2021

Work Zone ITS Implementation Tool Version 2.0

Users Guide

PREPARED FOR: FEDERAL HIGHWAY ADMINISTRATION

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16. Abstract This practitioner-friendly user guide describes the Work Zone Intelligent Transportation Systems (WZITS) Implementation Tool, prepared for the Federal Highway Administration (FHWA), and provides step-by-step instructions for its use. The WZITS Implementation Tool implements the logic and methodology described in the 2014 *Work Zone Intelligent Transportation Systems Implementation Guide*; users should refer to the implementation guide for information about the tool's underlying methods. The tool creates and manages a project file that provides users with (1) guidance during the WZITS decision-making process, and (2) a place to document the decisions made, along with relevant supporting information. The user guide includes four case studies that illustrate the use of the tool.			
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1 INTRODUCTION

This practitioner-friendly user guide describes the Work Zone Intelligent Transportation Systems (WZITS) Implementation Tool, prepared for the Federal Highway Administration (FHWA), and provides step-by-step instructions for its use.

The WZITS Implementation Tool implements the logic and methodology described in the FHWA *Work Zone Intelligent Transportation Systems Implementation Guide* (*1*); users should refer to the guide for information about the underlying methods incorporated into the tool. The tool creates and manages a project file that provides users with (*a*) guidance during the WZITS decision-making process, and (*b*) a place to document the decisions made, along with relevant supporting information. The user guide includes four case studies that illustrate the use of the tool.

1.1 OVERVIEW

ITS is the use of a broad range of communications-based information and electronics technologies to enhance transportation (*1*). Work zone ITS is the use of ITS to improve safety and mobility in and around work zones. Information provided by work zone ITS may be in the form of real-time traffic conditions, such as travel delays through a work zone or recommended diversion routes. This information can be used by motorists to alter their travel behavior, and by contractors and transportation agencies to alter traffic control strategies, traveler information, or work schedules. A work zone ITS deployment can be focused solely around safety or mobility, but it often supports both goals and can also help enhance productivity.

The WZITS Implementation Tool provides three core types of inputs, guidance, and documentation:

1. *Project Information*
2. *Project Wizards*
3. *Project Documentation*

Project Information inputs provide project reference information for the work zone and allow the user to add customized project documentation in addition to the standard inputs. General information about the overall roadway facility and the work zone scenario can also be specified using these inputs.

Project Wizards aggregate user inputs according to the guidance of the *Work Zone ITS Implementation Guide*. The wizards also provide decision-support through recommendations relating to project goals, ITS feasibility, team members and stakeholders, and potential ITS applications. The user can then combine the tool's recommendations with their own knowledge about a specific roadway and work zone when making decisions.

Lastly, *Project Documentation* questions reflect the guidance of the *Work Zone ITS Implementation Guide*. These questions are intended to ensure that the user has considered particular steps or aspects of the implementation process. This section of the tool also provides a place to document the decisions made over the course of the project.

1.2 KEY CHANGES

- Enhanced user-friendliness and interface facelift – simplified tool navigation with a more modern look and feel.
- Streamlined installation process, now independent of Java – Users no longer need to have Java installed on their computer to use WZITS, simply download the Windows Installer file (.msi) and install.
- Ability to change wizard scoring by agency
- Streamlined presentation of Steps 3-6
- Fact sheet improvements
- Comment Fields for most data entries – Comments useful for justification or reasoning for a certain selection.
- Pop-up windows for most fields
- Bug fixes and minor updates – Notably, the concept of operations image now correctly saves with the file.

1.3 INSTALLATION AND RUNNING

To install the Work Zone ITS Implementation tool, download the Windows installer file (.msi) from the following link: https://github.com/kittelson/WZITS_Tool. Once the file has downloaded, double-click the file to launch a guided installation wizard (Figure 1). Follow the instructions of the installation wizard to install WZITS. If desired, a specific install location can be specified for the program, but in general the standard location in C:\Program Files\WZITS TOOL should suffice for most users (see Figure 2). Note that installing the program will require administrator privileges for the computer.

Once the installation wizard has finished, both a desktop shortcut and a start menu item will have been created and can be used to launch the program.

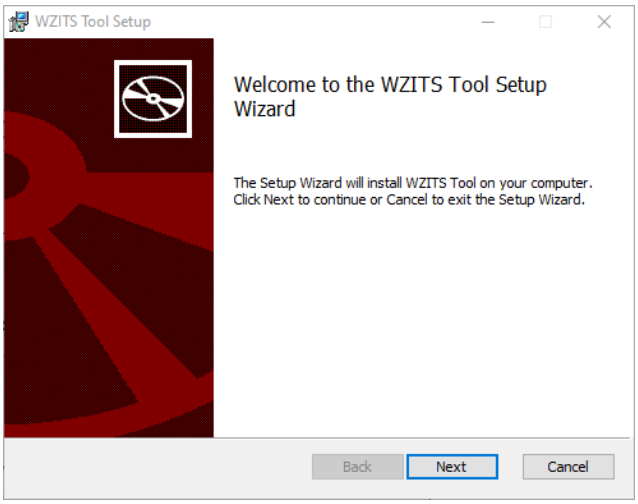


Figure 1: Step one of the WZITS Tool guided installation wizard.

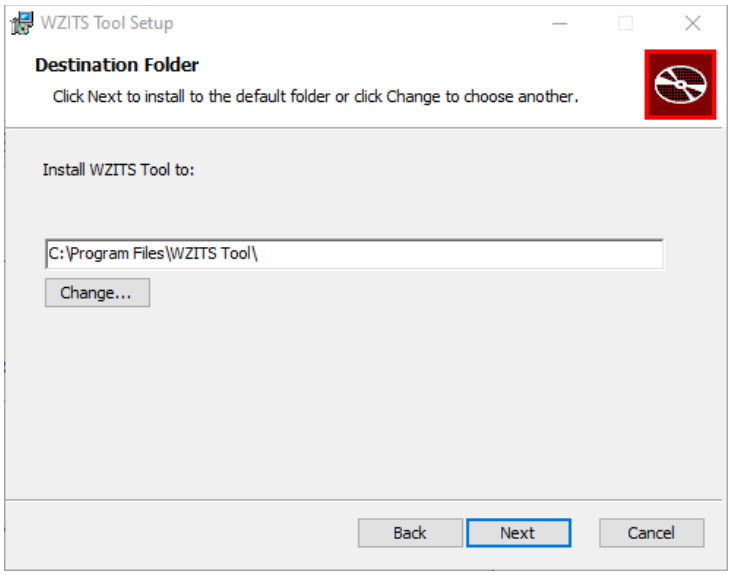


Figure 2: The WZITS Tool installation wizard with the default installation location for the tool.

Optional:

There are two options to uninstall WZITS. First, if the original installer is available, launching the install wizard provides an option to Uninstall WZITS (Figure 3). Alternatively, WZITS can be uninstalled using the "Add or Remove Programs" Windows built-in utility.

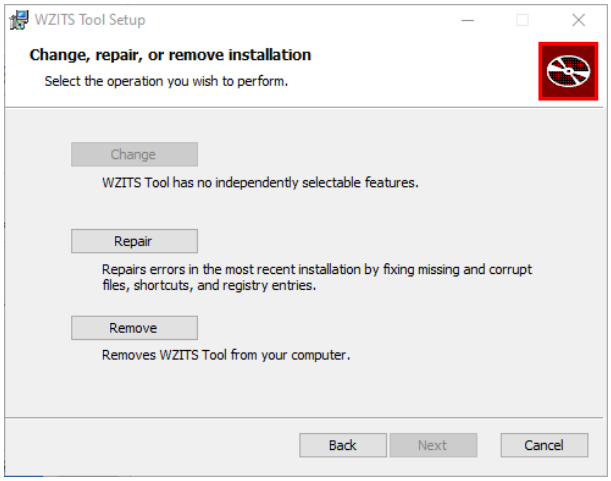


Figure 3. The WZITS tool installation wizard can be used to uninstall the WZITS Tool.

1.4 USER GUIDE ORGANIZATION

Section 2 of this user guide focuses on how to use the software. First, Sections 2.1 through 2.3 outline the tool's basic structure and features, including how to navigate through the software, how to start a new work zone ITS assessment, and how to save and reopen projects. Next,

Section 2.4 provides a detailed discussion of the tool's outputs. Finally, Section 2.5 describes the outputs produced by the tool.

Section 3 provides four case studies demonstrating how to use the tool. Finally, Section 4 provides a reference to the *Work Zone ITS Implementation Guide*.

2 WZITS IMPLEMENTATION TOOL USER GUIDE

This section presents an overview of the WZITS Implementation Tool and provides step-by-step descriptions on how to interact with the tool's various components. Screenshots are used extensively to illustrate key points. The focus is on user interaction with the tool, as opposed to a discussion of the individual steps of a WZITS assessment and their respective inputs. Section 2.4 provides a brief overview of these steps and their underlying logic; more detailed information can be found in the *Work Zone ITS Implementation Guide* (*1*).

2.1 NAVIGATING THE TOOL

The general layout of the tool's main window is shown in Figure 4. This window contains five key components, as indicated by the numbers in Figure 4:

1. Project Menubar
2. Project Workflow Toolbar
3. Step Navigator
4. Main Input Window
5. Project Dashboard

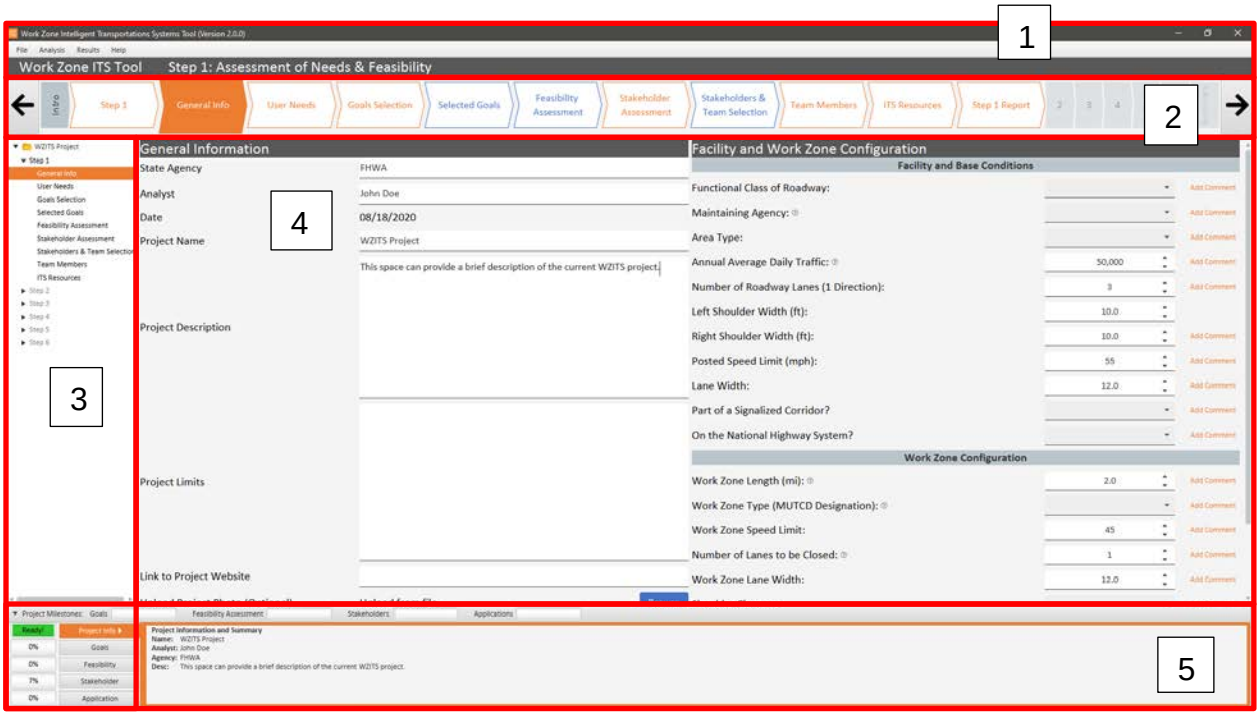


Figure 4: General Layout of the WZITS Implementation Tool.

