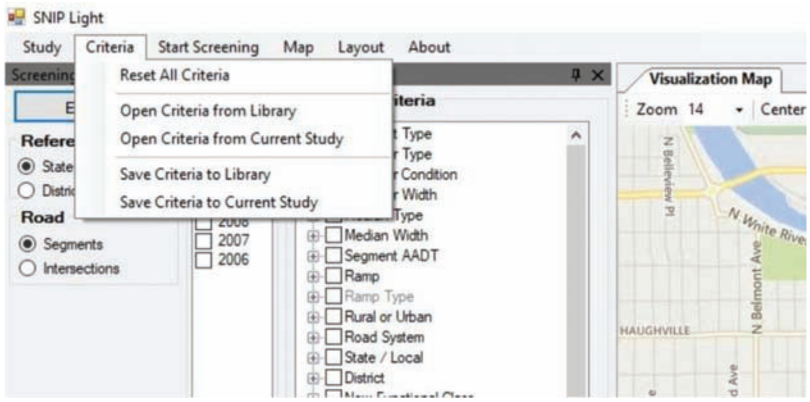


Figure 11 Criteria options in menu bar.

Typical Operations

Tasks that a user may typically perform in SNIP Light include the following:

1. **Creating new study folders or selecting existing ones.** These folders and their subfolders are used to store screening criteria and exported KML files. Every study folder created automatically includes subfolders for saved screening criteria.
2. **Screening road segments or intersections for crashes of user-defined types.** Screening is executed with criteria defined by the user. These criteria can be saved and executed later by the user.
3. **Ranking safety needs by certain types of segments and intersections.** This ranking is based on safety performance measures that account for the numbers of *Study* and *Reference Crashes* on segments and at intersections. The resulting ranked list is saved in a comma separated value (.csv) file placed in the *CriteriaLibrary* subfolder of the current study folder.
4. **Displaying the results (high-crash roads) in the SNIP Light interface, Google Earth, or ArcGIS Explorer.** The user may also visualize the results from previously run studies as long as the files have been exported (saved in the KML format).

SCREENING

The purpose of the *Screening* module is to identify which road elements experience an excessive number of crashes. The *Screening* panel includes lists of crash and road attributes. Selecting the desired attributes of roads and crashes defines the set of roads and crashes on these roads that possess the desired attributes; in other words, meet the screening criteria. Thus, the screening results include a list of road segments or intersections that meet the road criteria with the number of crashes that meet the crash criteria. The roads supplemented with crash statistics and other safety indicators are presented in a tabular form. Moreover, the results may also be viewed using the *Visualization Map*.

The Criteria task reads, creates, and saves criteria files. These file operations can be executed with the commands listed under the *Criteria* module in the top menu bar (Figure 11). The user has options to open and save criteria in the current study or the criteria library. Finally, *Reset All Criteria* completely erases all selected user choices.

The *Start Screening* command initiates the screening after all inputs have been entered.

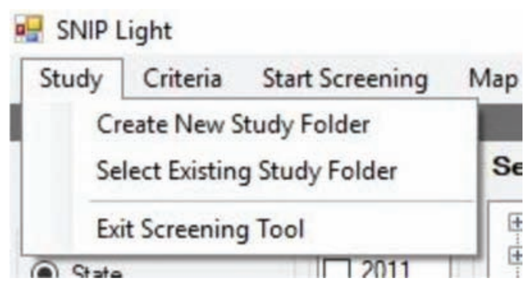


Figure 12 Create or open study folder.

Study Folder

Although it is not necessary to create new or access an existing study in order to perform a screening task, it is advisable to do so in order to be able to save the screening criteria and the results. A study can be selected or created at any time before or during defining the screening criteria by selecting the proper command in the *Study* menu option (Figure 12).

If a new study folder is created, then it becomes the current study folder. If the user decides to save screening criteria, SNIP Light saves them by default in the current study query folder. The user always has the option to choose a different folder outside the current study to save the file.

Study Area, Roads, and Years

The top portion of the *Screening* panel (Figure 13) allows the user to select the scope and analysis period using the following fields:

1. *Study Area.* Two reference options are available: *State* and *District*. Clicking on the *District* option opens a box displaying a list of available districts from which the user can select. Multiple choices are allowed.

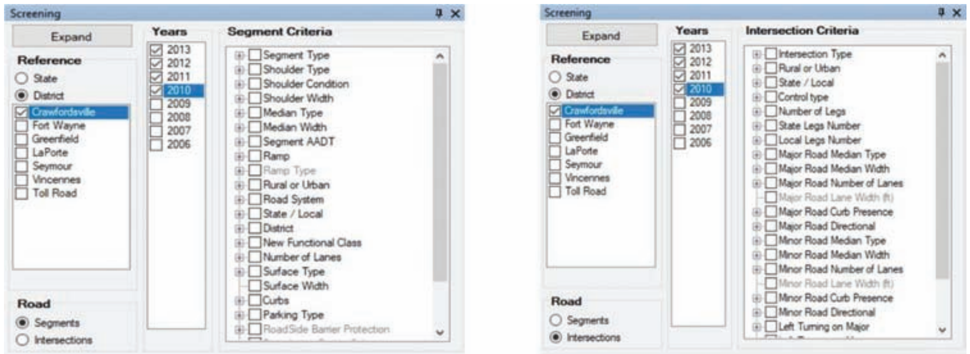


Figure 13 Selecting the scope and analysis period.

2. *Roads.* SNIP Light offers two different types of roads that can be analyzed: *Segments* and *Intersections*. Depending on which road type is selected, the appropriate criteria are displayed to the right as either the *Segment Criteria* or the *Intersection Criteria*.
3. *Years.* The years with crashes available in the database are presented. The user defines the study period by selecting the appropriate years. Typically, the study period includes consecutive years.

Road Selection Criteria

Depending on the type of road (*Segments* or *Intersections)* selected by the user in the *Screening* panel, the road criteria allow the user to select the specific road types, geometry conditions, and other characteristics under consideration in the study. Figure 14 illustrates the case where segments have been chosen by the user.

The selection criteria are presented as a list with all available characteristics for the chosen type of infrastructure element. Each characteristic node can be expanded to show the values that a specific characteristic can take. To expand the list, the user should click on the "+" sign. To collapse the list, the user should click on the "-" sign. The user can select multiple values by marking the boxes in front of the desired choices (Figure 14).

The *Expand/Collapse/Partial* button allows the user to expand, collapse or expand only the characteristics that has any selected value. The *Expand/Collapse/Partial* changes the action every time is clicked.

If the user selects or deselects an attribute, all values listed under that attribute are also selected or deselected. This action can be useful when the user wants to select (or deselect) most of the values of the attribute. Instead of checking many boxes, the user simply marks the attribute's box and then unchecks only a few undesired values of the characteristic.

Reset All Criteria in the *Criteria* option in the menu bar removes all the current criteria; thus, it allows one to start over in defining the screening criteria. After the user completes making all intended selections of road attributes, the user should select attributes of crashes to be selected if needed.

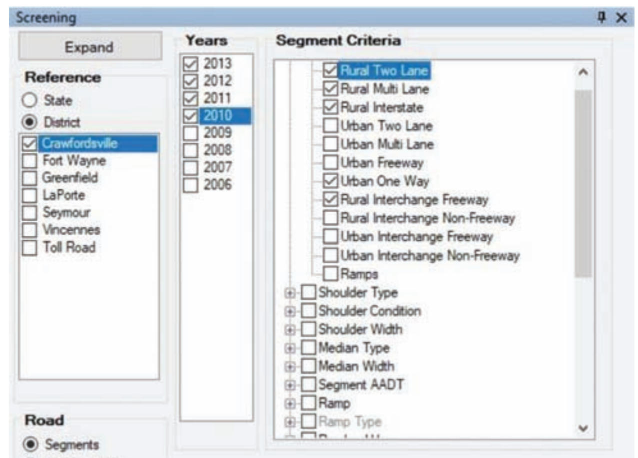


Figure 14 Element selection criteria.

Crash Selection Criteria

Study Crashes

The *Study Crashes* tab displays the lists of crash attributes that define the subset of crashes the user wants to use to estimate the road safety performance. For example, if the screening is to identify roads with a specific deficiency (for example, narrow road shoulders), the crashes potentially caused by this deficiency should be specified as study crashes (run-off-road crashes).

There are three groups of crash attributes in the selection lists: *Vehicle Criteria*, *Person Criteria*, and *Environmental Criteria* (Figure 15). It is important that the user understands how SNIP Light interprets the choices made in the selection lists. The following three rules apply:

Rule 1. Selecting multiple values of the same attribute is equivalent to selecting a crash that has any of the selected attribute values. It is equivalent to applying the logical operator "OR" in the crash criterion. For instance, selecting the *Daylight* and *Dawn/Dusk* values

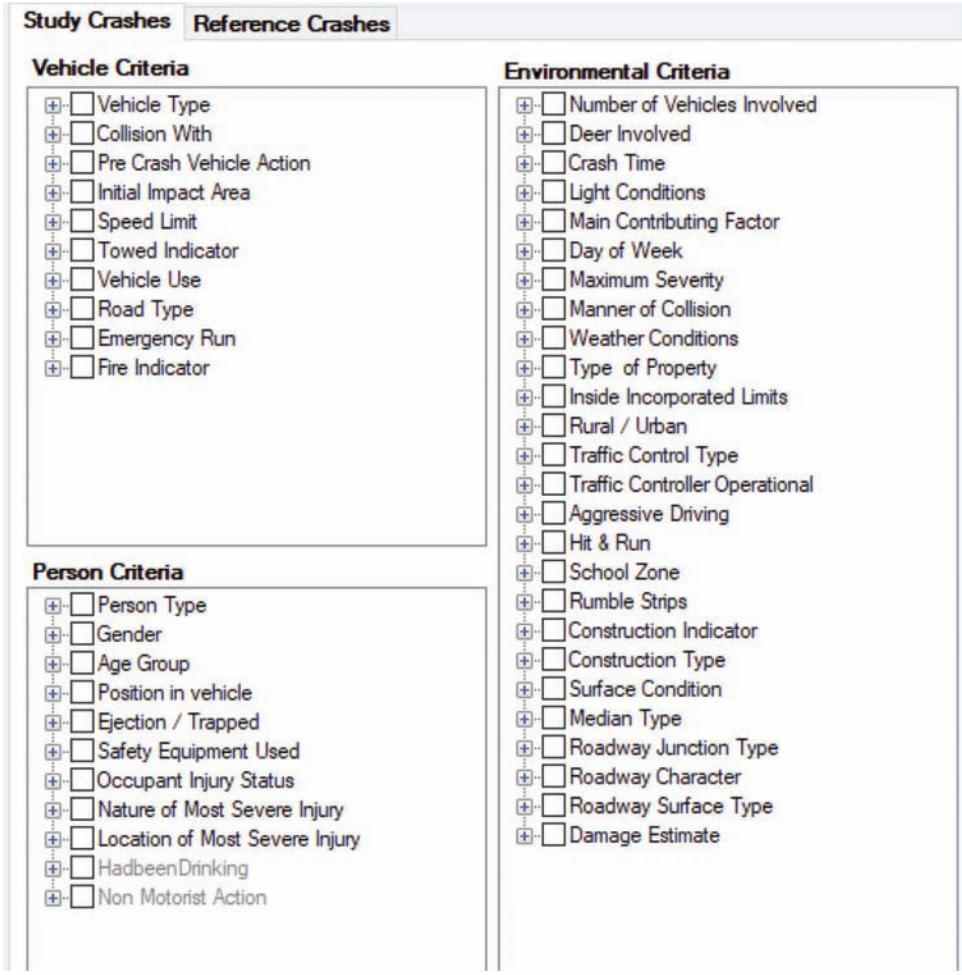


Figure 15 *Study Crashes* selection criteria.

of the *Light Conditions* results in selecting crashes that occurred during daylight OR dawn/dusk conditions:

Light Conditions = Daylight OR Light Conditions = Dawn/Dusk.

