



Transportation Management Center Staffing and Scheduling for Day-to-Day Operations

Final Tool Enhancement Document

March 2006

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| 16. Abstract The TMC Staffing and Scheduling Tool is a software tool designed to assist TMC managers in making scheduling decisions. The Tool Enhancement Document identifies desirable functions and features that could be included in an interactive software tool developed in a subsequent phase of this task order. This document contains, at a high level, the functional requirements of the tool, expected system and software requirements, identification of relevant standards, and a notional top-level design (for illustration purposes only). | | | |
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1 Introduction

1.1 Identification

The research presented in this document was performed by the Georgia Tech Research Institute (GTRI) under the sponsorship of the Federal Highway Administration (Contract No. DTFH61-01-C-00049). The contract officer's task order manager (COTM) is Raj Ghaman. The GTRI project director for this contract is Dr. Dennis J. Folds. The work was performed by researchers in GTRI's Electronic Systems Laboratory (ELSYS).

1.2 Purpose

The effective and efficient operation of transportation management centers (TMCs) depends on numerous factors including the utilization of human resources. The development of staff planning and scheduling systems to support the day-to-day operations of TMCs has been limited. The primary objective of the contract is to provide a Technical Document for managers, supervisors, human resources personnel, and private contractors who are responsible for TMC staffing and scheduling that addresses the concepts, methods, processes, tasks, techniques, and other issues related to work analysis, scheduling, and staff planning. The second objective is to create an easy-to-use tool that will assist TMC managers in making staff planning and scheduling decisions. The third objective is to define the functional requirements for an interactive software tool, to be developed in a subsequent initiative, that will fully support TMC managers in making staffing and scheduling decisions.

The present document addresses the third objective described above. This Tool Enhancement Document identifies desirable functions and features that could be included in an interactive software tool developed in a subsequent phase of this task order. This document contains, at a high level, the functional requirements of the enhanced tool, expected system and software requirements, identification of relevant standards, and a notional top-level design (for illustration purposes only).

1.3 Reference Documents

The *Tool Evaluation Report* developed in Task D of this project documents the results of an evaluation of the initial TMC Staffing and Scheduling Tool. Many of the recommendations that came from that evaluation were incorporated into the final version of the simple tool, and some additional recommendations that were beyond the scope of the simple tool were brought forward into this document as requirements. The *Tool Evaluation Report*, taken as a companion document to the present document, provides additional insight into the source of many of the requirements documented herein. It also contains some useful feedback from a member of the actual user population for the tool.

2 Functional Requirements for the Enhanced Tool

The functional requirements documented in this section address two broad areas of requirements: software capabilities that will be provided by the TMC Staffing and Scheduling Tool (hereafter referred to as “the tool”); and user interface features, including usability and accessibility requirements, that will be provided by the tool. The tool will consist of an online component (a web implementation of the technical document developed in Phase 1) and a downloadable component (a standalone software application, downloadable from the tool website).

2.1 General Tool Features

The general features of the tool consist of those features and functions that are not central to the performance of the tool, but serve to increase the usefulness, usability, and accessibility of the tool for all users.

2.1.1 Accessibility

The tool shall comply with the standards for accessibility set forth in the Electronic and Information Technology Accessibility Standards developed by the Access Board to implement Section 508 of the Rehabilitation Act (29 U.S.C. 794d), as amended by the Workforce Investment Act of 1998. (FRS Req. 1) The tool will comply with the standards in sections 1194.21 (Software Applications and Operating Systems), 1194.22 (Web-based Intranet and Internet Information and Applications), 1194.31 (Functional Performance Criteria), and 1194.41 (Information, Documentation, and Support) of the Section 508 standards as appropriate based on the final implementation of the tool.

2.1.2 Usability

The tool shall adhere to established human factors principles of good user interface design. (FRS Req. 2)

2.1.3 Logos

The tool shall contain all of the standard logos, meta tags, contact information, and other such material required by DOT and FHWA. (FRS Req. 3)

2.2 Online Component

The online component of the tool consists primarily of a web implementation of the technical document developed in Phase 1 of the project, supplemented with additional material developed specifically for the enhanced tool.

2.2.1 Provide Access to Technical Document

The tool shall provide access to the full text of the Transportation Management Center Staffing and Scheduling for Day-to-Day Operations document. (FRS Req. 4) The Transportation Management Center Staffing and Scheduling for Day-to-Day Operations document is the technical document developed in Phase 1 of this project. The tool will allow users to view (browse) the technical document within the tool interface, and will also allow users to download the complete text of the technical document in a format that

can be viewed independently of the tool interface (such as Microsoft Word or Adobe PDF).

2.2.2 Provide Access to Supplemental Material

The tool will provide access to supplemental material (beyond the contents of the Phase 1 technical document). This supplemental material will include introductory text, tutorials and case studies, a glossary and list of acronyms, and online help for the downloadable component of the tool.

2.2.2.1 Provide Introductory Text

The tool shall provide introductory text describing the content, purpose, and intended audience of the tool. (FRS Req. 5)

2.2.2.2 Provide Tutorials and Case Studies

The tool shall provide tutorials and case studies on various topics that compliment the contents of the technical document. (FRS Req. 6) This supplemental material should elaborate on or illustrate concepts presented in the technical document. For example, a tutorial on how to use a simulation program to model demand, or case studies on staffing and scheduling at various exemplar TMCs would be appropriate material to satisfy this requirement.