The *Project Menubar* (#1 in Figure 4) provides access to various commands and options, similar to the menus provided in any other application. The usage of these menu commands will be described as needed throughout Section 2.

The *Project Workflow Toolbar* (#2 in Figure 4) is located just below the menubar. The toolbar serves as both the primary navigational control for the tool and as a visual reference to where the user is in the WZITS assessment process. Section 2.1.1 discusses the use of the toolbar.

The *Step Navigator* (#3 in Figure 4) is located on the left side of the window. The steps involved in a WZITS assessment are displayed in the navigator in an expandable/collapsible tree format. Double-clicking any item in the tree will navigate directly to the corresponding step or sub-step in the assessment process.

The *Main Input Window* (#4 in Figure 4) occupies the center of the window. This area provides the inputs and outputs relevant to a specific step or sub-step of a WZITS assessment and its content changes as different steps are selected in the Project Workflow Toolbar or Step Navigator. The screenshot in Figure 4 shows the introduction screen that is displayed in the main input window each time the tool is launched.

Finally, the *Project Dashboard* (#5 in Figure 4) is hidden until the bar at the bottom of the window is clicked, thereby expanding the dashboard into the bottom section of the window. The dashboard displays the progress made in the WZITS assessment and provides key assessment milestones. Section 2.1.2 describes the dashboard in more detail.

2.1.1 PROJECT WORKFLOW TOOLBAR

Figure 5 displays views of the Project Workflow Toolbar in its collapsed and expanded states. In the toolbar's collapsed state (Figure 5a), only the top-level steps in the process are shown. In the toolbar's expanded state (Figure 5b), a selected step (in this case, Step 1) is expanded to display all the substeps associated with that step.

One function of the toolbar is to visually indicate the progress made in the WZITS assessment. The step currently being worked on is highlighted. In Figure 5a, the tool has just been opened with a new project and the "Intro" step is highlighted. None of the steps in the process have been worked on yet; these are displayed in a light blue color. In Figure 5b, Step 1 has been opened to reveal all the sub-steps associated with Step 1. The user has already worked on all the sub-steps in Step 1, as the light blue color has been replaced with brighter colors in each sub-step. Sub-steps shown with a brown background are ones where the user provides input to the tool or views tool output via the Main Input Window; these sub-steps turn orange when selected (for example, the Team Members sub-step is currently being worked on in Figure 5b). Sub-steps shown with a dark green background have an associated wizard for providing input, as described in Section 2.4.2; these sub-steps turn light green when selected.

(a) Collapsed State

(b) Expanded State

Figure 5: Close-up View of the Project Workflow Toolbar.

The toolbar's second function is to serve as the tool's main navigational control. The arrow buttons on the right and left sides of the toolbar allow the user to step forward and backward

through the WZITS assessment. The individual step icons expand and collapse as the user navigates through them and the sub-step currently being worked on is highlighted. In addition, the name of the current step being worked on is displayed in the grey bar at the top of the toolbar. The step and sub-step icons also double as buttons that can be used to jump directly to a specific step or sub-step.

2.1.2 PROJECT DASHBOARD

The Project Dashboard provides real-time feedback about project progress made and key assessment conclusions. By default, the project dashboard is collapsed, but it can be expanded by clicking the bar at the bottom of the window. In its collapsed state (Figure 6), the dashboard provides progress bars denoting progress toward the four key assessment milestones: Goals Selection, Feasibility Assessment, Stakeholders, and Applications. The progress bars are displayed in orange while the assessment is in process. The bars change to green once the all the requirements to reach the milestone have been completed.

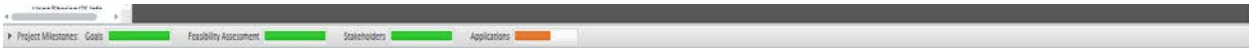


Figure 6: Example of the Project Dashboard in its Collapsed State.

In its expanded state (Figure 7), the Project Dashboard provides more detailed information about the progress of the WZITS assessment. Five tabs are provided: one for each of four assessment milestones, and a fifth with general project information. Indicators next to each tab show progress toward completing a milestone in orange with percent complete, changing to green and "Ready!" once the milestone is reached. In Figure 7, the user has selected the Goals tab. This tab shows the top goal that the user has selected out of each category of goals. The dashboard tabs can be a useful way to view important information from previous steps without having to navigate back to the step or sub-step in the Main Input Window.

Figure 7: Example of the Project Dashboard in its Expanded State.

2.2 STARTING A NEW WORK ZONE ITS ASSESSMENT

After starting the program, the user can create a new project or open an existing project. Opening an existing project is described next in Section 2.3. To begin a new WZITS assessment, click the large blue button at the bottom of the introduction screen, or navigate to Step 1 using the forward arrow in the Project Workflow Toolbar.

The first screen of each step provides a title card displaying the name of the corresponding step in the *Work Zone ITS Implementation Guide*, along with the names of the sub-steps associated with that step. While the tool's six main steps are consistent with the six steps presented in the *Work Zone ITS Implementation Guide*, the tool makes some changes to selected sub-steps to better facilitate the use of the guidance for design and decision-making purposes. For example,

the feasibility assessment has been moved earlier in the process to provide a more timely assessment of when to proceed to use the tool.

Figure 8 shows an example of the title card for Step 1. The sub-steps shown in orange correspond directly to sections in the *Work Zone ITS Implementation Guide*; the specific section number is shown for reference in a dark gray box below each of the orange sub-steps. For example, guidance for the User Needs sub-step can be found in Section 1.1 of the implementation guide. Sub-steps shown in light grey indicate inputs unique to the tool (general project information in this case). Finally, sub-steps shown in green are decision-support "wizards" that aggregate information from previous sub-steps to provide actionable items and interim outputs. These "wizards" are not explicitly described in the implementation guide; rather, they provide helpful structure to the guide's decision-making process.

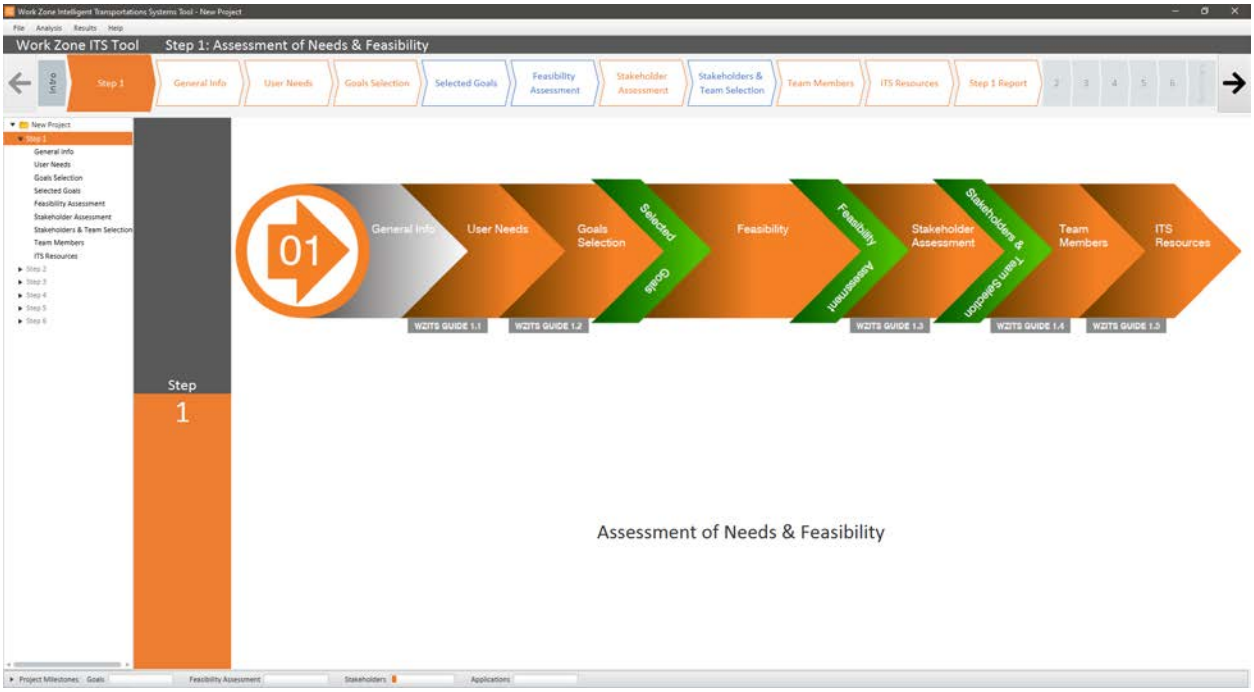


Figure 8: Title Card for Step 1: Assessment of Needs.

2.3 SAVING AND OPENING PROJECTS

The tool saves projects files in a custom .wzp format. To save a file, select either "Save Project" or "Save Project As" from the File menu. "Save Project As" can be used to save the file in a new location, with a new name, or both. If the active project has been saved previously, "Save Project" will write any new changes to the existing file. If the project has not yet been saved, "Save Project" will function the same as the "Save Project As" option.

To open a project file, select "Open Project" from the File menu and use the file explorer to select the desired .wzp file.

2.4 WORK ZONE ITS TOOL INPUTS

The tool's inputs can be divided into three categories: project information, wizard inputs, and project documentation. The majority of the tool's inputs fall into one of the two latter categories. The following subsections describe how to interact with each of the three input types.

2.4.1 PROJECT INFORMATION AND FACILITY CONFIGURATION

The tool's initial step, Introduction, is a new step that is not explicitly described in the *Work Zone ITS Implementation Guide*. This step allows the user to input general project reference information and to describe the overall roadway facility and work zone configuration. Inputs for this step are entered through a combination of text fields, drop-down choice boxes, and direct numerical inputs, as shown in Figure 9. General project information inputs are entered in the left-hand column within the Main Input Window, while facility and work zone configuration inputs are entered in the right-hand column.