Rule 2. Selecting values of different attributes results in selecting a crash that has ALL the selected attribute values. It is equivalent to applying the logical operator "AND." For instance, selecting the *Daylight* value for attribute *Light Conditions* and selecting the *Friday* value for characteristic *Day of Week* leads to selecting crashes that happened on Fridays AND during daylight conditions:

Light Conditions = Daylight AND Day of Week = Friday.

Rule 3. If the user defines vehicle, person, and environmental criteria, then the crashes that meet all these criteria are selected. It is equivalent to using the logical operator "AND." For example, selecting the *Daylight* and *Dawn/Dusk* values of the *Light Conditions* attribute on the *Environmental Criteria* list and selecting the *Van* value of the *Vehicle Type* attribute on the *Vehicle Criteria* list results in selecting crashes that occurred during daylight OR dawn/dusk conditions AND involved a van:

(Light Conditions = Daylight OR Light Conditions = Dawn/Dusk) AND Vehicle Type = Van.

After the criteria for selection of the *Study Crashes* is defined, the user may display the *Reference Crashes* tables by pressing the *Reference Crashes* tab.

Reference Crashes

In some studies, the user may want to know the proportion of study crashes in another group of crashes, called *Reference Crashes*. Thus, to make this proportion meaningful, the reference crashes must include all the study crashes. For example, if right-angle injury crashes at an intersection are to be studied, then all injury crashes at that intersection may be used as a reference. In another example, all crashes on a road segment may be used as reference crashes for fatal crashes on that segment. SNIP Light calculates the proportion of study crashes in reference crashes on a road element and provides a statistic that indicates if the proportion is higher than the average proportion in the selected group of road elements.

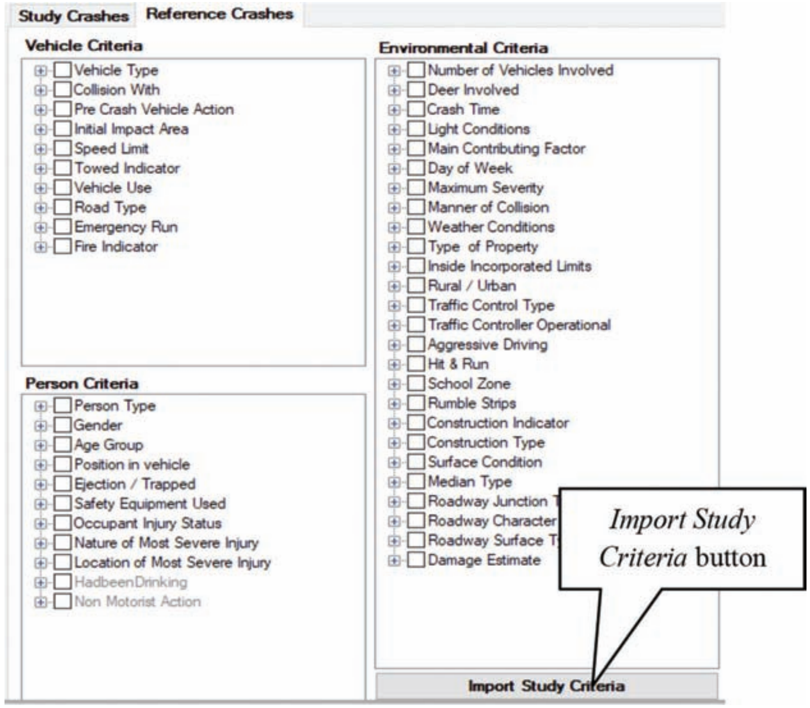


Figure 16 *Reference Crashes* selection criteria.

The reference crashes must include all the study crashes to make the proportion indicator meaningful. Although the user may define the study and reference crash criteria in any order, SNIP Light offers a more convenient option. The user should define the study crash criteria first. Then, the user may apply the same criteria to the reference crashes by clicking on the *Import Study Criteria* button (Figure 16). Clicking on the *Reference Crashes* tab reveals the same criteria applied to this group of crashes. In this case, both the selected groups of crashes would be identical and all the proportions equal 1. This result is allowed but not useful. The user should usually have more attributes selected for the study crash group than for the reference crash group.

It should be kept in mind that selecting ALL values of an attribute is equivalent to not using this attribute. The same effect is obtained by selecting no values of this attribute. Clicking twice on the box in the front of the attribute name removes all the value selections.

Saving and Retrieving Queries

The user can define new screening criteria for roads and crashes or can open saved criteria by using the file operation option in the top bar menu (Figure 17.) In SNIP Light, criteria files have the *.qry* extension (Figure 18). An opened criterion becomes current and it is presented to the user as selections on the attribute lists. The selection lists are in the collapsed mode except the attributes used in the screening criteria (Figure 19). The background color of a characteristic changes to light gray if it has some selected values. The user may then continue editing the opened criteria or, if all criteria have been already defined, may decide to execute them.

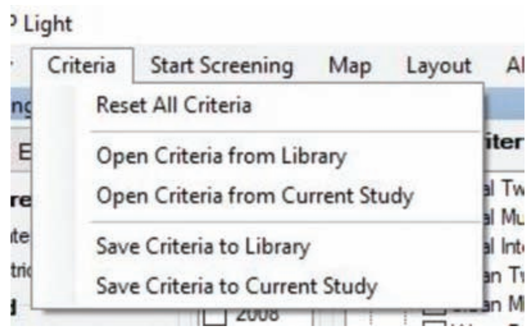


Figure 17 Options for saving, retrieving, or resetting criteria.

At any time throughout the process, the user can save the currently defined selections to a criteria file. To save criteria, the user clicks on the option that saves the criteria to the current study or the *Criteria Library* folder. It is important to note that the saved criteria file does not include any results.

The user can also reset the criteria (value selections on both lists of road and crash attributes) at any time by clicking the *Reset All Criteria* option.

Screening Execution and Results

Clicking the *Start Screening* option in the menu bar (Figure 20) executes the following steps:

- Verification of user selections for missing information.
- Extraction of elements satisfying road selection criteria.

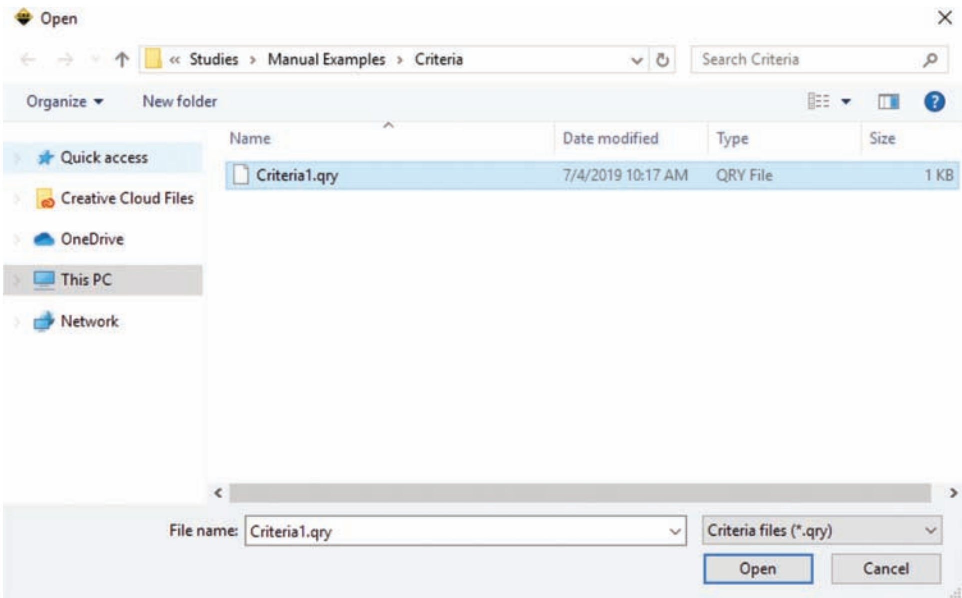


Figure 18 Folder with *.qry* files.

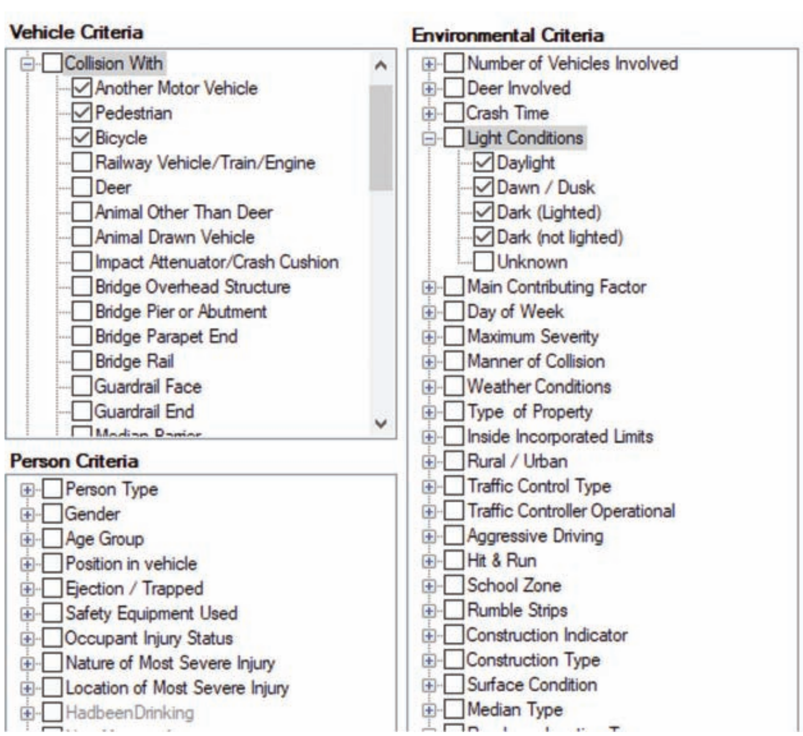


Figure 19 All branches collapsed, except for branches with selected options.

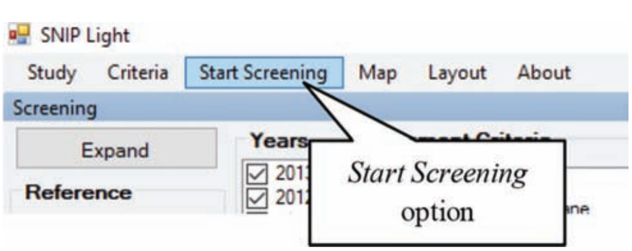


Figure 20 Selecting the *Start Screening* option.

- Extraction of study and reference crashes according to their respective selection criteria.
- Assigning the extracted crashes to the corresponding roads.
- Calculation of safety performance and statistical measures based on the assigned crashes.

If missing information is encountered by SNIP Light during the verification step, an error message including the needed actions is displayed. The user should select the proper tab, enter the missing information, and come to back to press the *Start Screening* option again.

The status of the screening process is displayed in the bottom left corner of the SNIP Light interface (Figure 21).

Once the road elements and crashes are extracted, SNIP Light proceeds with the screening operation. The results are displayed in the *Results Table* (Figure 22) and include detailed information about all the roads that satisfy the selection criteria in the study area.

Running the screening operation also calculates safety performance measures as well as the indicators for their statistical confidence (Figure 23). There are three basic safety performance measures that can be used to identify road elements (segments or intersections) with excessive number or severity of crashes: crash frequency, crash cost, and crash proportion. These measures are further explained in the Appendix. Two safety performance indices, the *Confidence F* and *Adjusted Index* I_A, are proposed to estimate the level of statistical confidence that the detected excessive number of crashes indicates a systematic issue rather than just the effect of random fluctuation.

Confidence F is the probability of a safety level equal to or better than the one observed during the period of analysis if the expected safety level in the long run is average for the type of location and under the given exposure. The higher the confidence of F, the stronger is the evidence that the location experiences a real safety problem. Values of F = 0.90 and higher are typically used.

Adjusted Index I_A is the difference between the safety observed during the period of analysis and the safety expected given the location type and exposure, divided by the standard deviation of the difference estimate on an equivalent normal distribution. It is a simplified measure of Confidence F. Values of $I_A = 1.5$ and higher provide sufficient evidence that the location is experiencing a real safety problem.

By clicking the *Export Results* button, the user can save the results to a .csv file. The default folder to which results are saved is the *Criteria* subfolder of the current study.