2.2.2.3 Provide Glossary

The tool shall provide a glossary that defines all terms used in the tool materials that are deemed to be in need of definition or explanation. (FRS Req. 7) The full glossary will be available for browsing, and certain terms in the text will link directly to their definitions in the glossary.

2.2.2.4 Provide List of Acronyms

The tool shall provide a list of acronyms that defines all acronyms used in the tool materials. (FRS Req. 8) The full list of acronyms will be available for browsing.

2.2.2.5 Provide Online Help

The tool shall provide online help for the downloadable component of the tool to assist users in using the software application. (FRS Req. 9) The online help will explain all of the features of the downloadable software application, describe all of the controls in the application, describe the inputs and outputs of the application, and provide examples illustrating the use of the application.

2.2.3 User Aids in the Online Component

The tool will contain user aids to make the tool more useful and usable for users. These user aids will include a search utility and navigation aids, and the ability to print any display of the online component of the tool.

2.2.3.1 Provide Search Utility

The tool shall provide a search utility that will allow users to enter search terms and receive search results in the form of a list of direct links to places in the tool text where the search terms were found. (FRS Req. 10)

2.2.3.2 Provide Navigation Aids

The tool shall provide navigation aids that will allow users to navigate quickly among the top-level tool pages, to navigate forward and back through series of pages, and to navigate up the page hierarchy from a lower level page to a higher level page. (FRS Req. 11) This functionality will be provided by a navigation bar that is present on the left side of every screen, and by the “Previous,” “Next,” and “Return” keys provided at the bottom of each page in a set of serial pages.

2.2.3.4 Printing

The tool shall allow printing of any information display provided to the user by the online component of the tool. (FRS Req. 12)

2.3 Downloadable Component

The downloadable component of the tool is a standalone software application (referred to hereafter as “the application”) that can be downloaded from the tool website. This application accepts user input related to employee preferences, available shifts, demand, and other factors, and uses an algorithm to compute staffing levels and employee schedules based on those inputs.

2.3.1 Accept User Input

Users will be required to provide input to the application (including employee preferences, shift definitions, and demand data, among other inputs) that the application will subsequently use to develop staffing and scheduling outputs. The application will allow users to save inputs to a file and reload them later, so users will not have to start from scratch every time they use the application.

2.3.1.1 Accept Employee Inputs

The application shall allow users to input the total number of employees available to be scheduled. (FRS Req. 13) Users can specify any number of employees (with a minimum of 1 employee required) for the application’s staffing and scheduling algorithm to use when computing its outputs.

The application shall allow users to optionally provide names for employees. (FRS Req. 14) Employees will be assigned generic default names (“Employee 1,” etc.), but users will be able to modify the default names to be employee-specific (“John Smith”), and the user-assigned names will be used when referring to the employees throughout the application.

The application shall allow users to input employee scheduling preferences. (FRS Req. 15) A preferences page will be available for each employee. Users will be able to specify the employee’s preferred shift assignment. Users will be able to specify

employee scheduling preferences (“do not schedule,” “try not to schedule,” “OK to schedule” (the default value), or “must schedule”) for every hour of every day in the planning period. Employee preferences will be taken into account by the application to the extent possible when outputs are calculated.

2.3.1.2 Accept Shift Inputs

The application shall allow users to add any number of shifts to which employees can be assigned. (FRS Req. 16) Users can define any number of shifts (with a minimum of 1 shift required) for the application’s staffing and scheduling algorithm to use when computing its outputs.

The application shall allow users to define the work period for each shift, on an hour-by-hour basis, out of a 24 hour day. (FRS Req. 17) Shifts can be full or part time, with a work period of any integer number of hours (with a minimum of 1 and a maximum of 24 hours), and the hours worked during the shift can be contiguous or non-contiguous.

The application shall allow users to remove previously defined shifts. (FRS Req. 18) Users can selectively delete shifts that had previously been added. Users can select multiple shifts for simultaneous deletion. A confirmation prompt will be provided upon deletion to guard against accidental deletions.

The application shall allow users to optionally assign names to shifts. (FRS Req. 19) Shifts will be assigned generic default names (“Shift 1,” “Shift 2,” etc.), but users will be able to modify the shift names to be more meaningful (“Day Shift,” “Second Shift,” “Evening Rush Hour,” etc.), and the user-assigned names will be used when referring to the shifts throughout the application.

2.3.1.3 Accept Demand Inputs

The application shall allow users to enter the demand (in terms of number of employees required) during each hour of each day of the planning period. (FRS Req. 20) For example, if the planning period is one week, one week’s worth of demand information will be entered, and the application will calculate schedules for a one week period.

2.3.1.4 Save and Load User Inputs

The application shall allow users to save all input values to a file. (FRS Req. 21) The application shall allow users to load previously saved input values from a file. (FRS Req. 22) The application’s user input requirements can be fairly extensive, and it is undesirable to require users to start anew every time they use the application to compute additional schedules. The user data, including employee, shift, and demand inputs, will be saved locally in a human- and machine-readable file (perhaps comma or tab delimited).