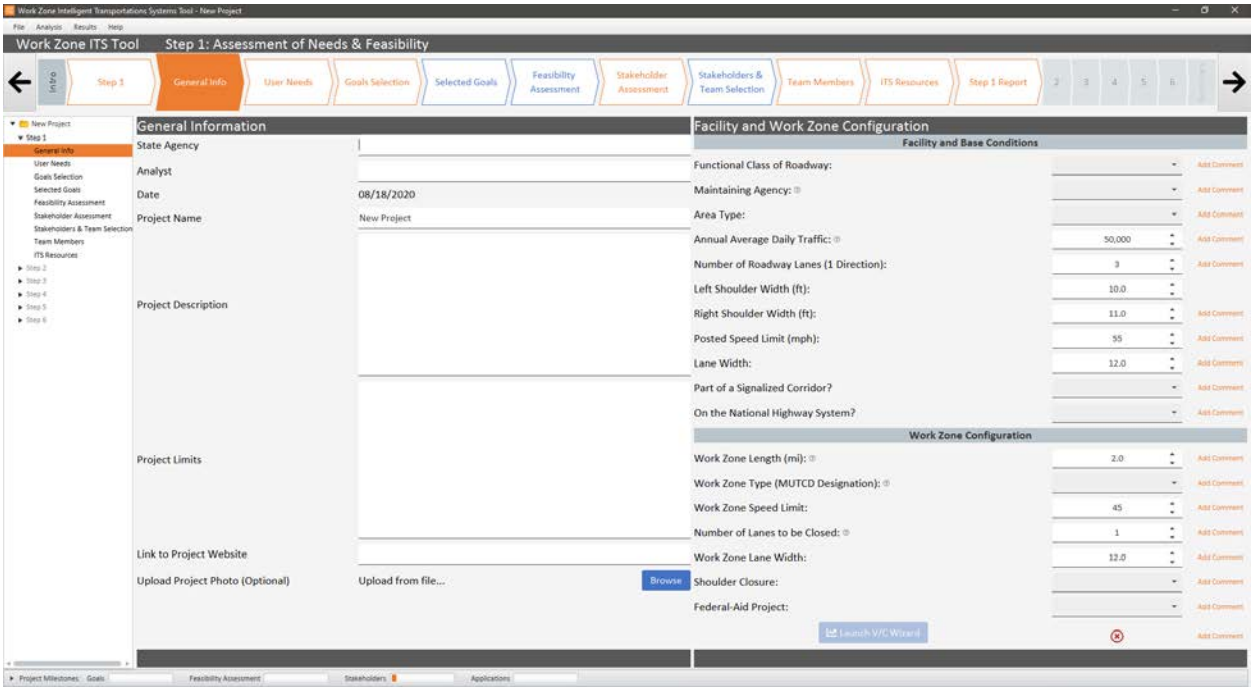


Figure 9: Project Information and Facility Configuration Inputs.

The user can optionally specify the following information about each project:

- State Agency
- Analyst
- Project Name
- Project Description
- Project Limits
- Project Website Link
- Project Photo

These inputs are used solely for record-keeping and documentation purposes, and it is to the user's discretion as to how much (or how little) information to provide.

Next, the user should provide a set of inputs relating to the facility and work zone configuration. These inputs are not meant to provide an exhaustive description of the facility and work zone. Rather, they are a subset of commonly used information that the tool uses to facilitate project documentation and the tool's decision-making logic. Many of the inputs are used to preemptively provide answers to questions where possible in later steps of the assessment. Where available, more information about a particular input can be viewed by clicking on an orange "?" next to the input name (see Work Zone Type in Figure 9).

As these inputs may not provide a complete picture of particular aspects of the facility or work zone, the user can optionally provide additional notes for an input by clicking the "Add Comment" link directly to the right of that input. Doing so will launch a small popup window with space for entering additional comments. These comments will be displayed later on in the documentation for the step. Figure 10 shows an example of the popup window for roadway functional class.

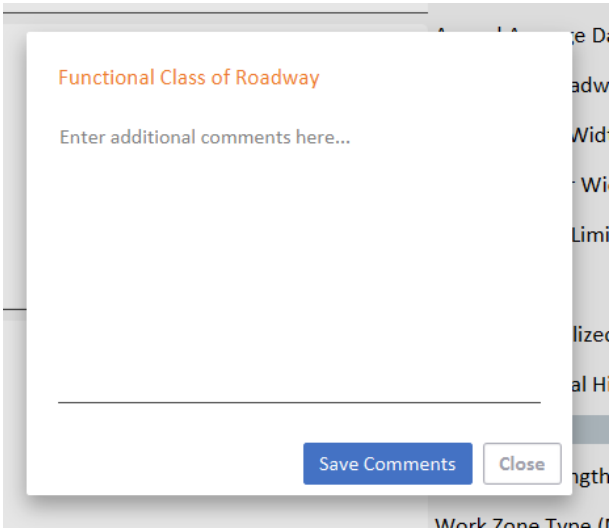


Figure 10: Example of an "Additional Comments" Popup Window.

2.4.2 WIZARD-STYLE INPUTS

Four decision-support "wizards" have been incorporated into the tool to provide guidance and decision-making support. The four wizards facilitate:

1. Selecting project ***goals*** for the use of work zone ITS,
2. Assessing the ***feasibility*** of using work zone ITS strategies for the project,
3. Selecting the ***stakeholders*** and team members most likely to be affected, and
4. Identifying the WZITS ***applications*** or technologies most likely to be effective for the project.

The Goals, Feasibility, and Stakeholder wizards are completed during Step 1 (as shown previously in Figure 8), while the Applications wizard is completed as the first activity in Step 2.

Using the wizard largely consists of answering a series of yes-or-no questions, although some wizards require additional inputs in the form of drop-down choice boxes. Figure 11 shows an example of the questions asked by the Goals wizard. The user should answer these questions to the best of their ability. In the event that a question is not applicable to a particular project, answering "No" will generally remove the question from consideration in scoring. Questions that are "greyed out" have been answered previously or are considered to be not applicable based on previous inputs.

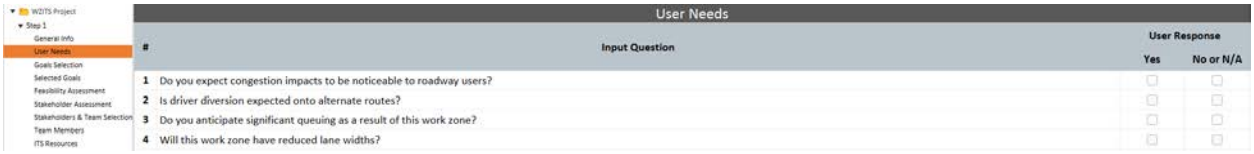


Figure 11: Example of Inputs Required for the Goals Wizard.

Each question is linked to a scoring matrix that is used to quantify an aspect of the assessment and to provide the user with a recommendation. These scoring matrices have been pre-determined, drawing from the *Work Zone ITS Implementation Guide*, in combination with the beta testing and outreach performed for the implementation tool. If desired, users can customize the scoring matrices by directly editing the tool's source code.

After all of a wizard's questions have been answered, the wizard will use the scoring matrices to quantify its assessment. In the case of the Feasibility wizard, this process results in an immediate score and recommendation, as shown in Figure 12.

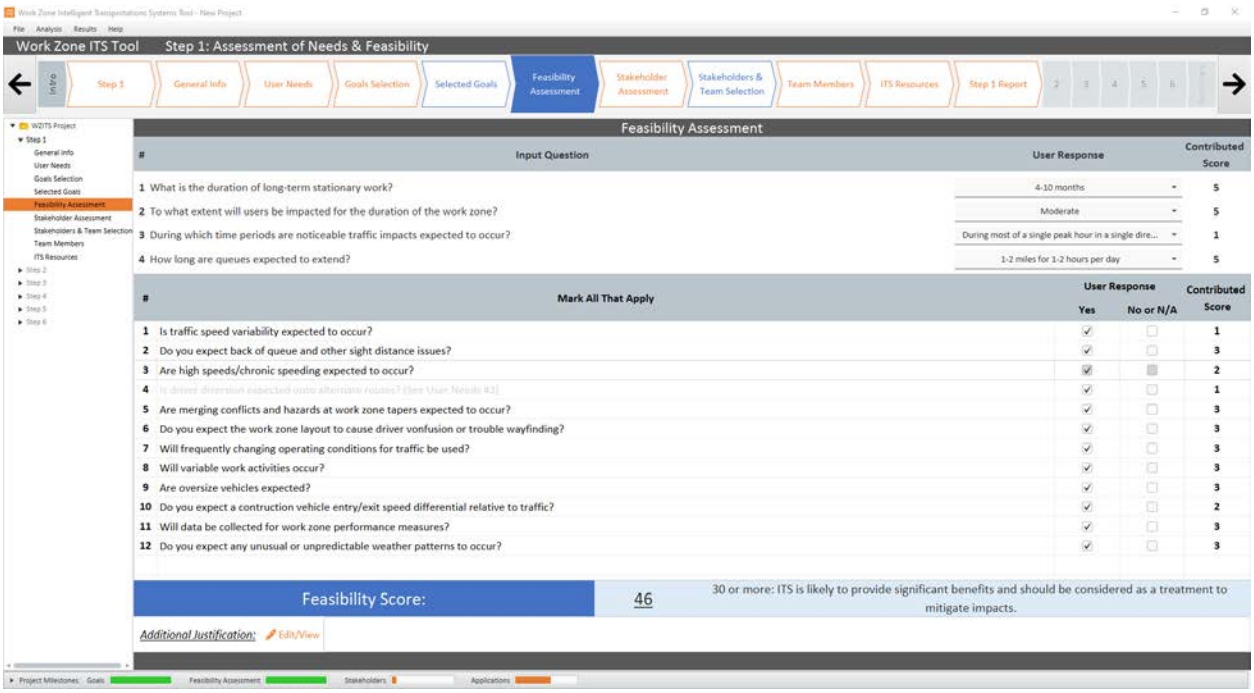


Figure 12: Example of the Outputs from a Feasibility Wizard Assessment.

In the case of the other three wizards, the tool provides a set of scored recommendations from which the user must make selections.

For example, the Goals wizard provides a set of recommended project goals, and the user is then asked to select the most important goals, drawing from the user's knowledge of the particulars of the project. An example is shown in Figure 13. Use the checkboxes in the right-most column to mark a specific goal for inclusion in the project. When provided, use an "edit" link to specify an aspect of a goal (e.g., to specify a maximum delay in the "Reduce daily peak period delays to XX minutes" goal).