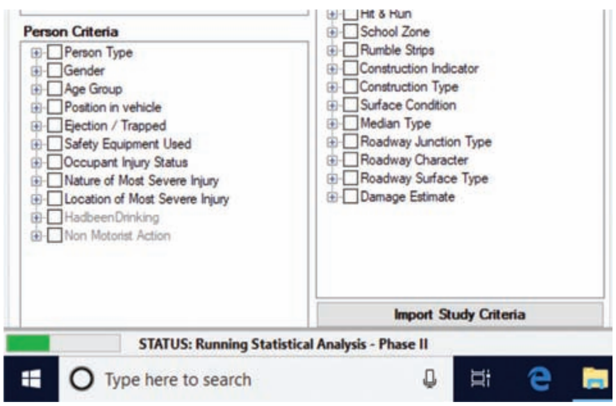


Figure 21 Status of the screening process.

VISUALIZATION

Screening results can be visualized using the *Visualization Map* in SNIP Light (Figure 24). Moreover, the display of how the results are presented is controlled using the *Visualization Settings*. Although SNIP Light is intended to function as a standalone tool, the software provides an option to export the results to the KML file format that can be used in tools such as Google Earth, Marble, or ArcGIS. The various visualization functionalities are described in this chapter.

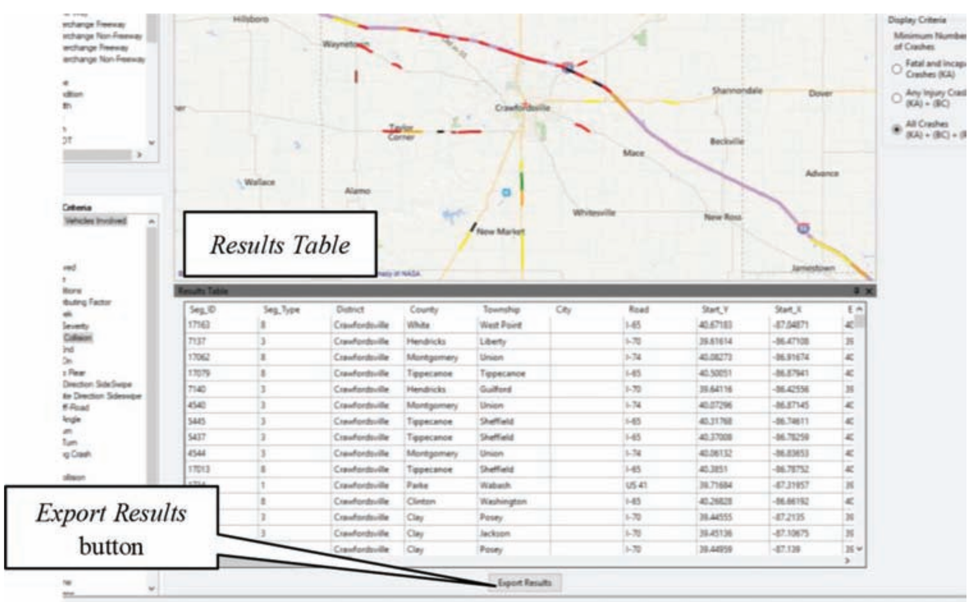
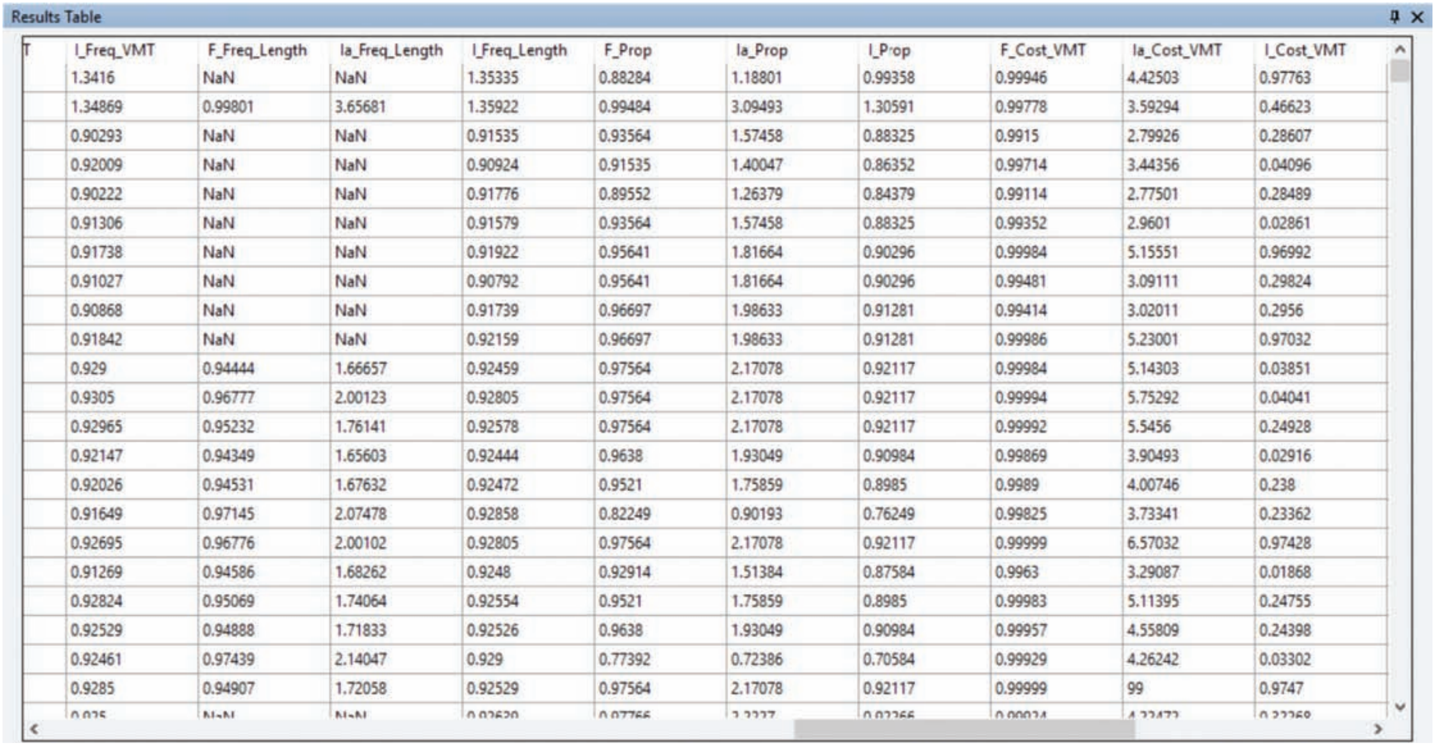


Figure 22 Output from the *Results Table.*



Results Table

I_Freq_VMT	F_Freq_Length	Ia_Freq_Length	I_Freq_Length	F_Prop	Ia_Prop	I_Prop	F_Cost_VMT	Ia_Cost_VMT	I_Cost_VMT
1.3416	NaN	NaN	1.35335	0.88284	1.18801	0.99358	0.99946	4.42503	0.97763
1.34869	0.99801	3.65681	1.35922	0.99484	3.09493	1.30591	0.99778	3.59294	0.46623
0.90293	NaN	NaN	0.91535	0.93564	1.57458	0.88325	0.9915	2.79926	0.28607
0.92009	NaN	NaN	0.90924	0.91535	1.40047	0.86352	0.99714	3.44356	0.04096
0.90222	NaN	NaN	0.91776	0.89552	1.26379	0.84379	0.99114	2.77501	0.28489
0.91306	NaN	NaN	0.91579	0.93564	1.57458	0.88325	0.99352	2.9601	0.02861
0.91738	NaN	NaN	0.91922	0.95641	1.81664	0.90296	0.99984	5.15551	0.96992
0.91027	NaN	NaN	0.90792	0.95641	1.81664	0.90296	0.99481	3.09111	0.29824
0.90868	NaN	NaN	0.91739	0.96697	1.98633	0.91281	0.99414	3.02011	0.2956
0.91842	NaN	NaN	0.92159	0.96697	1.98633	0.91281	0.99986	5.23001	0.97032
0.929	0.94444	1.66657	0.92459	0.97564	2.17078	0.92117	0.99984	5.14303	0.03851
0.9305	0.96777	2.00123	0.92805	0.97564	2.17078	0.92117	0.99994	5.75292	0.04041
0.92965	0.95232	1.76141	0.92578	0.97564	2.17078	0.92117	0.99992	5.5456	0.24928
0.92147	0.94349	1.65603	0.92444	0.9638	1.93049	0.90984	0.99869	3.90493	0.02916
0.92026	0.94531	1.67632	0.92472	0.9521	1.75859	0.8985	0.9989	4.00746	0.238
0.91649	0.97145	2.07478	0.92858	0.82249	0.90193	0.76249	0.99825	3.73341	0.23362
0.92695	0.96776	2.00102	0.92805	0.97564	2.17078	0.92117	0.99999	6.57032	0.97428
0.91269	0.94586	1.68262	0.9248	0.92914	1.51384	0.87584	0.9963	3.29087	0.01868
0.92824	0.95069	1.74064	0.92554	0.9521	1.75859	0.8985	0.99983	5.11395	0.24755
0.92529	0.94888	1.71833	0.92526	0.9638	1.93049	0.90984	0.99957	4.55809	0.24398
0.92461	0.97439	2.14047	0.929	0.77392	0.72386	0.70584	0.99929	4.26242	0.03302
0.9285	0.94907	1.72058	0.92529	0.97564	2.17078	0.92117	0.99999	99	0.9747

Figure 23 More output from the *Results Table.*

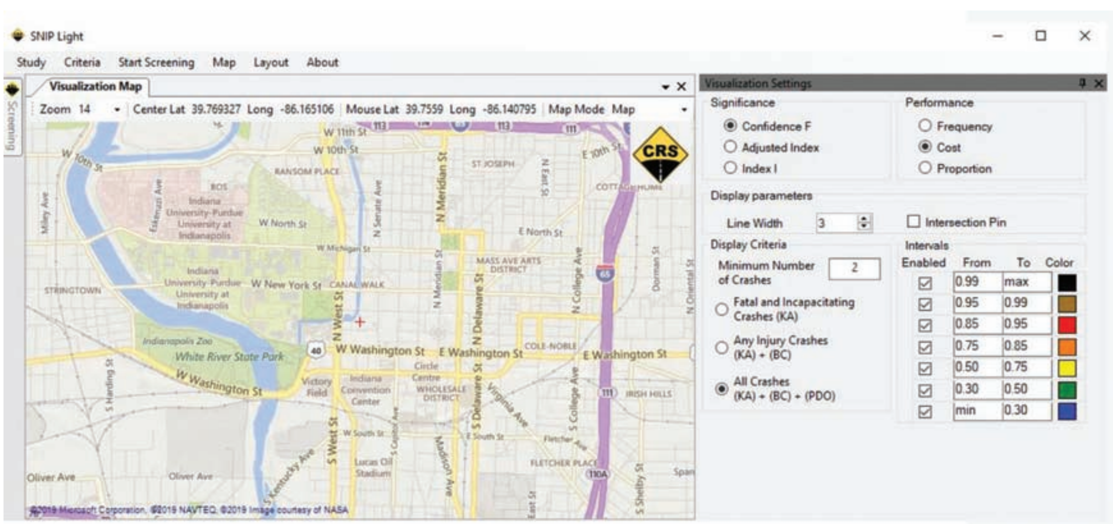


Figure 24 SNIP Light *Visualization Map* and *Visualization Settings.*

Visualization Settings

Visualization Settings (Figure 25) includes settings that determine how the results are displayed on the *Visualization Map*. The *Significance* subcomponent allows users to specify the safety performance index (*Confidence F*, *Adjusted Index* I_A, etc.) that they wish to use when displaying the results for the road elements on the map. Note that the color-coded *Intervals* automatically adjust depending upon which safety performance index is selected. Individual intervals may be changed by modifying the values in the *From* and *To* boxes or disabled by unselecting the adjacent *Enabled* box. The user also has the option to select the desired safety performance measure under the *Performance* subcomponent based upon either crash frequency, crash cost, or crash proportion.