The application shall prompt users to save modified data before exiting the program or loading a previously saved data file. (FRS Req. 23) If the input data has not been saved when the user attempts to exit the application or overwrite the current data by loading a

previously saved data file, the application will prompt the user to either save the current data or abandon changes and continue.

2.3.2 Generate Output

The application will use the input provided by the user to generate staffing and scheduling outputs, plus some other related outputs. Users will be able to export the output data to a file that can then be imported into another program, such as Microsoft Excel, and formatted for distribution.

2.3.2.1 Generate Staffing Outputs

The application shall generate staffing outputs. (FRS Req. 24) Staffing outputs include such information as the number of employees that would be needed on each shift on each day in order to satisfy the specified demand.

2.3.2.2 Generate Scheduling Outputs

The application shall generate scheduling outputs. (FRS Req. 25) Scheduling outputs include work schedules (work day and work shift assignments) for each employee, taking into account (to the extent possible) employee preferences.

2.3.2.3 Generate Other Outputs

The application shall calculate numeric assessments of schedule quality. (FRS Req. 26) These numeric values may include the number of hours of overstaffing or understaffing in the calculated schedule, and the scheduling efficiency, which is the number of employee hours required divided by the number of employee hours scheduled.

The application shall allow users to input the parameters needed for the program to calculate the relief factor. (FRS Req. 27) The relief factor is a multiplier that takes into account the average number of vacation days, sick days, and other days off per employee per year. The number of positions that need to be staffed is multiplied by the relief factor to yield the actual number of employees needed to staff that number of positions.

2.3.2.4 Export Outputs

The application shall allow users to export the calculated outputs to a file. (FRS Req. 28) The output data, including the staffing and scheduling outputs, schedule quality parameters, and the relief factor, will be exported to a local human- and machine-readable file (perhaps comma or tab delimited). The schedule output will be able to be imported into a program such as Microsoft Excel so that it can be formatted for distribution (for example, to notify employees of their work schedules).

2.3.3 User Aids in the Downloadable Component

The application shall provide status information and error messages. (FRS Req. 29) Examples may include a message stating that the currently displayed outputs are out of date because the inputs have been subsequently modified, and a message indicating that the specified demand cannot be met using the shifts that have been defined. The error messages will be clear and concise, and displayed prominently and in a timely manner.

The application shall provide access to the online help system provided on the tool website. (FRS Req. 30) This access may be provided in the form of hyperlinks or other navigation controls that will bring up a web browser and display the appropriate help content.

The application shall provide mouse-hover "tool tips" on all major interface elements. (FRS Req. 31) The tool tips will not take the place of the help content provided in the tool, but will instead serve as a “quick reference” to provide users with a quick reminder of the function of each element.

3 System and Software Requirements for the Enhanced Tool

3.1 Approach

As discussed above, the tool will consist of two components, each with different requirements: an online component and a downloadable component.

3.1.1 Online Component

The online component of the tool is basically a web implementation of the Phase 1 technical document. A client-server approach is recommended for the architecture of the online component of the tool. This approach allows for centralized storage of the underlying data on a dedicated server, and multiple, distributed clients that access the data. Although the data supporting the tool is expected to be static, this approach allows for easy updates to the data if the need arises.

A review of the functional requirements for the tool shows that much of the required capability is already offered by commercial-off-the-shelf (COTS) web browser applications. Web browsers offer the basic browsing, navigation, search, and printing capabilities that are required in the tool. Another advantage to this approach is that it is basically platform independent; almost any web browser in almost any operating system will be able to display the information provided by the tool.

3.1.2 Downloadable Component

The downloadable component of the tool is a standalone software application that can be downloaded from the tool website. Implementing the tool as an online web application was considered and rejected on the grounds that the benefits (one centralized copy of the code, fully web-based tool) were outweighed by the costs (complexity of implementing tool on the web, difficulty allowing data to be saved locally by an online tool). Instead, it is recommended that the application be written as a Java application that can be downloaded from the tool website.

Early in the design process, implementing the tool as an Excel spreadsheet was considered and rejected on the grounds that the algorithms that form the basis of the tool were too complex to be reasonably implemented in a spreadsheet. The Python programming language was also considered and rejected because setting up a client machine to run Python programs is somewhat complex for non-technical users.

Writing the application in Java offers several benefits. The software can be run on multiple platforms without modification (only the installation process and the way the software is packaged needs to be changed to run the software on a new platform). Java also provides a complete user interface library (Swing) and is available for a variety of platforms with easy installation. The Java Runtime Environment (JRE) is free, is easy for non-technical users to install, and is often already present on client machines.

3.2 Recommended Software Components

The software components of the online component of the tool include three commercial-off-the-shelf (COTS) tools: a web browser, a web server, and an indexing program for the search facility. COTS Perl script code will be used to perform searches and return search results. Custom script code written by the software development team will be used to implement the appearance of tool web pages. It is recommended that these scripts be written in PHP, a scripting language that can be executed as server-side CGI scripts.

The only software required to run the downloadable component of the tool on the client machine (besides the downloaded software application itself) is the Java Runtime Environment.