Note that while the priorities listed for the goals are based on the *Work Zone ITS Implementation Guide*, **these priorities are not intended to be the sole factors in the decision-making process;** rather, they should supplement the user's knowledge and be used to provide an initial assessment.

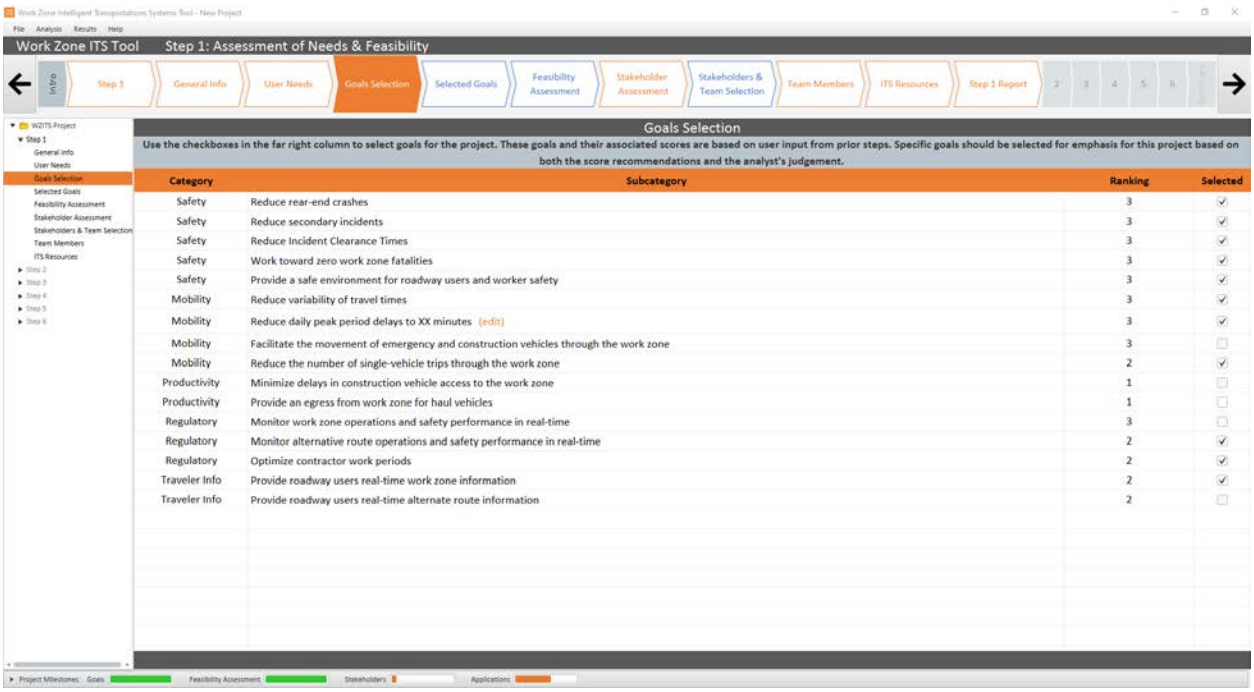


Figure 13: Example of the Goals Selection Step of the *Goals* Wizard.

Once the desired project goals have been selected from the list of recommended goals, the wizard's final step summarizes the selected goals, as shown in Figure 14. The selected goals will also appear in the fact sheet output for Step 1 (described in Section 2.5). In addition, the user can return to this sub-step at any time for reference.

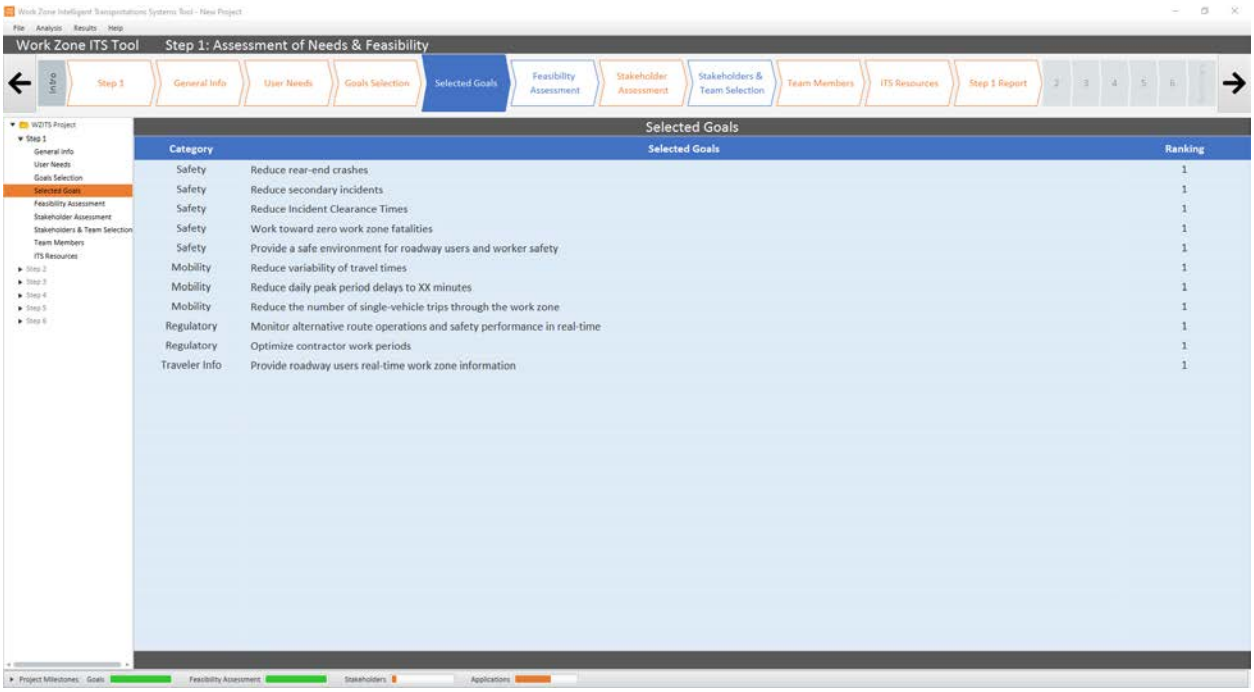


Figure 14: Example of Selected Goals Step of the Goals Wizard.

The Stakeholder wizard follows a similar three-step process of answering input questions, selecting project stakeholder and team members from a set of recommendations, and displaying a summary of the user's selections. Figure 15 shows an example of the Stakeholder wizard's input questions window, while Figure 16 shows an example of the team member recommendations produced by the wizard, along with their relative priorities. The user can mark agencies and groups as *core team members*, *stakeholders*, or *parties with little to no interest* (represented by the "N/A" column). Agencies or groups for which no selection is made are automatically placed into the "little to no interest" category.

Figure 17 shows an example of the Stakeholder wizard's summary results screen. The "edit" links next to each team member, stakeholder, and other organizations can be used to specify contact information and other relevant information, such as organization names. When clicked, these links open a pop-up window similar to the example shown in Figure 18 for a city transportation agency. The information entered in these pop-up windows will be stored in the project file for reference and will be displayed in an abbreviated manner in the fact sheet outputs.

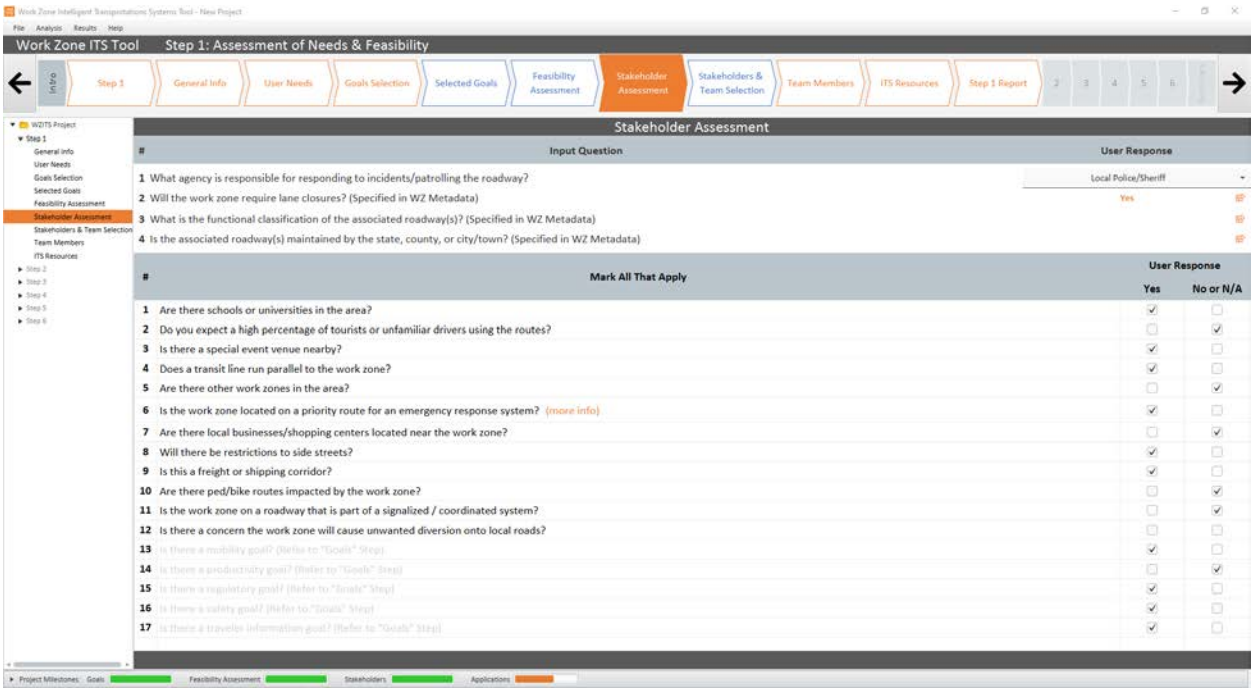


Figure 15: Example of Stakeholder Wizard Inputs.