The minimum number of crashes is an additional and important criterion of considering a road element as a high-crash road. This criterion addresses the

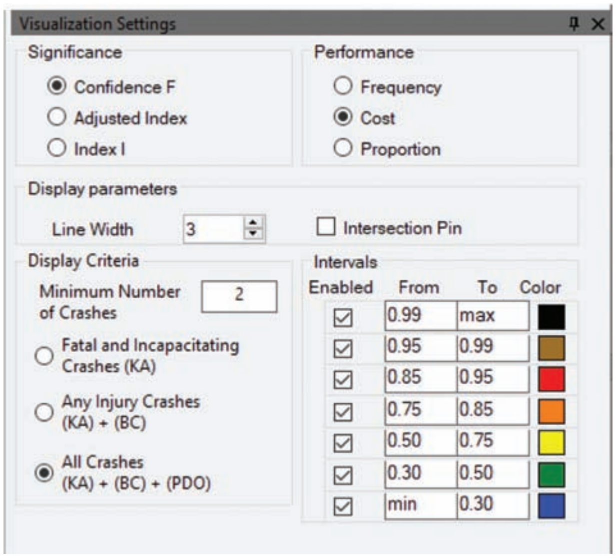


Figure 25 *Visualization Settings.*

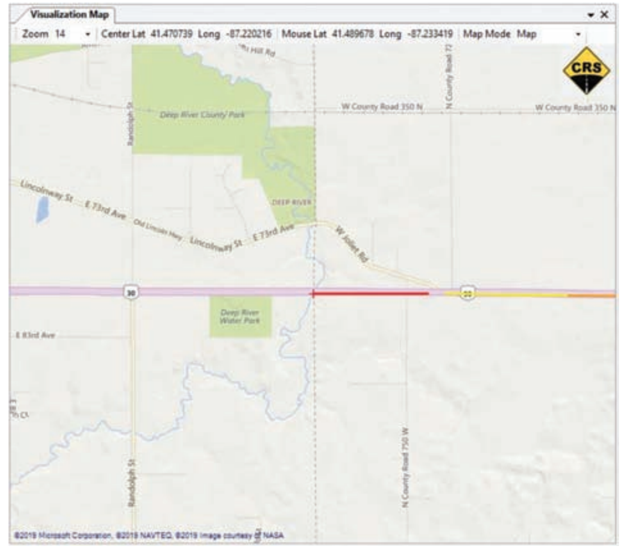


Figure 26 *Visualization Map.*

limitation of the F statistic for roads with very low crash frequency, such as low-volume county roads. In extreme cases, a segment with zero crashes can have a value of F higher than the threshold for high-crash locations. This result may be correct from the statistical point of view because zero may be a highly likely outcome for low-volume roads. On the other hand, selecting such a road as a high-crash location is incorrect from the safety management point of view. Under *Display Criteria*, the user may choose to select only the road elements meeting or exceeding the designated number of crashes. Crash types selectable by the user include *Fatal and Incapacitating Crashes (KA)*, *Any Injury Crashes (KA) + (BC)*, and *All Crashes (KA) + (BC) + (PDO)*.

Finally, the *Display Parameters* allow the user to change the width of the displayed lines or choose whether a pin is placed at the location of an intersection.

Visualization Map

Visualization Map (Figure 26) allows the user to display road elements based upon the chosen visualization options. The zoom level can be adjusted under the *Zoom* settings, which range from 7 (minimum zoom) to 20 (maximum zoom). The user may pan across the map by clicking, holding, and dragging the cursor across the map. Finally, *Map Mode* adjusts the type of background map that is displayed and includes the following three options: *Map Bing* (basic street map), *Satellite Bing* (satellite imagery), and *Hybrid Bing* (combination of satellite imagery and street map).

If the user desires to locate a specific road element on the map, they may do so by clicking the road element in *Results Table* (Figure 27); likewise, clicking on a road element in the *Visualization Map* automatically highlights the selected road element in the *Results Table*. An additional box (*Element Information*) appears, allowing the user to view element attributes such as the name, starting and ending coordinates, district, county, township, and city. The computed safety performance indices are also shown in a tabular format.

Creating KML File

Clicking on the *Export to KML* button under the *Map* option of the menu bar creates and saves KML files in the study folder of the study, with the same name as the input files that were processed but which add an indication of the selected safety performance measure.

KML is the file format used to display geographic data in a GIS browser, such as Google Earth, Marble, or ArcGIS Explorer Desktop. To display the results, Google Earth or ArcGIS Explorer Desktop must be installed. If neither is currently installed, Google Earth can be downloaded at no charge at http://www.google.com/earth/index.html. You can download ArcGIS Explorer Desktop at no charge at http://www.esri.com/software/arcgis/explorer/download

Upon opening (double-clicking), Google Earth is called automatically to open the SNIP Light-created KML file. Google Earth displays the full extent of the KML file with all the elements shown according to the user's settings. For zooming in, just double-click on the zone you want to zoom. The zoom level also can be controlled with the mouse wheel. It is important to note that if the KML file reaches the maximum number of elements Google Earth can display in a single view, then that subset of elements is not shown. If this situation happens, you need only to zoom in to display fewer elements at the same time.

By clicking on one of the displayed elements, a pop-up window with the calculated indexes and confidence values and the element ID is shown (Figure 28).

You will find more information about using Google Earth at http://www.google.com/earth/learn/.

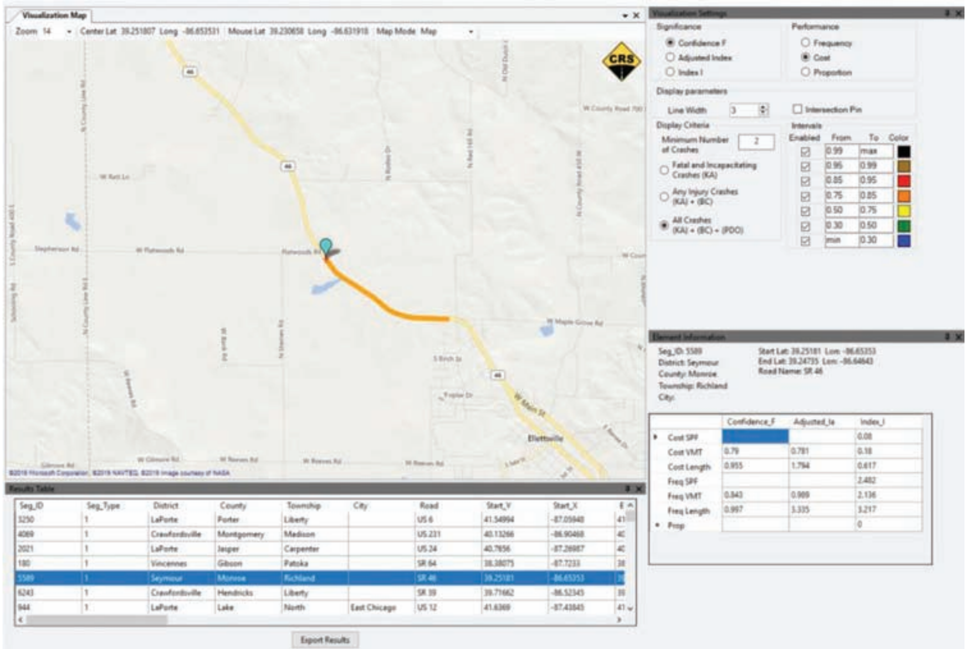


Figure 27 Selecting a road segment in the *Visualization Map*.

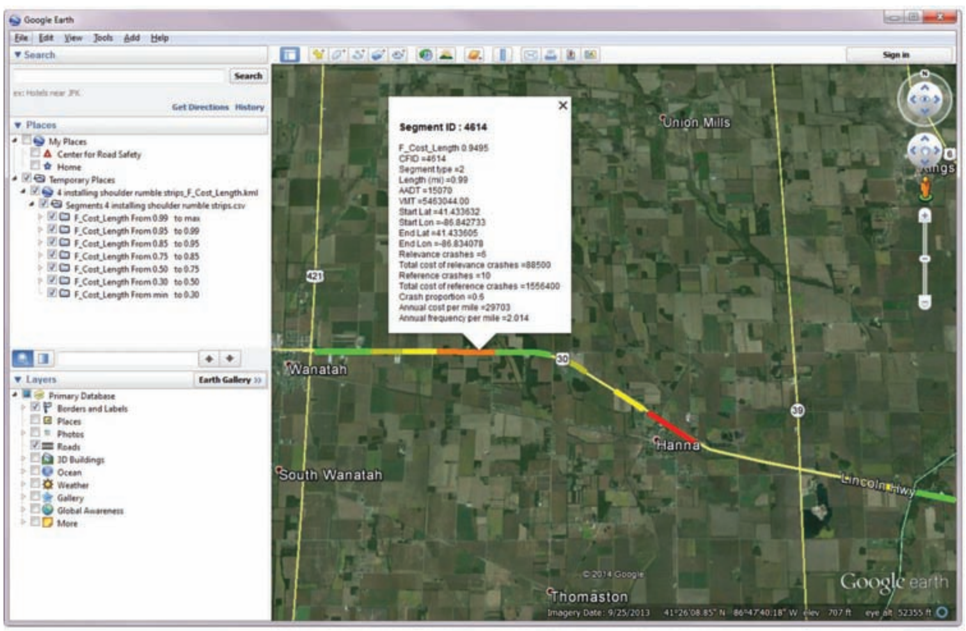


Figure 28 KML file displayed in Google Earth.

EXAMPLE: SCREENING

This chapter illustrates the features of SNIP Light, including the screening and visualization components.

Screening

The SNIP Light screening tool is used to select roads that meet user-specified road criteria, select crashes on those roads that meet user-specified crash criteria, and then calculate the safety performance measures and other statistics for the resulting combination of roads and crashes. The produced tables of roads with corresponding statistics are saved, and these results may be displayed using the visualization tools.

In the present example, SNIP Light is used to screen and visualize road segments on rural two-lane Indiana roads. The first step is to start the SNIP Light program. SNIP Light initially checks the database for any leftover tables from previous analyses, and if any are found,

Figure 29 Creating a new study folder.

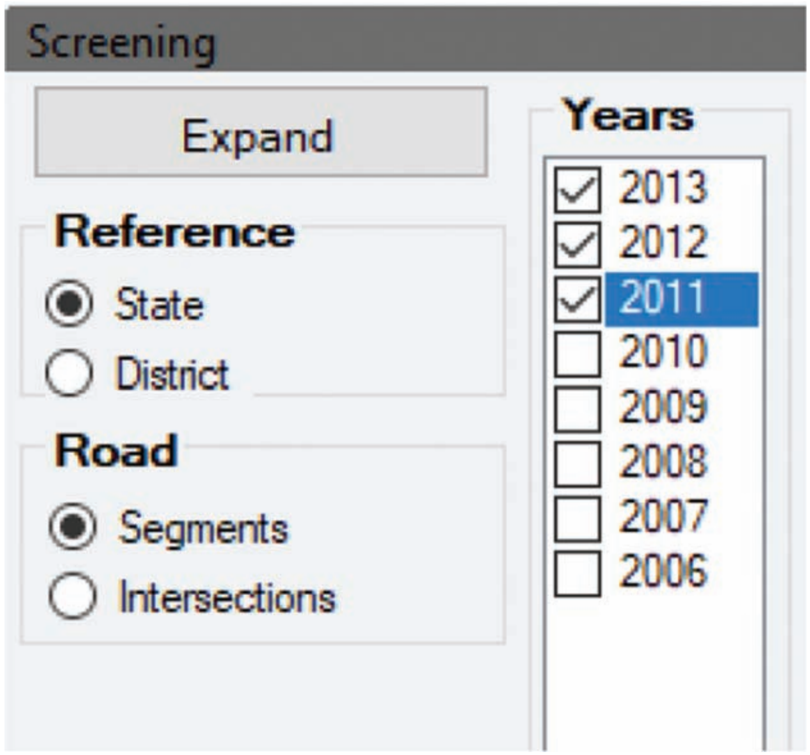


Figure 30 Selecting scope and analysis period for segments.

such tables are purged in preparation for the new query. Then, the user creates a study folder by clicking the menu option *Study/Create New Study Folder* (Figure 29). In this example, the name *Manual Examples* is used.