3.2.1 Client Web Browser

Users will access the tool using a client web browser application, which is used to view and interact with all elements of the tool. The web browser provides important functionality, such as the ability to download files to the user's local machine, and the ability to print any page in the tool. The web browser is a commercial-off-the-shelf (COTS) application and does not require any custom software.

3.2.2 Web Server

The web browser interacts with the web server over a network connection, using the Hypertext Transfer Protocol (HTTP). The server is responsible for receiving the data request from the client and serving the requested data back to the client. The Apache HTTP server, a secure, efficient, and extensible open-source HTTP server that is used by more than 70% of the websites on the Internet, is recommended as the web server for this tool.

3.2.3 Search Indexing Program

Swish-e, a fast, flexible, open-source indexing system, is recommended as the search indexing program for the tool. Swish-e provides an indexing program (written in C) that resides on the server as an executable. When executed, this program parses the website and builds a searchable index file containing all of the words found in the website. This program is executed by site administrators, and only needs to be executed when the static content of the site is modified.

3.2.4 Dynamic Web Services

For maximum flexibility and maintainability, the pages of the tool should be constructed dynamically (e.g., pages are all constructed using the same header, footer, and left navigation bar, with page-specific content in the main content area). These dynamic pages are created by custom scripts that are embedded into the source files and are executed by the server. The PHP (a recursive acronym for "PHP: Hypertext Preprocessor") scripting language is recommended for this functionality. The PHP Module should reside on the server machine.

Swish-e uses Perl, another server-side scripting language, to create the search results page. A Perl interpreter, such as ActivePerl, should reside on the server machine.

3.2.5 Java Runtime Environment

The Java 2 Platform, Standard Edition (J2SE) Runtime Environment allows end-users to run Java applications. If the JRE is not already present on the client machine, the current version can be downloaded from <http://java.sun.com/j2se/index.jsp> and installed on the client machine.

3.3 Implementation of Online Component

The online component of the tool is presented to users as hypertext. This format is a widely accepted electronic presentation medium, and can be viewed in a variety of ways. The tool should follow standards for HTML formatting and accessibility, so that the full range of hypertext viewers (e.g., web browsers, screen readers, Braille screens) will be compatible with the tool, to the extent that those viewers comply with the specified standards.

More specifically, the tool uses HTML to present information and effect controls for navigation. All on-screen styling should be accomplished via standard Cascading Style Sheets so that no information elements are conveyed purely by styling or presentation medium. Also, the implemented HTML should contain shortcuts and navigation aids that are invisible to normal web browser users, but are crucial and expected by users accessing the tool via screen reader or other assistive technology.

The online component of the tool should be designed to be usable at screen resolutions of 800 x 600 and higher. The most common platform and browser among users is expected to be Microsoft Internet Explorer running on Microsoft Windows systems. Thus, Microsoft Internet Explorer (whatever version is current when the tool is implemented) under Microsoft Windows should be the target client. However, because various web browsers differ in their implementation of the HTML and CSS specifications, the site should also be fully tested in other web browsers. The developer should test the tool using Netscape under Microsoft Windows, and Mozilla under Linux (using the most current version of each browser at the time of testing), and ensure that the tool is fully operational in these browsers.

Each page in the tool should contain the FHWA logo. Each page should contain a unique (to the server), brief, descriptive page title not exceeding 150 characters. Each page should contain a standard header and footer. The home page should contain a link to a privacy policy statement.

3.4 Implementation of Downloadable Component

It is recommended that the downloadable component of the tool be implemented in Java, with a user interface designed graphically in the NetBeans IDE. NetBeans allows the interface to be designed quickly, and produces Java code that can be compiled without any special tools.

It is recommended that the code be structured so that the complicated scheduling algorithms are each contained in a separate class so that the code is easier to maintain. These algorithm classes should not contain any user interface code. Messages and

constant strings should be defined at the beginning of each class so that the text can be easily changed.

The application should be compiled and made available for the Windows platform at a minimum. For the Windows platform, the compiled Java code and a CMD file that the user runs in order to execute the application should be zipped into a self-extracting zip file. The user would download the self-extracting zip file from the tool website, extract the contents of the file to a location on the local machine, and run the CMD file to execute the application. Similar steps would be necessary to deliver the application for other platforms.

4 Relevant Standards for the Enhanced Tool

The Federal Aviation Administration's *Human Factors Design Standard* (HFDS), available at <http://hf.tc.faa.gov/hfds/default.htm>, provides a single easy-to-use source of human factors design criteria. The standards therein should be applied to the design and implementation of both the online component and the downloadable component of the tool.

The following sections list other standards that should be applied to the individual components of the tool.

4.1 Standards for the Online Component

The online component of the tool should be coded, to the extent possible, in accordance with the HTML Version 4.01 specification (see <http://www.w3.org/TR/html4/>) and the CSS Version 2.1 specification (see <http://www.w3.org/TR/CSS21/>).