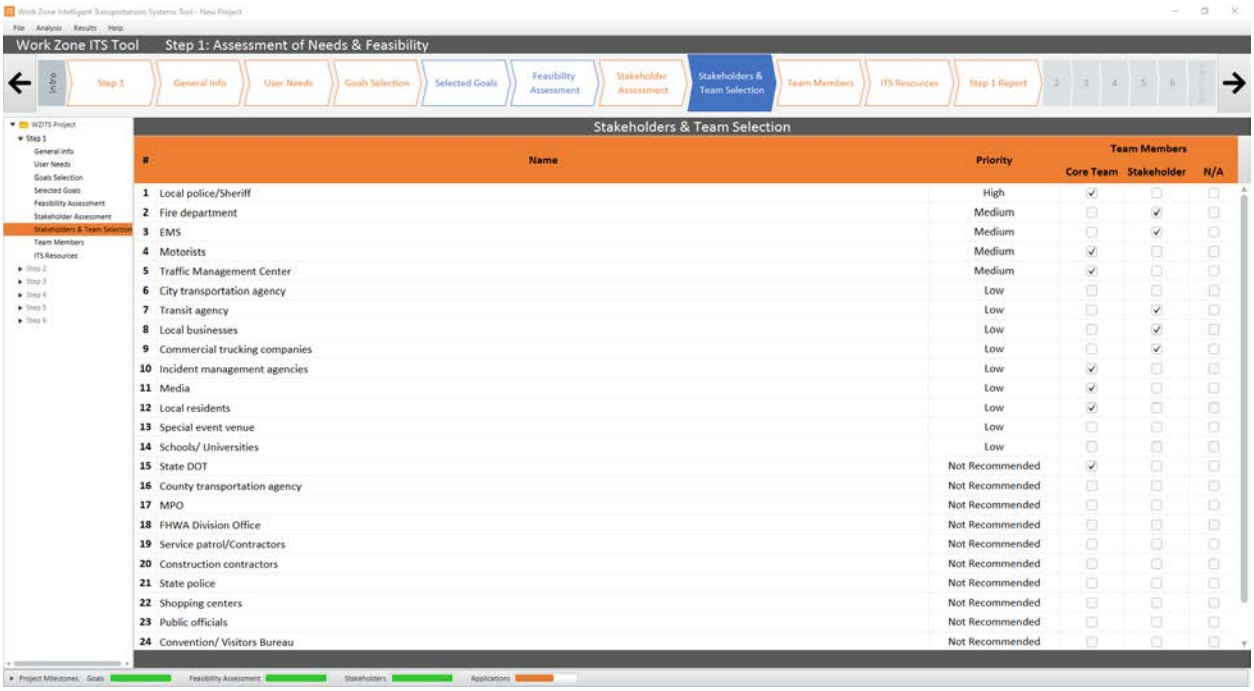


Figure 16: Example of Stakeholder Wizard Team Member Selection.

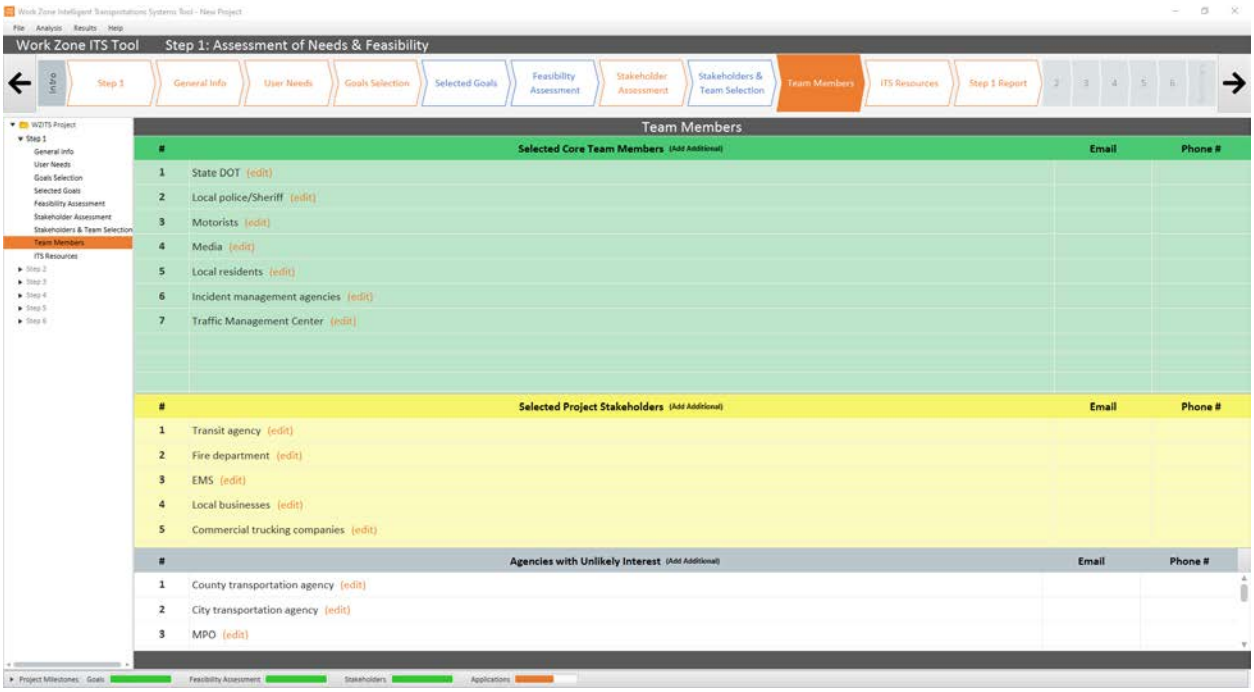


Figure 17: Example of the Stakeholder Wizard Summary Step.

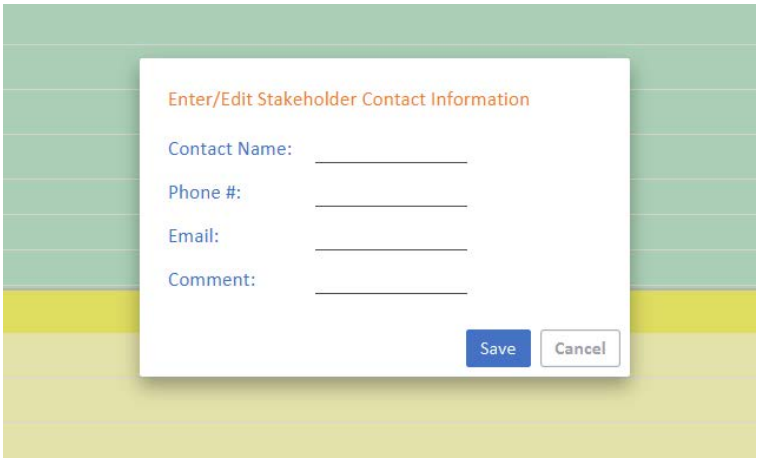
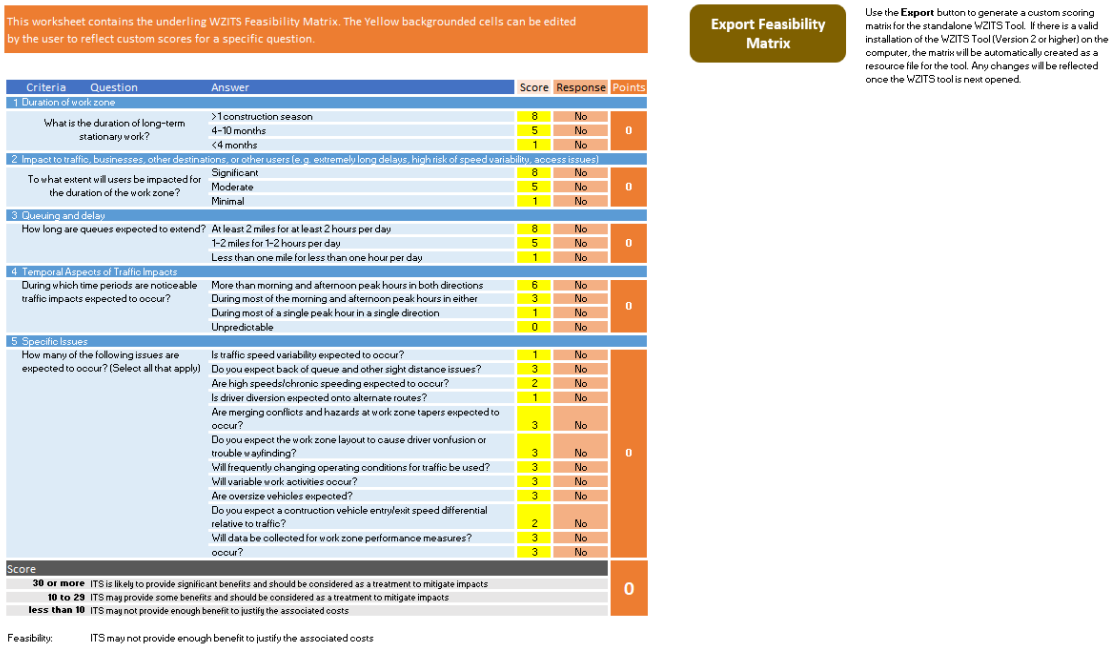


Figure 18: Example of the Stakeholder Contact Information Pop-up Window.

2.4.3 EDITABLE WIZARD SCORING BY AGENCY



This worksheet contains the underling WZITS Feasibility Matrix. The Yellow backgrounded cells can be edited by the user to reflect custom scores for a specific question.

Export Feasibility Matrix

Use the **Export** button to generate a custom scoring matrix for the standalone WZITS Tool. If there is a valid installation of the WZITS Tool (Version 2 or higher) on the computer, the matrix will be automatically created as a resource file for the tool. Any changes will be reflected once the WZITS tool is next opened.

Criteria	Question	Answer	Score	Response	Points
1 Duration of work zone					
	What is the duration of long-term stationary work?	>1 construction season	8	No	0
		4-10 months	5	No	
		<4 months	1	No	
2 Impact to traffic, businesses, other destinations, or other users (e.g. extremely long delays, high risk of speed variability, access issues)					
	To what extent will users be impacted for the duration of the work zone?	Significant	8	No	0
		Moderate	5	No	
		Minimal	1	No	
3 Queuing and delay					
	How long are queues expected to extend?	At least 2 miles for at least 2 hours per day	8	No	0
		1-2 miles for 1-2 hours per day	5	No	
		Less than one mile for less than one hour per day	1	No	
4 Temporal Aspects of Traffic Impacts					
	During which time periods are noticeable traffic impacts expected to occur?	More than morning and afternoon peak hours in both directions	6	No	0
		During most of the morning and afternoon peak hours in either	3	No	
		During most of a single peak hour in a single direction	1	No	
		Unpredictable	0	No	
5 Specific Issues					
	How many of the following issues are expected to occur? (Select all that apply)	Is traffic speed variability expected to occur?	1	No	0
		Do you expect back of queue and other sight distance issues?	3	No	
		Are high speeds/chronic speeding expected to occur?	2	No	
		Is driver diversion expected onto alternate routes?	1	No	
		Are merging conflicts and hazards at work zone tapers expected to occur?	3	No	
		Do you expect the work zone layout to cause driver confusion or trouble wayfinding?	3	No	
		Will frequently changing operating conditions for traffic be used?	3	No	
		Will variable work activities occur?	3	No	
		Are oversize vehicles expected?	3	No	
		Do you expect a contruction vehicle entry/exit speed differential relative to traffic?	2	No	
		Will data be collected for work zone performance measures?	3	No	
		occur?	3	No	
Score					
	30 or more	ITS is likely to provide significant benefits and should be considered as a treatment to mitigate impacts			0
	10 to 29	ITS may provide some benefits and should be considered as a treatment to mitigate impacts			
	less than 10	ITS may not provide enough benefit to justify the associated costs			

Feasibility: ITS may not provide enough benefit to justify the associated costs

Figure 19: Example of the editable Feasibility Matrix

2.4.4 PROJECT DOCUMENTATION INPUTS

The final type of input used by the tool are project documentation inputs. These inputs are not scored or used directly in the tool's decision-making guidance; instead, they provide records of the assessment steps that were taken along with all information relevant to the decisions that were made. This information is stored in the project file for future reference and appears in the fact sheet outputs.