The example query is executed for Indiana road segments (*Scope*) over the period 2011–2013 *(Years)* (see Figure 30 for the selections made in the *Screening* component).

The particular criteria for this study are rural two lane roads with shoulders narrower than six feet (which may present potential candidates for shoulder widening). To avoid segments crossing populated areas, the non-existence of curbs is also included as part of the element selection criteria.

To enter the above query conditions, the user makes the following selections under the *Segment Criteria* (Figure 31).

The crashes that can be linked with the narrow shoulders are single-vehicle and run-off-road crashes. To calculate the crash proportions, the number of single-vehicle and run-off-road (*Study Crashes*) are related to the number of all crashes on the segment (*Reference Crashes*).

The user should proceed to the *Environmental Criteria* under the *Study Crashes* tab and select option *1* in the *Number of Vehicles Involved* group and the *Ran Off-Road* option in the *Manner of Collision* group (Figure 32).

Since the reference crashes are all crashes, there should be no selections under the *Reference Crashes* tab (Figure 33).

Once the appropriate segment and crashes selections have been made, the user can execute the calculation of the crash frequencies, rates, proportions, costs, and other statistics for the selected segments. The user should click on the *Start Screening* menu option. The final results are displayed in the *Results Table* (Figure 34).

The table with the results should be exported as a .csv file by clicking the *Export Results* button that is

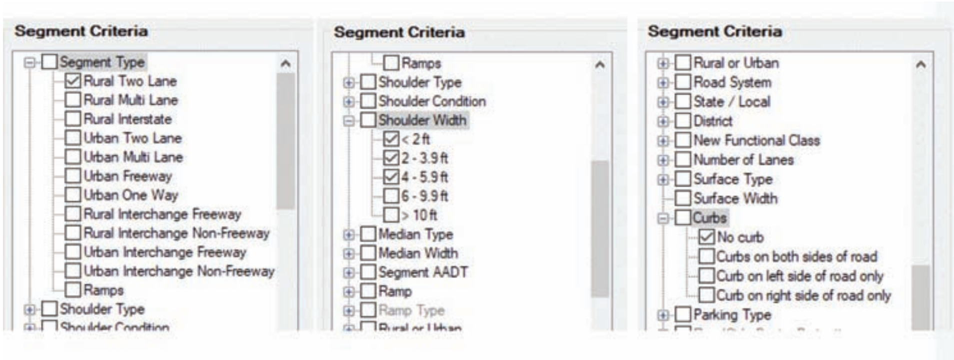


Figure 31 Segment Type = Rural Two Lane and Shoulder Width ≤6 ft and with no curb present.

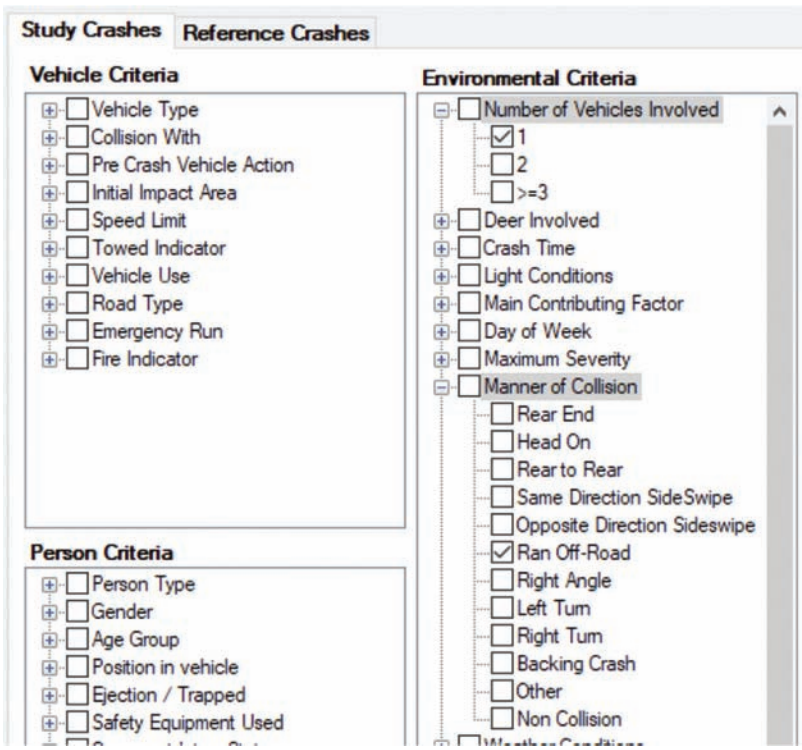


Figure 32 Choosing the study crashes.

located under to the *Results* table. When the button is clicked, the file is saved by default to the current study query folder; in our case, it the *Manual Examples/ Criteria* folder (Figure 35).

The user may wish to save criteria for future use. To save such criteria, the user must click the menu option *Criteria/Save Criteria to Current Study*, opening a file save dialog that by default prompts the current study folder (*Manual Examples/Criteria* folder). It should be noted that although the results of screening (table) are exported as a .csv file, the criteria definition is saved in a file with extension *.qry* (Figure 36.) Criteria definitions can be saved at any time, even before all the screening criteria are selected, which means that incomplete criteria will be saved and then restored upon reopening. This feature is useful when the user wants to stop and resume later.

Visualization

In this example, the values used in the *Visualization Settings* are set as follows (Figure 37).

The screening results of the high-crash, two-lane rural segments with narrow shoulders (less than six feet wide) are visualized at three different scales using the *Visualization Map*. Figure 38 shows the screening results across Indiana, while Figure 39 shows the segments in and around Spencer County in Southern Indiana. Finally, Figure 40 shows segments near Troy, IN.

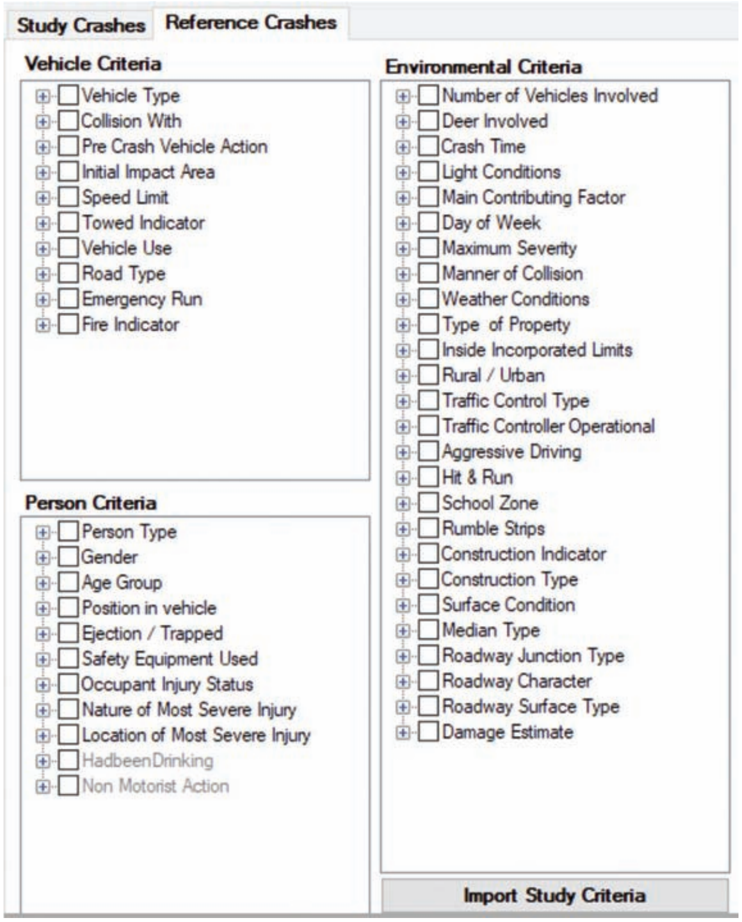
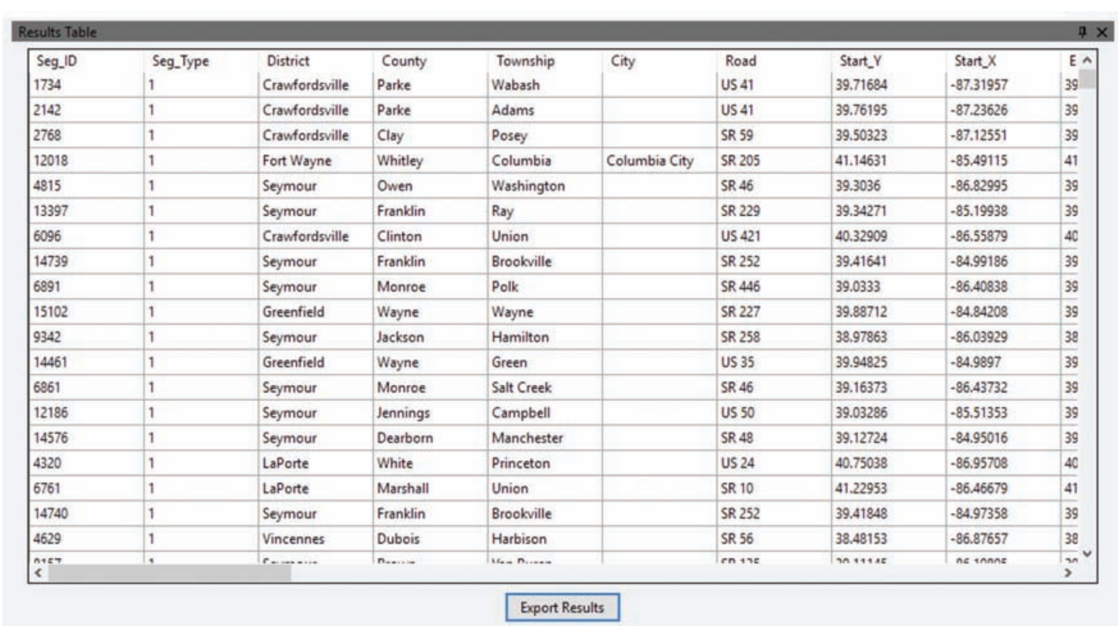


Figure 33 Selection tree for the reference crashes.



Results Table

Seg_ID	Seg_Type	District	County	Township	City	Road	Start_Y	Start_X	E
1734	1	Crawfordsville	Parke	Wabash		US 41	39.71684	-87.31957	39
2142	1	Crawfordsville	Parke	Adams		US 41	39.76195	-87.23626	39
2768	1	Crawfordsville	Clay	Posey		SR 59	39.50323	-87.12551	39
12018	1	Fort Wayne	Whitley	Columbia	Columbia City	SR 205	41.14631	-85.49115	41
4815	1	Seymour	Owen	Washington		SR 46	39.3036	-86.82995	39
13397	1	Seymour	Franklin	Ray		SR 229	39.34271	-85.19938	39
6096	1	Crawfordsville	Clinton	Union		US 421	40.32909	-86.55879	40
14739	1	Seymour	Franklin	Brookville		SR 252	39.41641	-84.99186	39
6891	1	Seymour	Monroe	Polk		SR 446	39.0333	-86.40838	39
15102	1	Greenfield	Wayne	Wayne		SR 227	39.88712	-84.84208	39
9342	1	Seymour	Jackson	Hamilton		SR 258	38.97863	-86.03929	38
14461	1	Greenfield	Wayne	Green		US 35	39.94825	-84.9897	39
6861	1	Seymour	Monroe	Salt Creek		SR 46	39.16373	-86.43732	39
12186	1	Seymour	Jennings	Campbell		US 50	39.03286	-85.51353	39
14576	1	Seymour	Dearborn	Manchester		SR 48	39.12724	-84.95016	39
4320	1	LaPorte	White	Princeton		US 24	40.75038	-86.95708	40
6761	1	LaPorte	Marshall	Union		SR 10	41.22953	-86.46679	41
14740	1	Seymour	Franklin	Brookville		SR 252	39.41848	-84.97358	39
4629	1	Vincennes	Dubois	Harbison		SR 56	38.48153	-86.87657	38

Export Results

Figure 34 Final results table.