The tool should comply with the standards for accessibility set forth in Section 1194.22 (Web-Based Intranet and Internet Information and Applications) of the Electronic and Information Technology Accessibility Standards developed by the Access Board to implement [Section 508 of the Rehabilitation Act](#) (29 U.S.C. 794d), as amended by the Workforce Investment Act of 1998. These standards codify the best practices for assuring that assistive technologies work with Internet-based presentations. The tool will also comply with the standards in sections 1194.31 (Functional Performance Criteria), and 1194.41 (Information, Documentation, and Support) of the Section 508 standards as appropriate based on the final implementation of the tool.

4.2 Standards for the Downloadable Component

The downloadable component of the tool should be coded, to the extent possible, in accordance with the *Code Conventions for the Java Programming Language* set forth by Sun. The document is available at <http://java.sun.com/docs/codeconv/>.

The application should comply with the standards for accessibility set forth in Section 1194.21 (Software Applications and Operating Systems) of the Electronic and Information Technology Accessibility Standards developed by the Access Board to implement [Section 508 of the Rehabilitation Act](#) (29 U.S.C. 794d), as amended by the Workforce Investment Act of 1998. These standards codify the best practices for assuring that assistive technologies work with software applications. The application will also comply with the standards in sections 1194.31 (Functional Performance Criteria), and 1194.41 (Information, Documentation, and Support) of the Section 508 standards as appropriate based on the final implementation of the application.

5 Notional Design for the Enhanced Tool

The following sections provide notional design information and illustrations for the online component and downloadable component of the tool. This information is presented for illustration purposes only and is not intended as a formal design specification.

5.1 Notional Design of the Online Component

Figure 1 illustrates the general page layout for the online component of the tool. The pages of the website are divided into four areas: a left navigation bar that extends the entire height of the page, a page header area (probably containing the FHWA logo and other constant page elements) at the top of the page, a page footer (probably containing contact information and other constant page elements) at the bottom of the page, and a content area where the page-specific content is displayed for each page in the site.

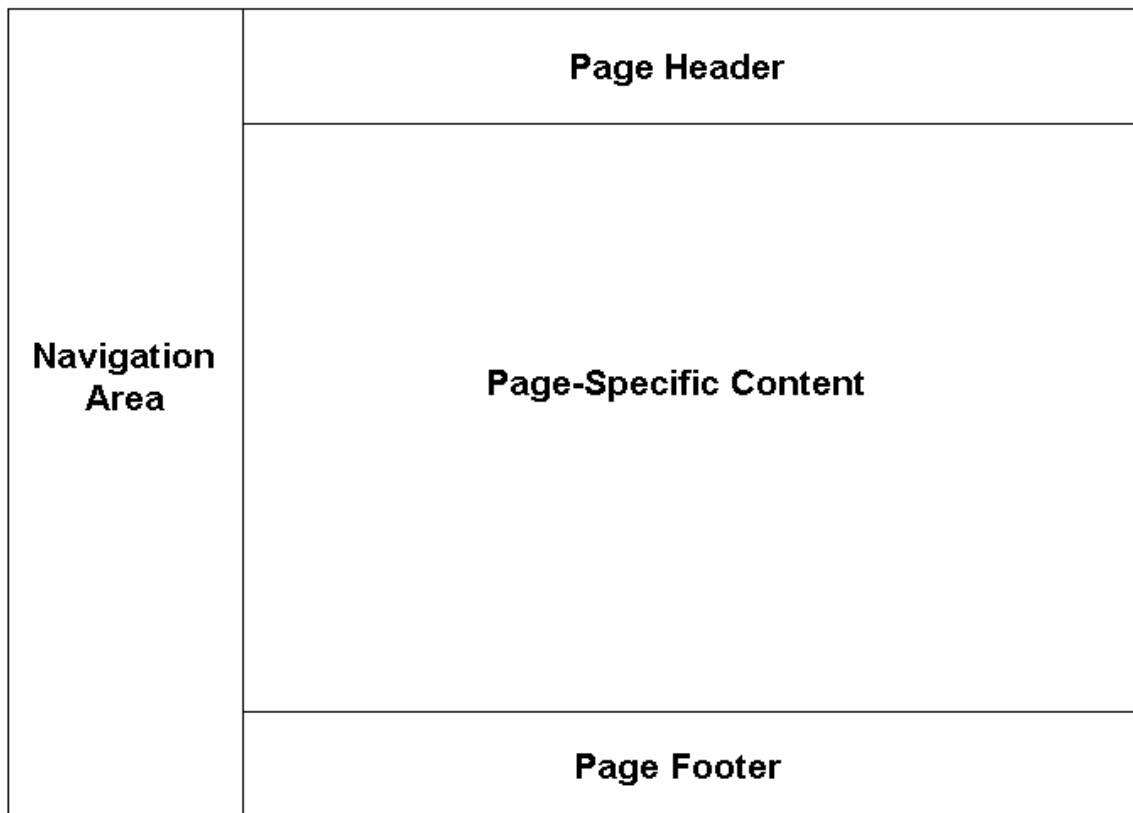


Figure 1: General page layout for the online component of the tool.

Figure 2 is a sample style illustration for the home page of the online component of the tool. The blue, white, and gray color scheme and the use of a sans-serif font is based on the current design of the FHWA website. Notice the FHWA logo prominently displayed at the top of the page in the page header area, and links to the major sections of the tool website displayed in the left navigation bar. (The page footer is not displayed.)