Project documentation inputs are presented in the form of questions and comment areas. The questions include yes-or-no questions, multiple-choice questions, and open-ended questions requiring the user to fill out a comment field with the relevant information and/or justification. Each question should be answered to the best of one's ability. The comments boxes can be used to indicate questions that are not applicable to a particular project. Figure 20 shows an example of the project documentation inputs related to costs.

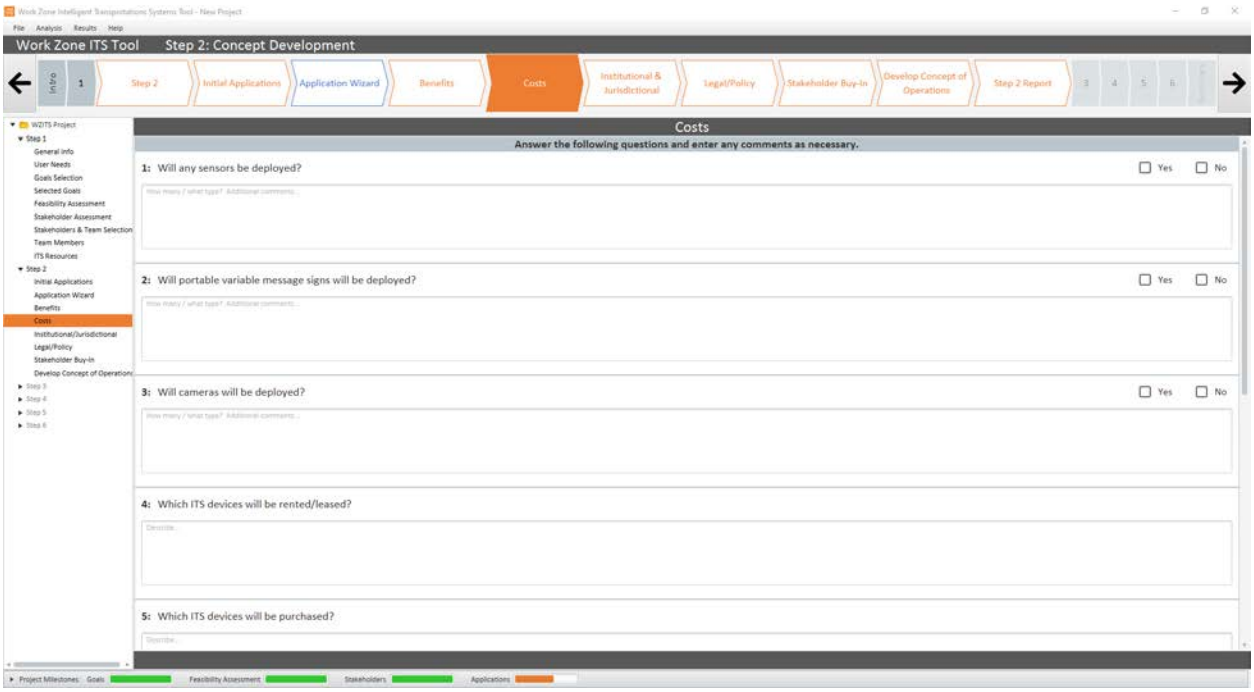


Figure 20: Example of Project Documentation Inputs.

2.5 WZITS IMPLEMENTATION TOOL OUTPUTS

The tool generates eight fact sheet outputs over the course of the work zone ITS assessment. Steps 1 and 2 generate two fact sheets each, while Steps 3 to 6 generate one fact sheet each. These fact sheets aggregate the information input into the tool and the guidance determined from these inputs into a set of concise reference sheets.

The fact sheets can be accessed from the "Step Report" sub-step once all of the other sub-steps associated with that step have been completed. Figure 21 shows an example of the first fact sheet generated in Step 1. Fact sheets can also be exported as PDF files by selecting "Export to PDF" from the Results menu, as shown in Figure 22.

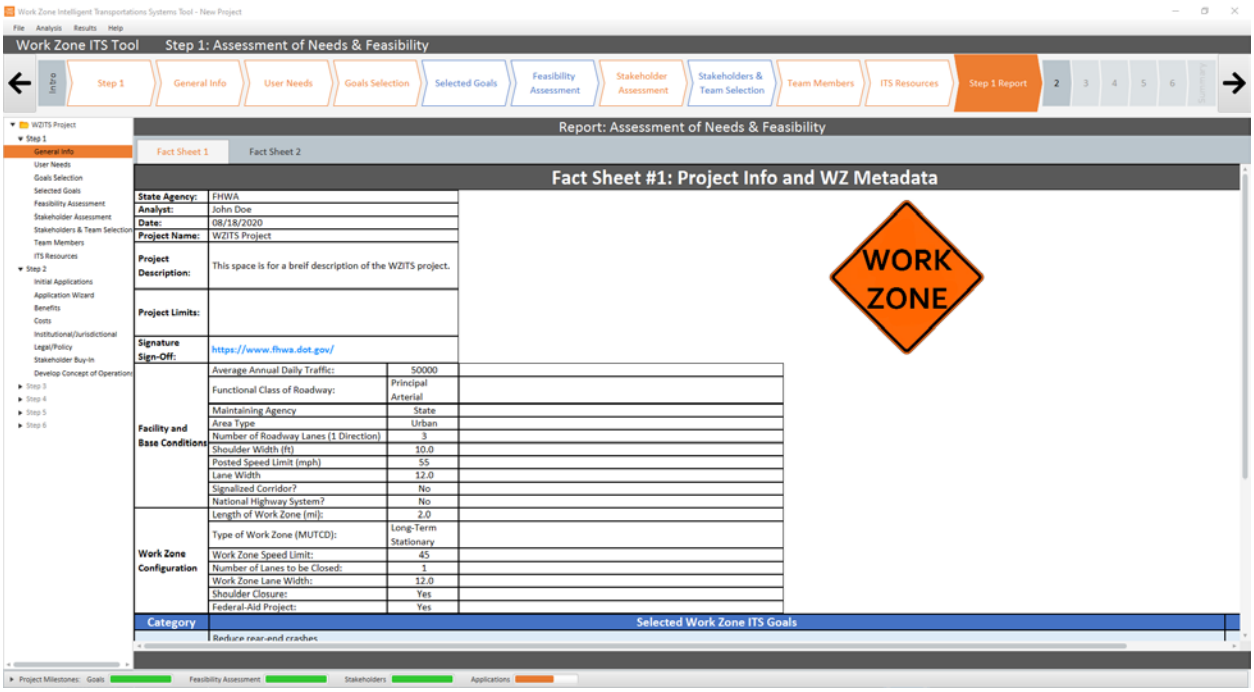


Figure 21: Example of the First Fact Sheet of Step 1.

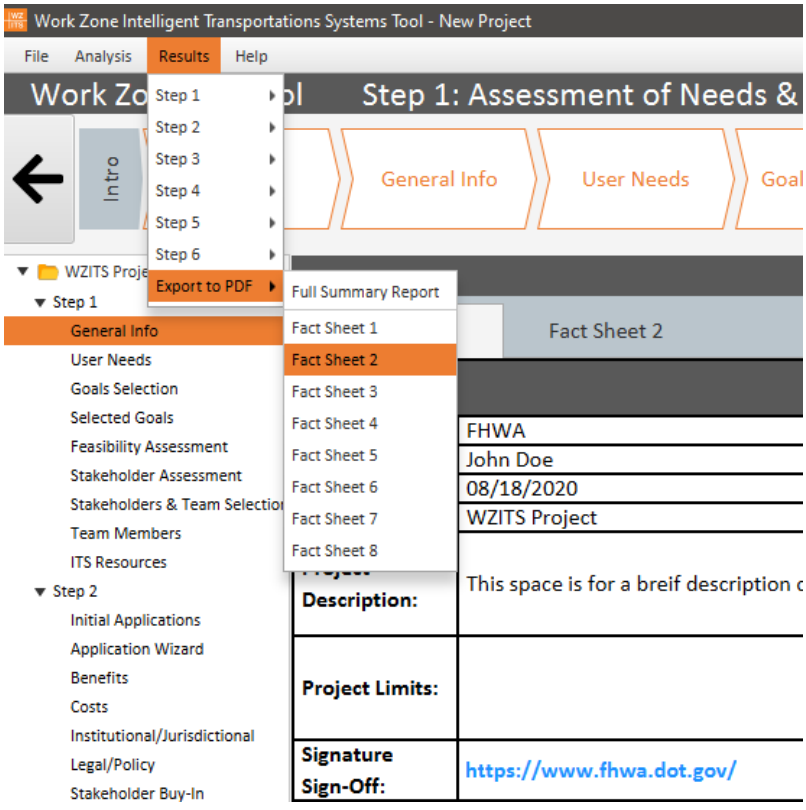


Figure 22: Demonstration of Exporting a Fact Sheet in PDF Format.

3 CASE STUDIES

This section presents a set of four case studies that demonstrate example usages of the WZITS Implementation Tool. The focus of these case studies is largely on the early stages of the WZITS process, because some of the projects had not actually gone through ConOps, procurement, deployment, and WZITS system evaluation at the time of writing. Therefore, the case studies are intended to illustrate how an agency can use the *Work Zone ITS Implementation Guide* and implementation tool to assist in evaluating WZITS feasibility, goal setting, application, and stakeholder involvement.

3.1 CASE STUDY 1: ROAD WIDENING IN RALEIGH, NC

The North Carolina Department of Transportation (NCDOT) completed a roadway widening project along Interstate I-40 in Raleigh, NC in 2011. This case study assumes that the implementation tool had been applied to the project prior to construction.

The project widened 6.2 miles of I-40 from west of Wade Avenue (State Road 1728) to east of the Jones Franklin Road (S.R. 5039) bridge. The project's stated goal was to reduce congestion and improve traffic flow in one of the most heavily congested areas in the Research Triangle. An overview map of the project is shown in Figure 23.