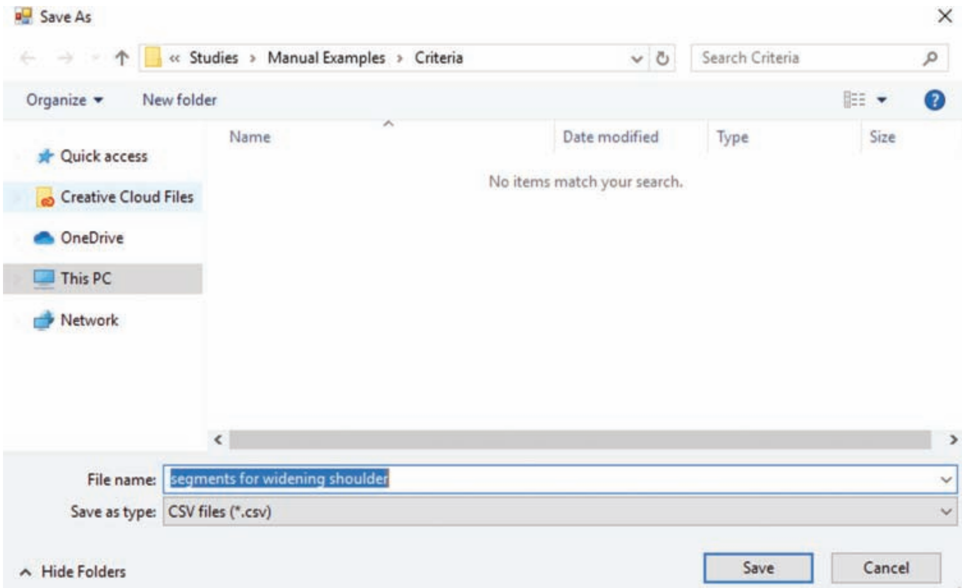


Figure 35 Exporting results to current study criteria folder.

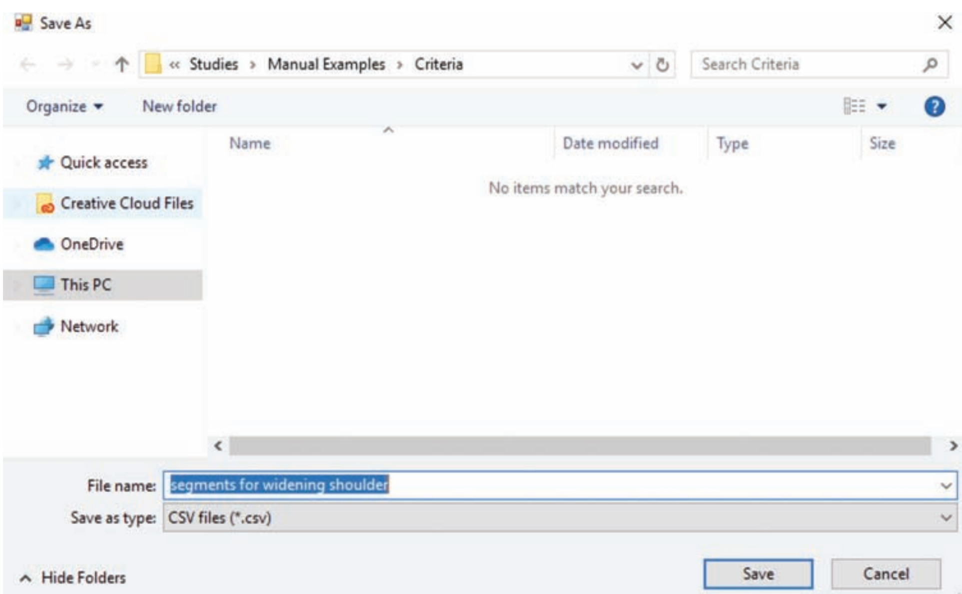


Figure 36 Saving criteria definition to current study criteria folder.

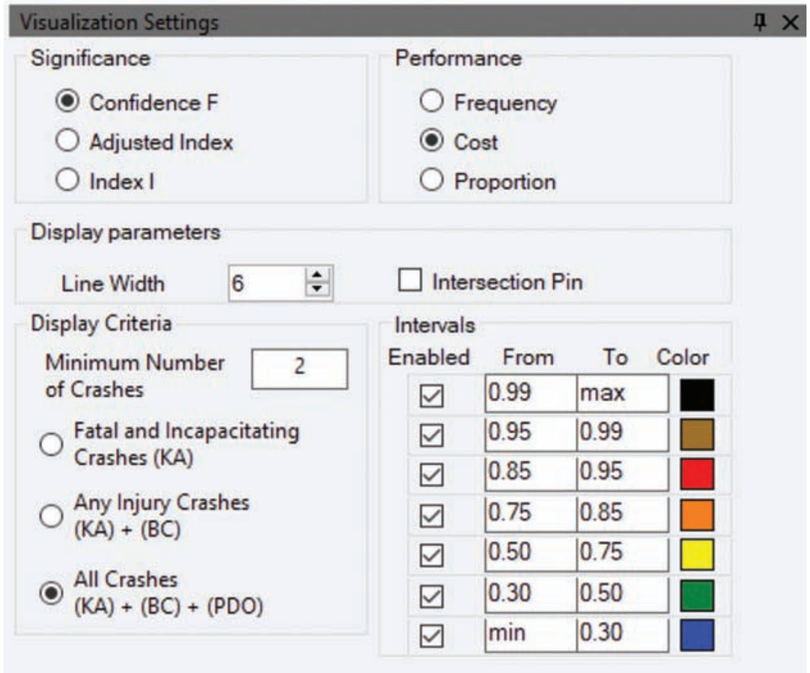


Figure 37 Visualization tool settings.

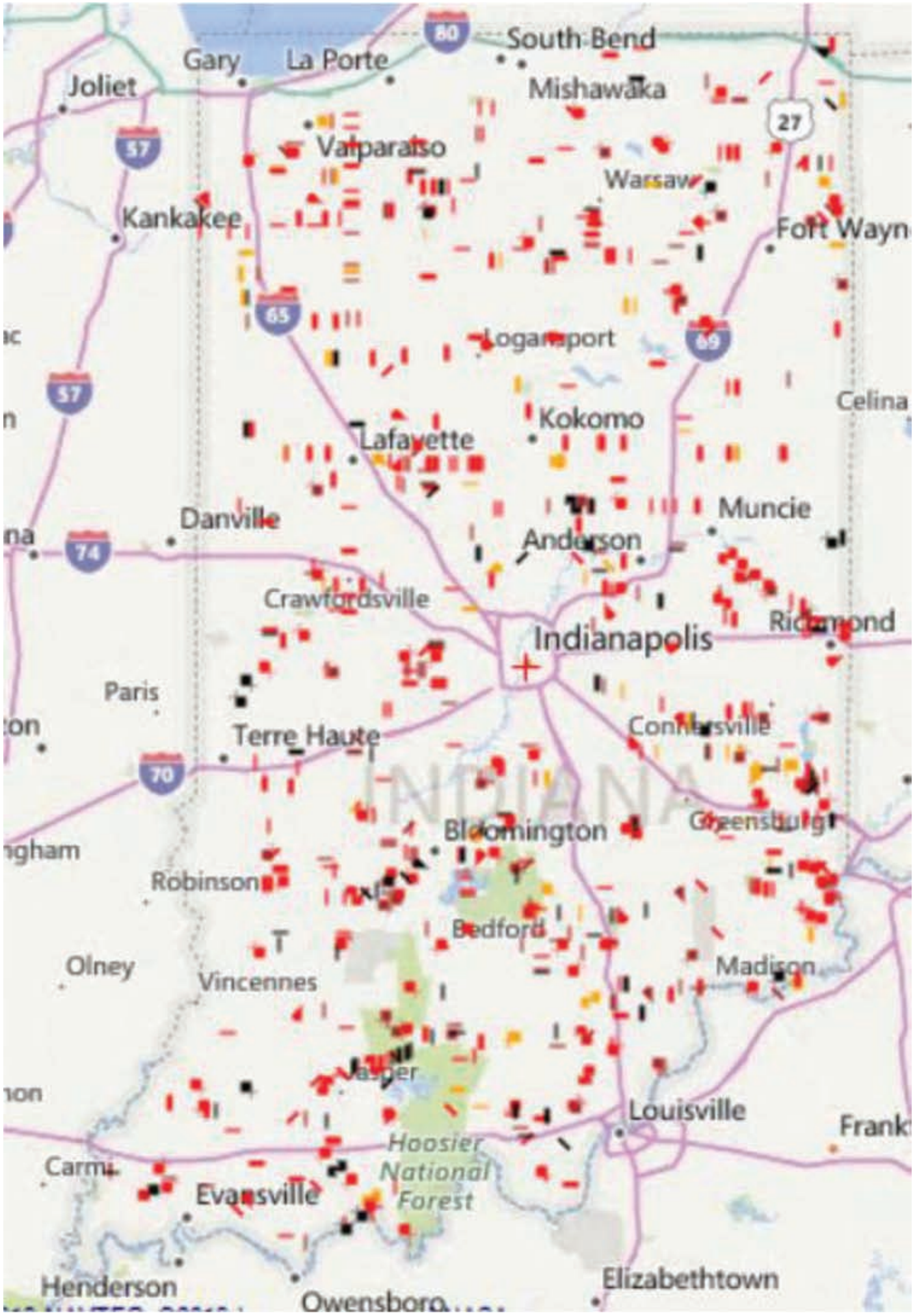


Figure 38 High-crash rural two-lane segments with narrow shoulders in Indiana.

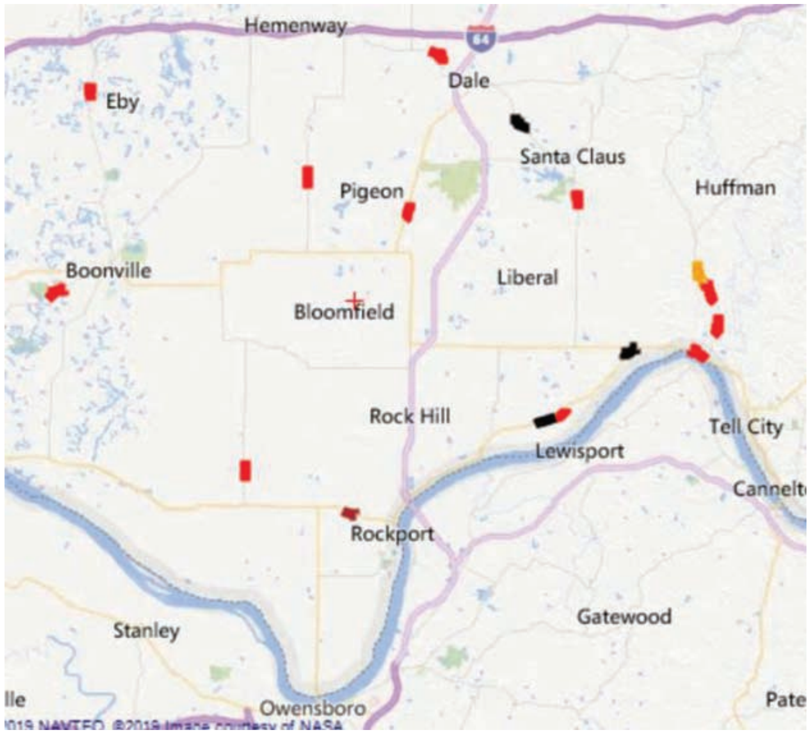


Figure 39 High-crash rural two-lane segments with narrow shoulders in and around Spencer County.

Figure 40 High-crash rural two-lane segments with narrow shoulders on SR 66 and SR 545 near Troy, Indiana.

REFERENCE

Tarko, A. P., Li, M., Romero, M., & Thomaz, J. (2014). *A systematic approach to identifying traffic safety needs and intervention programs for Indiana: Volume II—SNIP2 user manual* (Joint Transportation Research Program Publication No. FHWA/IN/JTRP-2014/04). West Lafayette, IN: Purdue University. https://doi.org/10.5703/1288284315498

APPENDIX: SCREENING CONCEPTS

Identification Method

The SNIP safety identification method is designed to fulfill the agency's need for both systematically screening the road network and investigating identified safety issues. The following components are necessary for the identification task:

1. study area, type of screened roads, and screening criteria;
2. safety performance measures;
3. exposure measures; and
4. problem significance measures.