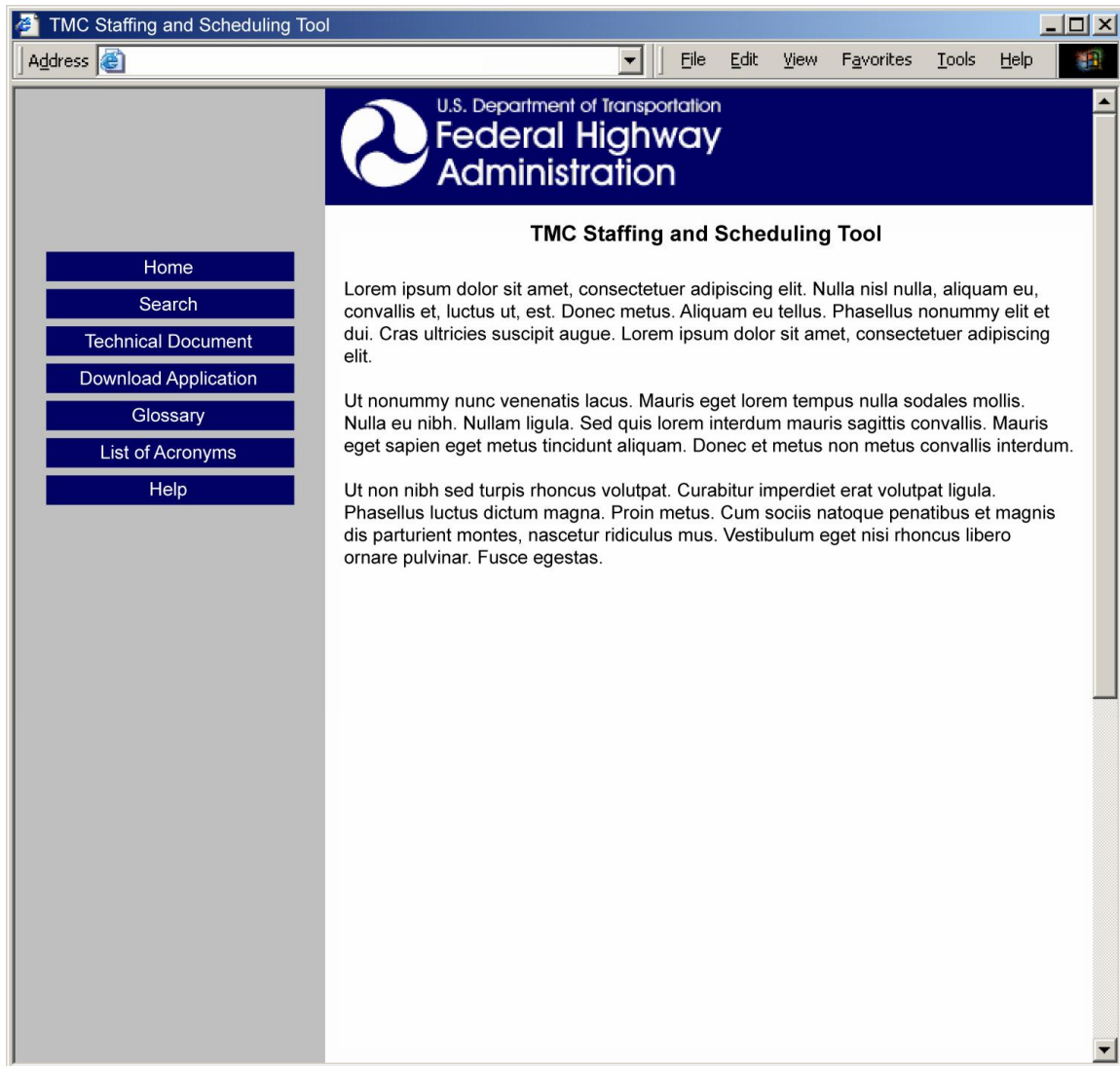


Figure 2: Sample style illustration for the online component of the tool. The tool home page is illustrated.

Figure 3 is a sample style illustration for a single page of the technical document in the online component of the tool. The left navigation bar and page header are constant elements that are the same on every page. Text from the technical document is displayed in the page-specific content area. Navigation controls that enable the user to step to the previous or next section of the document or return to the document table of contents are displayed at the bottom of the page. (The page footer is not displayed.)