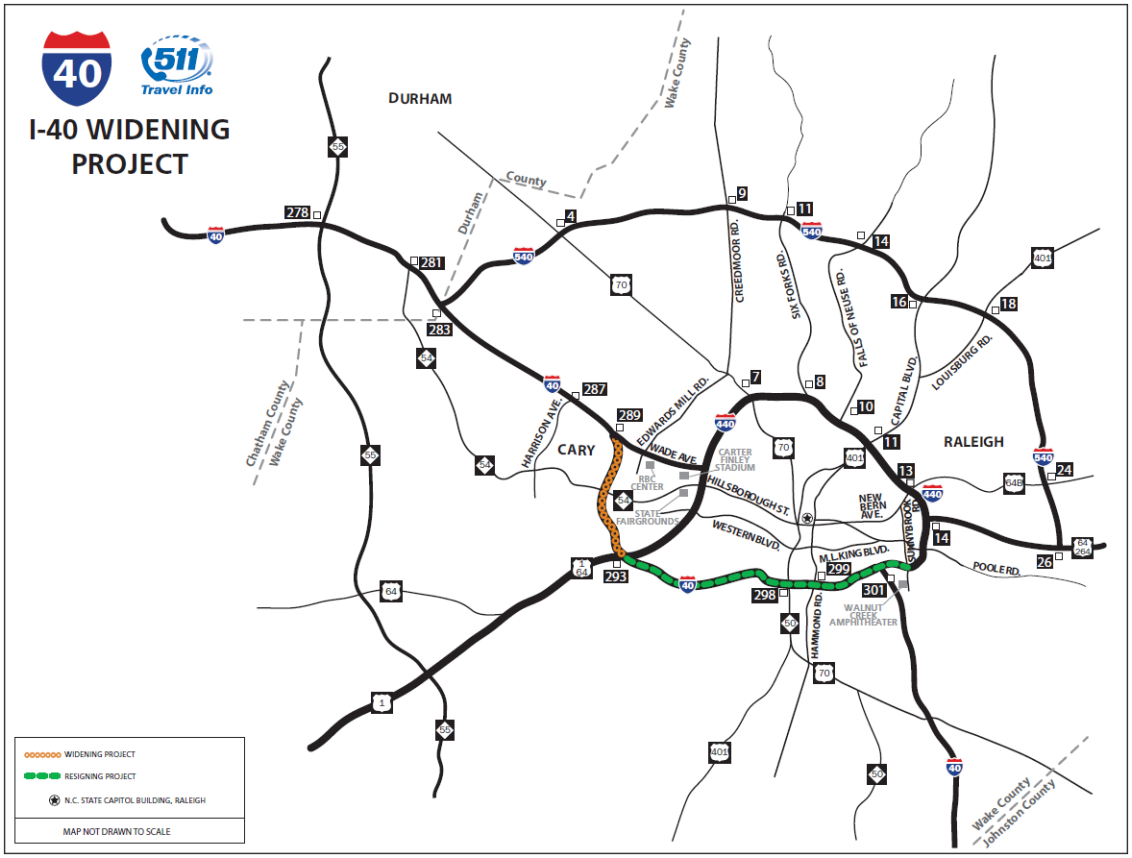


Figure 23: Raleigh, NC Case Study Overview (Source: NCDOT)

Lane closures were allowed between 9 p.m. and 6 a.m. Monday through Friday, until 9 a.m. on Saturday, and until 10 a.m. on Sunday. One extended weekend lane closure was allowed to occur from 9 p.m. Friday to 6 a.m. Monday in the eastbound lanes between Harrison Avenue and Wade Avenue.

The project was constructed using the design–build method. Design–build is an innovative procedure that allows NCDOT to conduct a project's design, environmental permitting, right-of-way acquisition, utility relocation, and construction concurrently under one contract. These steps help reduce construction time and help the department avoid cost inflation.

To minimize impact from construction vehicles, the contractor installed two conveyer belt systems near the N.C. 54 interchange to transport stone and asphalt to the median area. The contractor estimated that the use of the conveyors eliminated 237 lane closures and nearly 12,000 truck trips that otherwise would have been needed to haul the materials from the I-40 travel lanes. The conveyer belt system is shown in Figure 24.

Figure 24: Photos of the Raleigh, NC Case Study Conveyer Belt System

Following the guidance in *Work Zone ITS Implementation Guide* and the implementation tool's wizards, information about the I-40 widening project was used to complete Step 1 and Step 2 of the work zone assessment process to determine the following:

- System goals;
- Feasibility of the project as a Smart Work Zone;
- Most applicable Smart Work Zone applications; and
- List of stakeholders.

Starting with the Goal Wizard, a series of twenty questions were answered related to the roadway geometry, expected congestion and queuing, and performance targets. Based on these responses, the wizard recommended a number of goals in the mobility, safety, productivity, regulatory, and traveler information categories and provided a ranking for each of these recommended goals (see Table 1). For the I-40 case study, the highest-ranked goals were:

- Mobility: reduce variability of travel times,
- Safety: reduce rear-end crashes, and
- Regulatory: Monitor work zone operations and safety in real-time.

Additional mobility goals included reducing delays and single-vehicle trips through the work zones. Additional safety goals included reducing secondary crashes and incident clearance times. These recommendations matched well with NCDOT's focus and policy for this work zone.

Table 1: Goal Wizard Output for the Raleigh, NC Case Study

Category	Recommended User Goals by WZITS Tool	Score
Mobility Goals	Reduce variability of travel times	High
	Reduce daily peak period delays to XX minutes	Medium
	Reduce the number of single-vehicle trips through the work zone	Medium
	Facilitate the movement of emergency and construction vehicles through the work zone	Medium
Safety Goals	Reduce rear-end crashes	High
	Reduce secondary incidents	Medium
	Reduce Incident Clearance Times	Medium
	Provide a safe environment for roadway users and worker safety	Medium
	Work toward zero work zone fatalities	Medium
Productivity Goals	Minimize delays in construction vehicle access to the work zone	Low
	Provide an egress from work zone for haul vehicles	Low
Regulatory Goals	Monitor work zone operations and safety performance in real-time	High
	Reduce work zone delays to within XX minutes	Medium
	Monitor alternative route operations and safety performance in real-time	Medium
	Optimize contractor work periods	Medium
Traveler Information Goals	Provide roadway users real-time work zone information	Medium
	Provide roadway users real-time alternate route information	Medium

Next, the Feasibility Wizard was used to answer a series of questions related to work zone duration, impacts, and delays, along with specific issues affecting the work zone. Based on the answers to these questions, an ITS feasibility score was generated for the project. The Feasibility Wizard provides one of three outcomes: (1) WZITS is recommended and will provide benefits, (2) WZITS may provide benefits, and (3) WZITS may not provide benefits. For this case study, the feasibility score was 36 points, which results in a recommendation that WZITS be designed and implemented for this project. A score of 30 or more suggests that ITS is likely to provide significant benefits and should be considered as a treatment to mitigate impacts.

The Application Wizard was then applied to generate a recommendation for the type of WZITS to implement. A series of questions were answered that were based on the goal categories but related to the construction project. The answers to these questions were used to recommend WZITS applications, as shown in Table 2. For the I-40 case study, the top two recommended applications were:

- Queue warning system, and
- Real-time traveler information system.

Table 2: Application Wizard Output for the Raleigh, NC Case Study

Recommended WZITS Applications	Score
Queue Warning	High
Real-time Traveler Information	High
Incident Management	Medium
Variable Speed Limit	Medium
Performance Measurement	Medium
Dynamic Lane Merge	Medium
Temporary Ramp Metering	Low
Construction Vehicle Entrance/ Exit Warning	Low

The Stakeholder Wizard was applied to the case study to assist the NCDOT project designer with determining the project stakeholders. This wizard asks a series of questions related to the project and the land use surrounding the work zone. Based on the answers to the questions, the wizard recommended a list of potential stakeholders for the project, as shown below in Table 3.

Table 3: Recommended Stakeholder List for the Raleigh, NC Case Study

Recommended Stakeholders by WZITS Tool	Score
FHWA Division Office	High
Local police	High
Motorists	Medium
Traffic Management Center	Medium
Local businesses	Medium
EMS	Medium
Commercial trucking companies	Medium
Incident management agencies	Medium
State DOT	Medium
Transit agency	Medium
Fire department	Medium
Media	Medium
City transportation agency	Low
Shopping centers	Low
Local residents	Low
Special event venue	Low
County transportation agency	Low
MPO	Low
Service patrol/ contractors	Low
Construction contractors	Low
Public officials	Low
Schools/ Universities	Low
Convention/ Visitors Bureau	Low
State police	Low

3.2 CASE STUDY 2: BRIDGE REPLACEMENT IN ANDOVER, MA

In this case study, the Massachusetts Department of Transportation (MassDOT) plans to replace a bridge on Interstate 495 that crosses over Route 28 in Andover, MA. Figure 25 shows an aerial view of the project location.

Figure 25: Overview of the Bridge Replacement Case Study in Andover, MA

The project will take place over a four-year staged construction period. The construction project will have the following four stages:

- Stage 1 (6 months) — Construct a temporary bridge in the existing median.
- Stage 2 (18 months) — Move I-495 northbound traffic to the temporary bridge, demolish the existing I-495 northbound bridge and reconstruct a new I-495 northbound bridge.
- Stage 3 (18 months) — Move I-495 northbound traffic to the new bridge, shift I-495 southbound traffic to the temporary bridge, demolish the I-495 southbound bridge and reconstruct a new I-495 southbound bridge.
- Stage 4 (6 months) – Shift traffic to the newly constructed I-495 southbound bridge and remove the temporary bridge in the median.

Various traffic characteristics are known about the roadway and about the temporary bridge that will be constructed. Following the guidance in *Work Zone ITS Implementation Guide* and the implementation tool's wizards, the information about the bridge replacement project was used to complete Step 1 and Step 2 of the work zone ITS assessment process and determine the following:

- System goals,
- Feasibility of the project as a Smart Work Zone,
- Most applicable Smart Work Zone applications, and
- List of stakeholders.

Starting with the Goal Wizard, a series of twenty questions were answered related to the roadway geometry, expected congestion and queuing, and performance targets. Based on the responses, the goal wizard output matrix provided a number of goals in the mobility, safety, productivity, regulatory, and traveler information categories and also provided a ranking for each of the associated goals (see Table 6).

The Goal Wizard assists agencies in determining goals for their projects. For the I-495 case study, the highest ranked goal is in the safety category: reduce rear-end crashes. Additional goals include reducing secondary crashes and incident clearance times. In the mobility category, it is recommended that delays are reduced to within MassDOT's adopted 12-minute rule and to reduce travel time variability.

Table 4: Goal Wizard Output for the Andover, MA Case Study.