Study Area, Road Element, and Screening Criteria

Study Area. The study area is the geographic area, or part of the road network, in which the user wishes to conduct the screening. In the safety screening tool, three levels of study areas are available: state, county, and city/town. The study area can be limited to a particular county/township or multiple counties/townships.

Road Element and Type. A road element is the smallest part of the road to be screened. In general, there are two types of road elements: segments and intersections. Segments include stretches of road between at-grade intersections, freeway ramps, and bridges. A study area defines a group of road elements in the study area the user wishes to screen.

Screening Criteria. After defining the study area and type of elements, it is important to define the screening criteria. The screening criteria include road criteria and crash criteria defined in the *Screening* tab.

Screening Crash Criteria

Crash criteria allow focus screening on a specific type of crash. For example, an agency might be interested in fatal or incapacitating injury types of crashes or in nighttime crashes. For example, focusing screening on alcohol-related crashes identifies road elements for an enforcement purpose. The crash screening criteria involve values of crash attributes desired in selected crashes.

Screening Road Criteria

Choosing candidate roads for a specific road improvement program should focus on roads with relevant geometry conditions that experience excessive numbers of relevant types of crashes. For example, selection of road segments that may be considered for median barriers should focus on segments with narrow medians an excessive number of cross-over crashes.

Safety Performance Measures

After a user defines the study area, road type, and screening criteria, it is important to select the ***safety performance measure*** out of the ones available in SNIP Light:

- *Crash Frequency.* Crash frequency is the annual count of all crashes or a specific subset of crashes as determined by the user.
- *Crash Cost.* Crash cost is the average total cost of the annual number of all crashes or a specific subset of crashes as determined by the user.
- *Crash Rate.* The crash rate is the crash frequency divided by the exposure. The exposure measure depends on the type of road element.
- *Crash Proportion.* The proportion is the ratio of study crashes to reference crashes (e.g., the proportion of rear-end crashes to the total number of crashes).

Exposure Measures

Exposure is used to calculate that crash rate as the ratio of the crash count and the exposure. A specific measure of exposure depends the type of road and its value is averaged over the analyzed period. The example measures of exposure include AADT for intersections, and VMT and road length for road segments (see Table 1).

Statistical Evaluation

Notation

Basic variables:
c = number of studied crashes during the analysis period,
w = cost of crashes on road element during the analysis period,
m = estimate of the expected crashes or cost during the analysis period and for the exposure,
v = variance of the m estimate.

TABLE 1
Example Exposure Measures for Different Road Elements (not all available in SNIP)

Element of Investigation	Exposure
County	Population, VMT, Registered Vehicle, Area
City	Population, VMT, Registered Vehicle, Area
Township	Population, VMT, Registered Vehicle, Area
State Segment	Link Volume (ADT, VMT), Length
State-State Intersection	Total Approach Volume (ADT, VMT)
State-Local Intersection	State (major) Road Volume
Ramp	Link Volume (ADT, VMT), Length
Bridge	Link Volume (ADT, VMT), Length

Variables needed to calculate w, m, and v:

e = exposure on road element (AADT, length L, VMT during the analysis period),
r = number of reference crashes on road element during the analysis period,
u = unit crash cost,
N = number of road elements in the group of roads,
S = total number of studied crashes in the group of roads during the analysis period,
R = total number of reference crashes in the group of roads during the analysis period,
E = total exposure in the group of roads during the analysis period,
W = total cost of crashes in the group of roads during the analysis period,
sub k = severity level k.

Two distributions are used to evaluate the statistical significance of the safety problem: Gamma distribution and Negative Binomial Distribution. Gamma distribution has parameters α and β, such that mean is $\alpha\beta$, and variance is $\alpha\beta^2$ and density: $f(\lambda)=\frac{1}{\beta^{\alpha}\Gamma(\alpha)}\lambda^{\alpha-1}$ $\exp(-\lambda/\beta)$. The Negative Binomial distribution can be viewed as a mixture of Poisson distributions with the Poisson parameter λ distributed according to the Gamma. The parameters of Negative Binomial the distributions are inherited from the Gamma. The mean is $\alpha\beta$, and the variance is $(\alpha\beta+\alpha\beta^2)$, and density: $P(c)=\frac{\Gamma(\alpha+c)}{\Gamma(\alpha)c!}\left(\frac{\beta}{1+\beta}\right)^{c}\left(\frac{1}{1+\beta}\right)^{\alpha}$. The MS Excel parameterization of the Gamma distribution is as introduced above while the Negative Binomial distribution uses parameters: $r = \alpha+1$ and $p = 1/(1+\beta)$.

Concepts

Let c be the recorded number of crashes of a certain type used to evaluate a road element's safety during the analysis period. An agency wants to know if this number of crashes indicates that there is a safety problem on the considered road element. The safety problem is confirmed if the number of crashes c is significantly higher than the number expected for the exposure e on the considered road element.

There are a number of exposure measures (e.g., the traffic volume entering an intersection or the vehicle-miles travelled along a road segment). The number of crashes m expected for the exposure is the product of the average crash rate S/E in the considered group of roads and the exposure e on the studied road element.

The segment length can be used if the traffic volume is missing. This option is reserved for local roads that typically do not have traffic volumes measured. The number of crashes m expected for the exposure is the product of the average crash density in the group of roads and the length of the studied road element.

Checking if the considered crashes constitute too large of a proportion of a wider category of crashes (reference crashes) is another important safety test. For example, all intersection crashes may serve as reference crashes for a proportion of right-angle crashes. The number of crashes m expected in this case is the product of the reference proportion S/R (average proportion of intersection crashes that are right-angle crashes in the group of considered intersections) and the reference crashes r at the studied intersection.

Crash Frequency (Count)

The first step is to estimate the crash rate S/E in the considered group of roads, where S is the total number of considered crashes in the group of roads and E is the total exposure in that group. The expected number of crashes m on the considered road element is the product of the exposure e on this road element and the crash rate S/E in the road group: $m = e \cdot S/E$. The variance of this estimate is caused by the varying number of S crashes scaled with e/E. The estimate m is distributed according to the Gamma distribution $G(\alpha = S, \beta = e/E)$ with the variance $v = \alpha\beta^2 = S(e/E)^2$.

The test of whether the actual number of crashes c is larger than the number m expected for the exposure e is done through checking whether the crash count c is sufficiently far into the right tail of the distribution of the crash counts around the uncertain Gamma-distributed mean m. This test calls for using the Gamma-mixture of Poisson distributions, thus for using the Negative Binomial distribution $NB(\alpha = S, \beta = e/E)$. The crash count c indicates that the current safety on the road element is worse than expected for the exposure if the cumulative distribution NB at c takes a high value (i.e., higher than 0.95). This value is called *Confidence* F_{CF}—the probabilistic measure which varies between 0 and 1.

Using the Excel notation, the calculation of confidence F is:

$F_{CF} = \Sigma_{x=0..c}$ NegBinom.Dist(x, $r = \alpha+1$, $p = 1/(1+\beta)$) = Beta.Dist($1/(1+\beta)$, α, c+1, 1), or more specifically: F_{CF} = Beta.Dist(1/(1+e/E), S, c+1,1)

Another method of statistical significance is the *Index* I_{CF}, the quality control measure that indicates the difference between the estimated safety and the target safety (expected for the exposure) measured with the standard deviation of the difference estimate. A high value of index I, for example, higher than 2, indicates a safety problem:

$$I_{CF}=\frac{c-m}{\sqrt{v}}.$$

The value I_{CF} may be questionable and inconsistent with the significance F_{CF} if the underlying distribution is strongly skewed to the right (Gamma and Negative Binomial distributions tend to be skewed if the expected value is close to zero). It may lead to an I-based ranking that is inconsistent with the F-based ranking. Since agencies may prefer using index I_{CF}, an adjusted I_{AF} value is proposed that is determined based on the calculated F_{CF} value. It uses an "equivalent" normal distribution which preserves the original m, c, and F_{CF} values. The equivalent parameter σ_e needs to be calculated.

Given that the standardized cumulative normal distribution can be closely and conveniently approximated with the logistic function:

$$\Phi_1(c) \cong 1 - \frac{1}{1+\exp\left(1.7\cdot\frac{c-m}{\sigma}\right)}$$

the equivalent σ_e that provides the same F value as the Gamma distribution is

$$F_{CF} \cong 1 - \frac{1}{1+\exp\left(1.7\cdot\frac{c-m}{\sigma_e}\right)} \text{ or:}$$

$$\sigma_e = \frac{1.7(c-m)}{\ln\left(\frac{F_{CF}}{1-F_{CF}}\right)}$$

The adjusted I_{AF} value can be calculated as follows:

$$I_{AF} = \frac{s-m}{\sigma_e} = \frac{\ln(F_{CF})-\ln(1-F_{CF})}{1.7}.$$

To control the overflow error, small values of F_{CF} and 1-F_{CF} should not be used. Instead, an assumed small negative value of ln(F) and ln(1-F) (e.g., -99) should be used. Since the equation for I_{AF} is an approximation (although a close one), I_{AF} should be set at a value 0 of s = m to avoid an obviously counter-intuitive result.

The relationship between index I_{AF} and significance F_{CF} is shown in Figure 41 and summarized in Table 2. It can be concluded that I_{AF} lower than 1.25 indicates no or weak statistical evidence of a safety problem (F_{CF}<0.90), and I_{AF} between 1.3 and 1.7 indicates considerable evidence (F_{CF} between 0.90 and 0.95), and I_{AF} between 1.7 and 2.7 indicates strong evidence (F_{CF} between 0.95 and 0.99), and I_{AF} larger than 2.7 indicates very strong evidence.

Proportion of Crashes

The reference proportion is the estimated proportion of studied crashes S in the reference crashes R in the group of roads: S/R. The expected number of crashes at a single road element which corresponds to the reference proportion is calculated as: m = r·S/R, where r is the number of reference crashes on the road element and S/R is the proportion of studied crashes in the reference crashes in the group of roads (reference proportion). The variance of the estimate m is caused by the variability of all the component crash counts: r, S, and R. These counts are not independent from each other as explained in Figure 42. To estimate the variance of the m estimate, the crashes in the group of considered roads have been divided into four counts: c, c1, c2, c3, and c4 in a way that these counts vary independently and can be used to calculate the counts r, S, and R:R = c+c1+c2+c3, S = c+c1, and r = c+c2. The derivation

TABLE 2
Levels of Statistical Evidence

Statistical Evidence of Safety Problem	Confidence F_{CF}	Index I_{AF}
None or Very Weak	<0.80	<0.8
Weak	0.80–0.90	0.8–1.3
Considerable	0.90–0.95	1.3–1.7
Strong	0.95–0.99	1.7–2.7
Very Strong	>0.99	>2.7

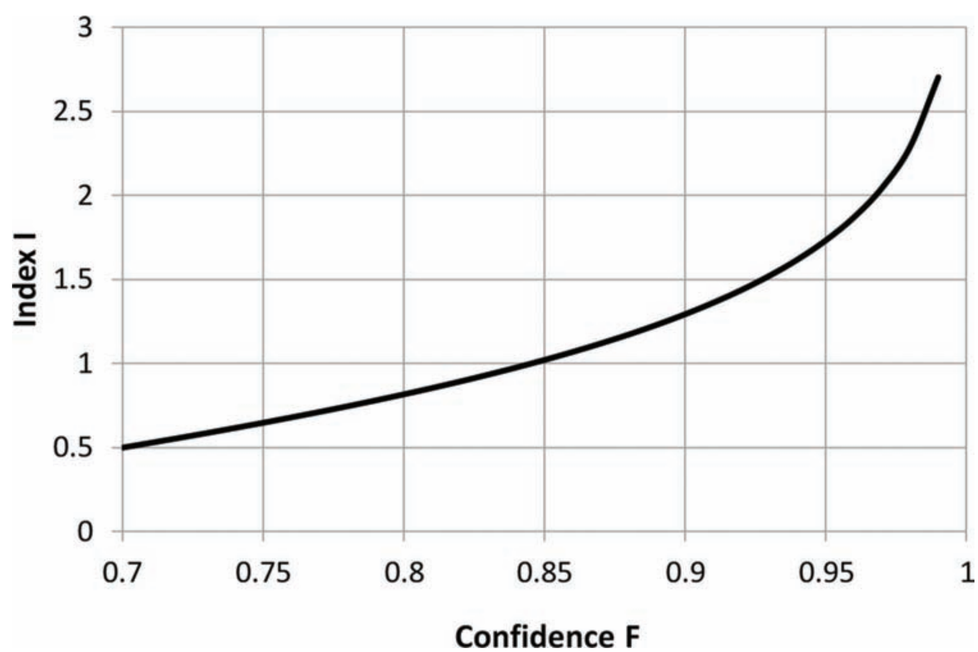


Figure 41 Relationship between the index of frequency I and the significance of level F.