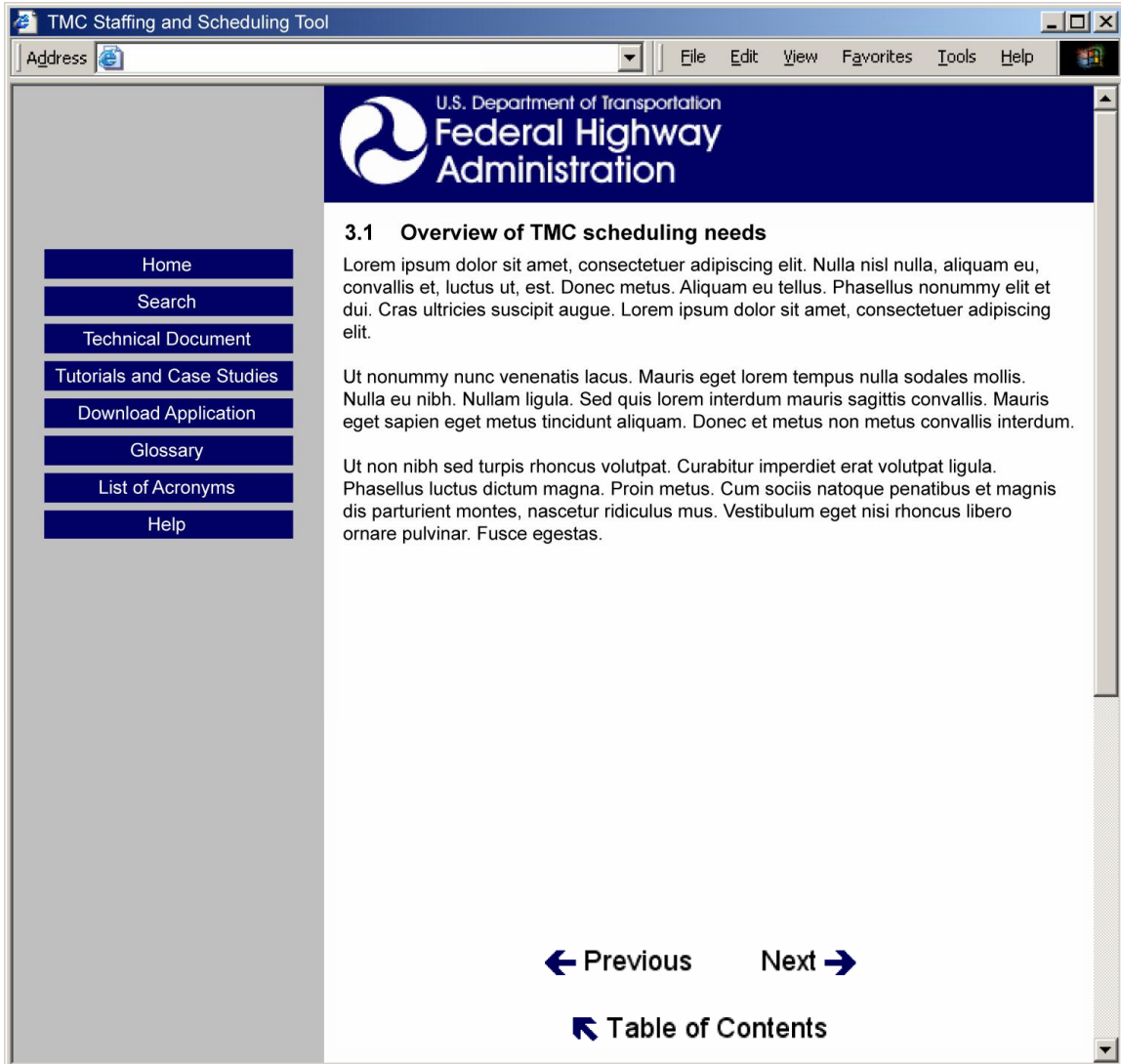


Figure 3: Sample style illustration for the online component of the tool. A page from the technical document, with navigation controls, is illustrated.

5.2 Notional Design of the Downloadable Component

Figure 4 is a sample style illustration for the Shifts and Demand tab of the downloadable component of the tool. The appearance of the interface elements in this illustration are typical of those created using the NetBeans IDE to create Java user interfaces.

An ordered, tabbed layout is used. In this design concept, the user would start by defining the employees and their scheduling preferences on the Employee Preferences tab. Next, the user would define the shifts to be used and the demand that must be satisfied. The user would press the Calculate button, and the calculated staffing and scheduling outputs would be displayed on the Schedule Output tab.

Calculation of the relief factor is separate from the main workflow through the tool, and is contained on a separate tab.

The screenshot shows the 'TMC Staffing and Scheduling Tool' window with four tabs: 'Employee Preferences', 'Shifts and Demand', 'Schedule Output', and 'Relief Factor'. The 'Shifts and Demand' tab is active. It contains an 'Inputs' section with a 'Shift work hours' table. The table has columns for Shift (1) and hours (0-23). Below the table are 'Add' and 'Remove' buttons. Further down is a 'Number of operators required by day and hour' table with columns for Day (Monday-Sunday) and hours (0-23). At the bottom of the window are 'Save...', 'Load...', and 'Calculate' buttons.

Figure 4: Sample style illustration for the downloadable component of the tool. The “Shifts and Demand” tab is currently selected.

Figure 5 presents an alternate design concept for the Shifts and Demand tab. In this design, the row and column labels are rearranged to make their associations more explicit, and the demand entry table is rearranged to simplify the process of entering demand data for a given day.