Category	Recommended User Goals by WZITS Tool	Score
Mobility Goals	Reduce daily peak period delays to 12 minutes	Medium
	Reduce variability of travel times	Medium
	Facilitate the movement of emergency and construction vehicles through the work zone	Medium
	Reduce the number of single-vehicle trips through the work zone	Medium
Safety Goals	Reduce rear-end crashes	High
	Reduce secondary incidents	Medium
	Reduce Incident Clearance Times	Medium
	Provide a safe environment for roadway users and worker safety	Medium
	Work toward zero work zone fatalities	Medium
Productivity Goals	Minimize delays in construction vehicle access to the work zone	Low
	Provide an egress from work zone for haul vehicles	Low
Regulatory Goals	Monitor work zone operations and safety performance in real-time	Medium
	Reduce work zone delays to within XX minutes	Medium
	Monitor alternative route operations and safety performance in real-time	Low
	Optimize contractor work periods	Low
Traveler Information Goals	Provide roadway users real-time work zone information	Low
	Provide roadway users real-time alternate route information	Low

Next, the Feasibility Wizard was used to answer a series of questions related to the work zone duration, impacts, and delays, along with specific issues affecting the work zone. Based on the answers to these questions, an ITS feasibility score was generated for the project. The Feasibility Wizard provides one of three outcomes: (1) WZITS is recommended and will provide benefits, (2) WZITS may provide benefits, and (3) WZITS may not provide benefits. For this case study, the feasibility score was 37 points, which results in a recommendation that WZITS be designed and implemented for this project. A score of 30 or more suggests that ITS is likely to provide significant benefits and should be considered as a treatment to mitigate impacts.

The Application Wizard was then applied to generate a recommendation for the type of WZITS to implement. A series of questions were answered that were based on the goal categories but related to the construction project. The answers to these questions were used to recommend WZITS applications, as shown in Table 5. For the I-495 case study, the top two recommended applications to be implemented are:

- Real-time traveler information system, and
- Queue warning system.

Table 5: Application Wizard Output for the Andover, MA Case Study.

Recommended WZITS Applications	Score
Real-time Traveler Information	High
Queue Warning	Medium
Incident Management	Low
Variable Speed Limit	Low
Performance Measurement	Low
Dynamic Lane Merge	Low
Automated Enforcement	Low
Construction Vehicle Entrance/ Exit Warning	Low
Temporary Ramp Metering	Low

The Stakeholder Wizard was applied to the case study to assist the MassDOT project designer with determining the project stakeholders. The stakeholder wizard asks the user a series of questions related to the project and the land use surrounding the work zone. Based on the answers to the questions, the wizard recommends a list of potential stakeholders for the project, as shown below in Table 6.

Table 6: Recommended Stakeholder List for the Andover, MA Case Study.

Recommended Stakeholders by WZITS Tool	Score
Traffic Management Center	High
Commercial trucking companies	Medium
Motorists	Medium
Local businesses	Medium
State DOT	Low
Service patrol/ contractors	Low
Construction contractors	Low
EMS	Low
Media	Low
Incident management agencies	Low
Local police	Low
County transportation agency	Low
MPO	Low
FHWA Division Office	Low
Fire department	Low
Public officials	Low
City transportation agency	Low
State police	Low
Shopping centers	Low
Local residents	Low
Special event venue	Low

3.3 CASE STUDY 3: NORTH WASHINGTON BRIDGE IN BOSTON, MA

The Massachusetts Department of Transportation (MassDOT), in conjunction with the City of Boston, plans to replace the North Washington Street Bridge between Boston's North End and Charlestown neighborhoods. Figure 26 shows the project limits.

Figure 26: North Washington Street Bridge Project (Source: MassDOT).

The project will take place over a three-year staged construction period. The construction project will have the following four stages (and sub-stages):

- Stage 1A — Closes the sidewalk on the east side of the bridge and establishes the work zone. Shared bicycle lane markings (sharrows) are added.
- Stage 1B — Reduces the bridge capacity from four lanes to two lanes with all travel on the west side of the bridge. Detours are put in place.
- Stage 2 — Provides an additional travel lane for a total of three lanes: one inbound into the North End and two outbound exiting the North End.
- Stage 3 — Shifts the three lanes of traffic to the east side of the bridge.
- Stage 4A — Reopens all four lanes for travel and provides a one-way buffered bicycle lane and sidewalk on the west side of the bridge.

- Stage 4B — Maintains the travel lanes provided in Stage 4A but the transition areas entering and exiting the bridge structure shift the work zones to allow the final stages of the project to tie into the existing City streets.

Various traffic characteristics are known about the roadway and the planned work zone. Using the implementation tool, the following information was completed for the project:

- Assessment of Needs;
- Concept Development and Feasibility;
- Detailed System Planning and Design;
- Procurement;
- System Deployment; and
- System Operation, Maintenance, and Evaluation.

The Goal Wizard provided recommended user goals, as shown in Table 7. The WZITS feasibility score generated by the Feasibility Wizard was 35. A score of 30 or more suggests that ITS is likely to provide significant benefits and should be considered as a treatment to mitigate impacts. Based on the project goals and the overall WZITS feasibility, the Application Wizard then provided a set of recommended work zone ITS applications, as shown in Table 8.

Table 7: Goal Wizard Output for the Boston, MA Case Study.

Category	Recommended User Goals by WZITS Tool	Priority
Safety Goals	Work toward Zero work zone fatalities	Medium
	Reduce rear-end crashes	Medium
	Provide safe environment for roadway users and worker safety	Low
Mobility Goals	Reduce variability of travel times	Medium
	Reduce the number of single-vehicle trips through the work zone	Medium
Regulatory Goals	Optimize contractor work periods	Low
Traveler Info Goals	Provide roadway users real-time work zone information	Medium
	Provide roadway users real-time alternative route information	Medium

Table 8: Application Wizard Output for the Boston, MA Case Study.

Recommended WZITS Applications	
Queue Warning	Medium
Real-time Traveler Information	High
Incident Management	Low
Dynamic Lane Merge	Low
Variable Speed Limit	Medium
Automated Enforcement	Low
Construction Vehicle Entrance/ Exit Warning	Not Recommended
Temporary Ramp Metering	Low
Performance Measurement	Medium

The WZITS tool recommended that one or more ITS solutions be incorporated into the project, along with a number of identified goals for the deployment. The tool further identified a number of potential strategies to consider for the project.

3.4 CASE STUDY 4: ROADWAY WIDENING IN ASHE COUNTY, NC

The North Carolina Department of Transportation (NCDOT) is widening U.S. 221 from U.S. 421 in Deep Gap to U.S. 221 Business/N.C. 88 in Jefferson, NC. The 16.1-mile project will widen the main corridor into Ashe County for commuters and commercial vehicles into a four-lane median-divided highway. Figure 27 provides an overview map of the project.

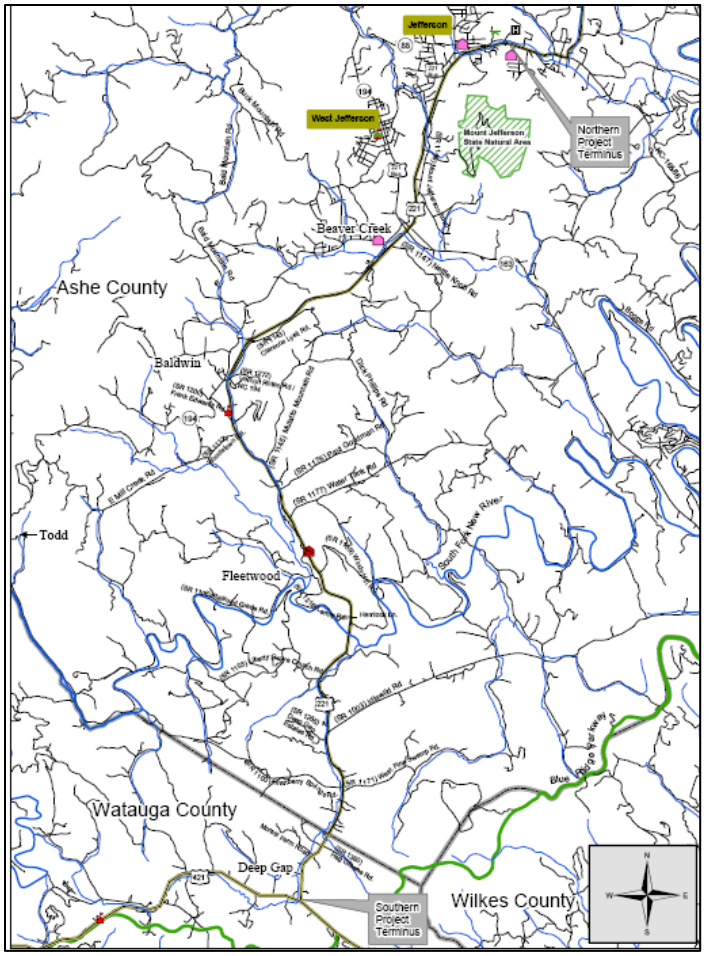


Figure 27: NCDOT US 221 Case Study Overview (Source: NCDOT).

As planned, the project work includes the following five sections:

- Section A — U.S. 421 to Idlewild Road in Watauga and Ashe counties (2.8 miles)
- Section B — Idlewild Road to North of South Fork New River in Ashe County (1.8 miles)
- Section C — South Fork New River to South of N.C. 194 in Ashe County (4 miles)
- Section D — South of N.C. 194 to North of N.C. 163 in Ashe County (4 miles)
- Section E — N.C. 163 to U.S. 221 Business/N.C. 88 in Jefferson (3.5 miles)

Various traffic characteristics are known about the roadway and the planned work zone. Using the implementation tool, the following information was completed for the project:

- Assessment of Needs;
- Concept Development and Feasibility;
- Detailed System Planning and Design;
- Procurement;
- System Deployment; and
- System Operation, Maintenance, and Evaluation.

Applying the Goal Wizard generated the set of recommended user goals shown in Table 9. The WZITS feasibility score generated by the Feasibility Wizard was 20. This score suggests that ITS may provide some benefits on the predominantly rural facility and should be considered as a treatment to mitigate impacts. A score of 30 or more suggests that ITS is likely to provide significant benefits and should be considered as a treatment to mitigate impacts. Based on the project goals, the Application Wizard then provided a set of recommended WZ ITS applications, which are summarized in Table 10.

Table 9: Goal Wizard Output for the US 221 Case Study.

Category	Recommended User Goals by WZITS Tool	Priority
Safety Goals	Reduce secondary incidents	Medium
	Reduce incidence clearance times	Medium
	Work towards zero work zone fatalities	Medium
	Provide a safe environment for roadway users and worker safety	Medium
Productivity Goals	Provide an egress from work zone for haul vehicles	Low
Regulatory Goals	Optimize contractor work periods	Low

Table 10: Application Wizard Output for the US 221 Case Study.

Recommended WZITS Applications	
Queue Warning	Low
Real-time Traveler Information	Low
Incident Management	Low
Dynamic Lane Merge	Not Recommended
Variable Speed Limit	Low
Automated Enforcement	Low
Construction Vehicle Entrance/ Exit Warning	Low
Temporary Ramp Metering	Low
Performance Measurement	Medium

The implementation tool recommended that one or more ITS solutions should be considered for the project and identified a number of potential goals for the deployment. The tool further

identified a number of potential strategies to consider for the project, although they generally scored low compared to the previous case studies.

4 REFERENCES

Federal Highway Administration, Work Zone Intelligent Transportation Systems Implementation Guide, January 2014

Massachusetts Department of Transportation. 2017.

North Carolina Department of Transportation. 2017.