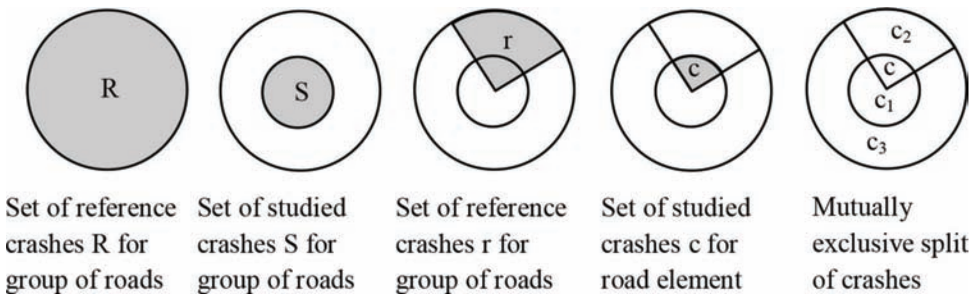


Figure 42 Dependence between crash counts.

of the variance of estimate m; $v = (2crSR + r^2SR + rS^2R - 3r^2S^2)/R^3$ is described below.

The variance of $m = rs/d$ is calculated as the variance of $m = (c+c_1)(c+c_2)/(c+c_1+c_2+c_3)$ with four independent sources of Poisson variance: c, c_1, c_2, and c_3. The variance is derived from the following equation:

$$\operatorname{var} m(c,c_1,c_2,c_3) = \left(\frac{\partial m}{\partial c}\right)^2 \cdot c + \ldots + \left(\frac{\partial m}{\partial c_3}\right)^2 \cdot c_3.$$

The validity of the derived variance and of the assumption of Gamma distribution applied to this criterion has been evaluated using a simulation of 10,000 values of the m estimates for two distinct sets of values of c, r, s, and d. The simulated distribution of the m estimates and corresponding Gamma distributions with the parameters calculated in steps 2, 3, and 4 are shown in

Figure 43 for ($c = 10$, $s = 210$, $r = 210$, $d = 510$, $m = 45.3$, $v = 18.1$) and Figure 44 for ($c = 1$, $s = 6$, $r = 3$, $d = 18$, $m = 0.44$, $v = 1.0$). The simulation-based evaluation confirms the validity of the method for estimating right-hand distribution tails of m estimates.

Estimation of the significance F_{CP} is made using equation

$F_{CP} = \text{Beta.Dist}(1/(1+\beta), \alpha, c+1, 1)$,

where $\alpha = m^2/v$ and $\beta = v/m$, thus

$F_{CP} = \text{Beta.Dist}(1/(1+v/m), m^2/v, c+1, 1)$.

The adjusted Index I_{AP} is calculated as:

$$I_{AP} = \frac{\ln(F_{CP}) - \ln(1 - F_{CP})}{1.7}.$$

Cost Criterion

Traffic volume, AADT, and segment length are useful in calculating the expected cost of crashes on the studied road element. The expected cost of crashes can be obtained by multiplying the crash cost rate per unit exposure averaged for the studied road network with the exposure values for the studied road element.

The expected cost of crashes on a road segment or at an intersection exceeds the expected cost under the given exposure. An estimate of the expected number of crashes at severity level k is distributed according to Gamma with parameters $\alpha = c_k$ and $\beta = 1$. Thus, the mean value is $m_k = c_k$ and the variance is $v_k = c_k$. The scaling property of the Gamma distribution allows assuming that the cost of all crashes of severity k at the location is also distributed as Gamma with parameters: $\alpha = c_k$, $\beta = u_k$. The corresponding mean $mk = c_k u_k$, and variance $v_k = c_k u_k^2$. Thus, the cost of all crashes on the road is:

$$w = \sum\nolimits_k c_k u_k$$

and the close approximation of the variance of cost estimate (confirmed with Monte Carlo experiments) is:

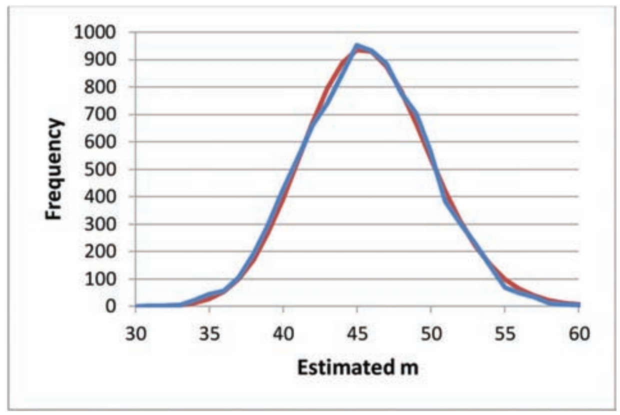


Figure 43 Case 1—Simulated (blue) versus calculated (red) distributions of m estimates.

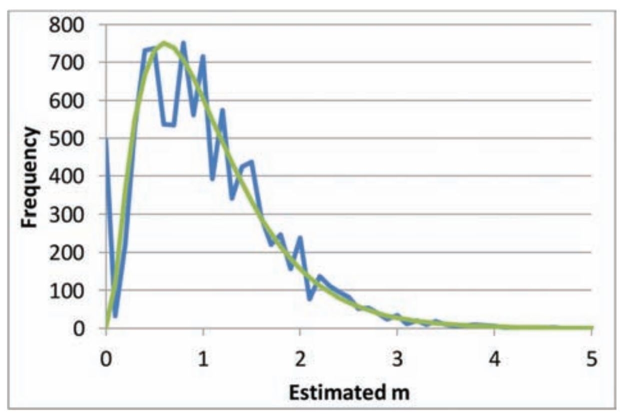


Figure 44 Case 2—Simulated (blue) versus calculated (green) distributions of m estimates.

$$v_1 = \sum_k c - k u_k^2.$$

If the cost of crashes on the road expected for the exposure can be calculated as: m = e·W/E, where e is the exposure on the considered road element, W is the total cost of crashes in the group of roads, and E is the total exposure in the group of roads. The estimate m has variance $v_2 = \sum_j \frac{V_{wj}}{E^2}$, which is the total cost variance and E is the total exposure in the road group.

The variance of the difference between the w and m estimates is approximated with the sum of the two component variances v_1 and v_2. The test is this time based on the Gamma distribution:

$$F_{CC} = 1 - \text{Gamma.Dist}\left(w, \alpha = \frac{m^2}{v_1 + v_2}, \beta = \frac{v_1 + v_2}{m}, 1\right)$$

and index I_{AC} is calculated as before:

$$I_{AC} = \frac{\ln(F_{CC}) - \ln(1 - F_{CC})}{1.7}.$$

Computations

Table 3 summarizes all calculations for the three screening criteria.

TABLE 3
Confidence F and Index I for the Three Screening Criteria

Screening Criterion	Crashes/ Cost on Road Element	Crashes/Cost Expected on Road Element M	Variance V	Significance F	Index I	Index I_e
Crash Frequency– Simplified SFP	A	$m = \Sigma_k m_k$	$v_1 = A + 1$* $v_2 = \Sigma_k d_k m_k^2$ $v = v_1 + v_2$	F = Beta.Dist (1/(1 + v_2/m), m^2/v_2 + 1, c + 1, 1)	I = (A-m)/$v^{1/2}$	I_e = (ln(F)-ln (1-F))/1.7
Crash Frequency– Full SFP	A	$m = \Sigma_k SPF_k(e)$	$v_1 = A + 1$* $v_2 = \Sigma_k d_k m_k^2$ $v = v_1 + v_2$	F = Beta.Dist (1/(1 + v_2/m), m^2/ v_2 + 1, c + 1, 1)	I = (A-m)/$v^{1/2}$	I_e = (ln(F)-ln (1-F))/1.7
Crash Proportion	A	$m = r(S/R)$	$v_1 = A + 1$* $v_2 = (2crSR + r^2SR + rS^2R - 3r^2S^2)/R^3$ $v = v_1 + v_2$	F = Beta.Dist (1/(1 + v/m), m^2/ v_2 + 1, c + 1, 1)	I = (A-m)/$v^{1/2}$	I_e = (ln(F)-ln (1-F))/1.7
Crash Cost– Simplified SPF	$U = \Sigma_k A_k u_k$	$m = \Sigma_k m_k u_k$	$v_1 = \Sigma_k (A_k + 1^*) u_k^2$ $v_2 = \Sigma_k d_k m_k^2 u_k^2$ $v = v_1 + v_2$	F = Gamma.Dist (w, m^2/v, v/m, 1)	I = (U-m)/$v^{1/2}$	I_e = (ln(F)-ln (1-F))/1.7
Crash Cost– Full SPF	$U = \Sigma_k A_k u_k$	$m = \Sigma_k SPF_k(e) u_k$	$v_1 = \Sigma_k (A_k + 1^*) u_k^2$ $v_2 = \Sigma_k d_k m_k^2 u_k^2$ $v = v_1 + v_2$	F = Gamma.Dist (w, m^2/v, v/m, 1)	I = (U-m)/$v^{1/2}$	I_e = (ln(F)-ln (1-F))/1.7

*Obtained by combining the non-informative prior with count A. Increase the count A by the mean count in the group of roads instead of 1 if this mean is less than 1. The adjustment cannot be lower than a certain minimum.

Notation in the alphabetic order:

A = number of crashes on road element, Ak = number of studied crashes of severity k; d = over-dispersion parameter of SPF; e = exposure on road element (AADT, length L, VMT); m = estimate of the crashes or cost expected for the exposure; r = number of reference crashes on road element during; R = total number of reference crashes in the group of roads; S = total number of studied crashes in the group of roads; SPF(e) = estimated expected crash count on a segment for the exposure e; U = cost of crashes on road element; uk = unit cost of crash of k severity; v = variance of the m estimate.

About the Joint Transportation Research Program (JTRP)

On March 11, 1937, the Indiana Legislature passed an act which authorized the Indiana State Highway Commission to cooperate with and assist Purdue University in developing the best methods of improving and maintaining the highways of the state and the respective counties thereof. That collaborative effort was called the Joint Highway Research Project (JHRP). In 1997 the collaborative venture was renamed as the Joint Transportation Research Program (JTRP) to reflect the state and national efforts to integrate the management and operation of various transportation modes.

The first studies of JHRP were concerned with Test Road No. 1—evaluation of the weathering characteristics of stabilized materials. After World War II, the JHRP program grew substantially and was regularly producing technical reports. Over 1,600 technical reports are now available, published as part of the JHRP and subsequently JTRP collaborative venture between Purdue University and what is now the Indiana Department of Transportation.

Free online access to all reports is provided through a unique collaboration between JTRP and Purdue Libraries. These are available at http://docs.lib.purdue.edu/jtrp.

Further information about JTRP and its current research program is available at http://www.purdue.edu/jtrp.

About This Report

An open access version of this publication is available online. See the URL in the citation below.

Tarko, A. P., Thomaz, J., & Romero, M. (2019). *SNIP light user manual* (Joint Transportation Research Program Publication No. FHWA/IN/JTRP-2019/26). West Lafayette, IN: Purdue University. https://doi.org/10.5703/1288284317136