Inputs

Shift work hours:

| | | Hour of Day | | | | | | | | | | | | | | | | | | | | | | | |
|-------|---|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|--------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| Shift | 1 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| | 2 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| | 3 | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |

Number of employees required for each hour of the day

| | | Day of Week | | | | | | |
|-------------|----|-------------|---------|-----------|----------|--------|----------|--------|
| | | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
| Hour of Day | 0 | 3 | | | | | | |
| | 1 | 3 | | | | | | |
| | 2 | 3 | | | | | | |
| | 3 | 4 | | | | | | |
| | 4 | 4 | | | | | | |
| | 5 | 5 | | | | | | |
| | 6 | 6 | | | | | | |
| | 7 | 7 | | | | | | |
| | 8 | 7 | | | | | | |
| | 9 | 6 | | | | | | |
| | 10 | 5 | | | | | | |
| | 11 | 6 | | | | | | |
| | 12 | 6 | | | | | | |
| | 13 | 5 | | | | | | |
| | 14 | 5 | | | | | | |
| | 15 | 6 | | | | | | |
| | 16 | 7 | | | | | | |
| | 17 | 7 | | | | | | |
| | 18 | 6 | | | | | | |
| | 19 | 5 | | | | | | |
| | 20 | 5 | | | | | | |
| | 21 | 4 | | | | | | |
| | 22 | 4 | | | | | | |
| | 23 | 3 | | | | | | |

Figure 5: Alternative design concept for the Shifts and Demand tab.

Figure 6 presents an alternate design concept for the Schedule Output tab. In this design, the two output tables are combined into a single table, and an additional table has been added to make it easy to see where over or understaffing is occurring.

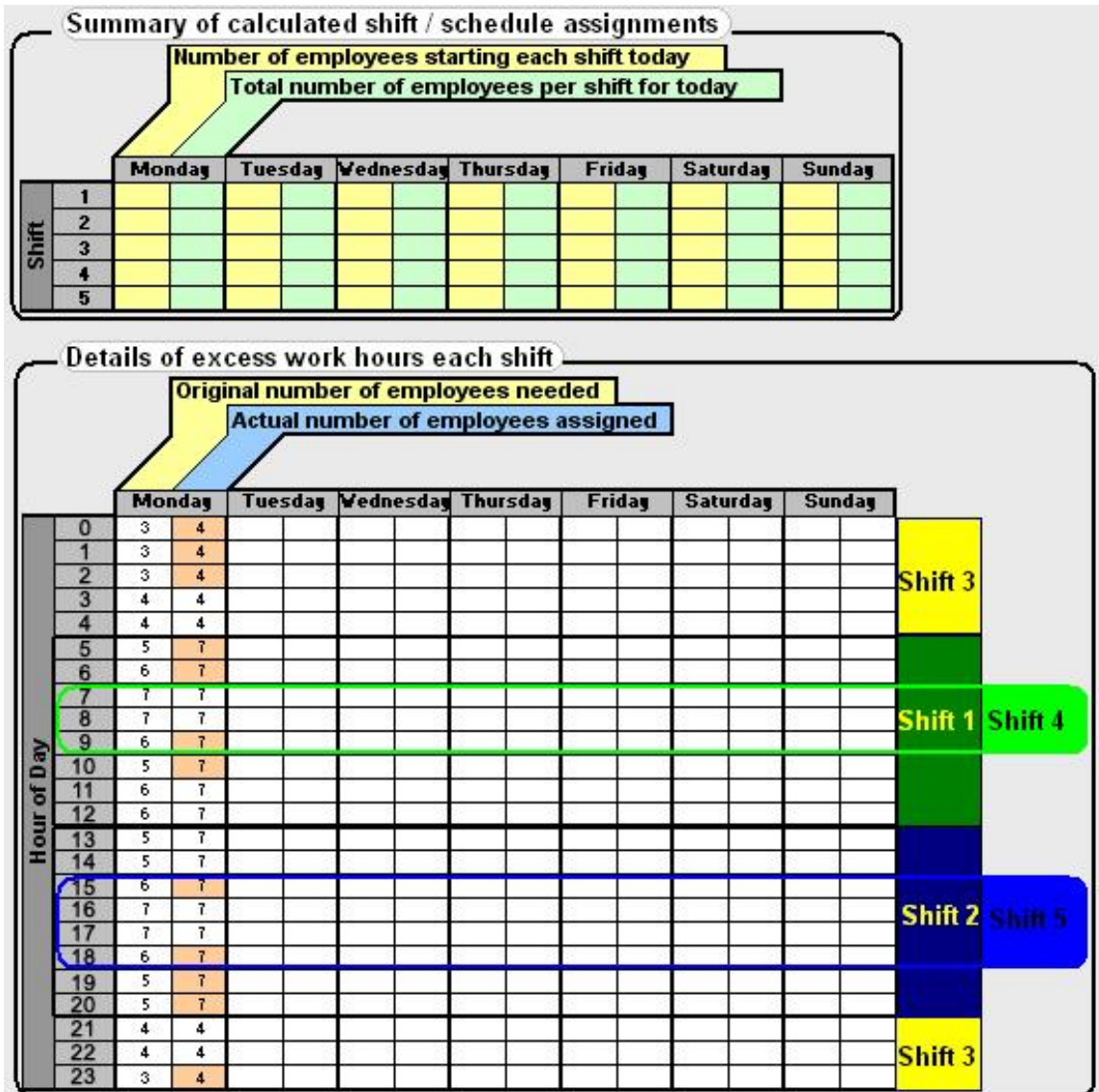


Figure 6: Alternative design concept for the Schedule Output tab.

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