Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/TX-04/0-1752-10		

4. Title and Subtitle	5. Report Date
ADVANCED TRANSPORTATION MANAGEMENT SYSTEM (ATMS) EVALUATION—USER INTERFACE	October 2003
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Hassan A. Charara, Robert E. Brydia, and Kevin N. Balke	Report 0-1752-10

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Texas Transportation Institute The Texas A&M University System College Station, Texas 77843-3135	11. Contract or Grant No. Project No. 0-1752

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Texas Department of Transportation Research and Technology Implementation Office P. O. Box 5080 Austin, Texas 78763-5080	Letter Report: September 2001 – August 2003
	14. Sponsoring Agency Code

15. Supplementary Notes

Project performed in cooperation with the Texas Department of Transportation and the Federal Highway Administration.

Project Title: TransLink® Research Program

16. Abstract

The Advanced Transportation Management System (ATMS) developed by the Texas Department of Transportation (TxDOT) is a critical tool in transportation management centers (TMCs) across Texas. User acceptance often depends on how easy or useful the software is to use. This interaction is typically controlled by the user interface. This report details an evaluation of the TxDOT ATMS product.

In general, the ATMS client screens conform well to accepted design principles for user interfaces. While slight problems were identified at a number of locations, the overall user interface is excellent and provides an operator with the ability to quickly enter information and examine the status of the roadway and field devices.

In comparison, the ATMS data entry screens were not as polished and suffer from a number of common user interface problems that lead to confusion. This confusion could lead to incorrect data entry and incorrect configuration of the ATMS product.

17. Key Words	18. Distribution Statement
Advanced Transportation Management System, ATMS, User Interface	No restrictions. This document is available to the public through NTIS: National Technical Information Service Springfield, Virginia 22161 http://www.ntis.gov

19. Security Classif.(of this report)	20. Security Classif.(of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	26	

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

ADVANCED TRANSPORTATION MANAGEMENT SYSTEM (ATMS) EVALUATION—USER INTERFACE

by

Hassan A. Charara
Associate Research Scientist
Texas Transportation Institute

and

Robert E. Brydia.
Associate Research Scientist
Texas Transportation Institute

Kevin N. Balke, Ph.D., P.E.
TransLink® Center Director
Texas Transportation Institute

Report 0-1752-10
Project Number 0-1752
Project Title: TransLink® Research Program

Performed in cooperation with the
Texas Department of Transportation
and the
Federal Highway Administration

October 2003

TEXAS TRANSPORTATION INSTITUTE
The Texas A&M University System
College Station, Texas 77843-3135

DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the Federal Highway Administration (FHWA) or the Texas Department of Transportation (TxDOT). This report does not constitute a standard, specification, or regulation. The engineer in charge was Kevin N. Balke, P.E. (Texas, #66529).

ACKNOWLEDGMENTS

This project was conducted as part of the TransLink® research program and was performed in corporation with the Texas Department of Transportation and the Federal Highway Administration. The project team recognizes the following TransLink® partners for their generous support of the TransLink® research program:

- U.S. Department of Transportation, Federal Highway Administration;
- Texas Department of Transportation;
- Metropolitan Transit Authority of Harris County;
- Texas Transportation Institute; and
- Rockwell International.

The project team would also like to recognize the following individuals for their support of this specific project:

- David Gibson, Federal Highway Administration;
- Mark Olson, Federal Highway Administration;
- Al Kosik, Traffic Operations Division, Texas Department of Transportation;
- Richard Reeves, Traffic Operations Division, Texas Department of Transportation;
- Sally Wegmann, Houston District, Texas Department of Transportation;
- Terry Sams, Dallas District, Texas Department of Transportation;
- Wallace Ewell, Fort Worth District, Texas Department of Transportation; and
- Pat Irwin, San Antonio District, Texas Department of Transportation.

TABLE OF CONTENTS

Page

INTRODUCTION **1**
EVALUATION CRITERIA **1**
Visibility 1
Feedback 2
Mappings 2
Cues and Affordances 3
Minimize User Memory Load 3
Consistency 3
Clearly Marked Exits 3
Good Error Messages 4
Shortcuts 4
Help and Documentation 4
ATMS UI EVALUATION **4**
ATMS Client Subsystem Evaluation 5
ATMS Client v.2 Main Screen 5
Consistency 5
Mappings and Cues 5
Help and Documentation 5
New Incident, New Maintenance, and New Road Closure Report Screens 6
Lists of Incidents, Maintenance, and Road Closure Reports 9
System Configuration Screen 10
Level of Service and Lane Control Signal Screens 11
LCU Maintenance, SCU Maintenance, and Monitor Detectors Screens 13
ATMS Data Entry Screens 14
Poor Mappings 14
Too Much Information Per Screen 14
No Visible Sequence of Data Entry on Screens 15
Error Messages 15
CONCLUSIONS **16**
REFERENCES **17**

LIST OF FIGURES

Page

Figure 1. ATMS Client's Edit Menu. 5
Figure 2. ATMS Client Main Screen. 6
Figure 3. First Screen of the New Incident Report. 7
Figure 4. Second Screen of the New Incident Report. 7
Figure 5. New Maintenance Report. 8
Figure 6. New Road Closure Report. 8
Figure 7. List of Incidents. 9
Figure 8. List of Maintenance Reports. 9
Figure 9. List of Road Closure Reports. 9
Figure 10. ATMS Client Configuration Screen. 10
Figure 11. LCS Observation and Management Screen. 11
Figure 12. LCS Control Screen. 12
Figure 13. Level of Service Display. 12
Figure 14. LCU Maintenance Screen. 13
Figure 15. SCU Maintenance Screen. 13
Figure 16. Monitor Detectors Screen. 14
Figure 17. ATMS Data Entry Sample Error Message. 15
Figure 18. ATMS Data Entry Sample Error Message. 15
Figure 19. ATMS Data Entry Sample Error Message. 15

ADVANCED TRANSPORTATION MANAGEMENT SYSTEM (ATMS) EVALUATION—USER INTERFACE

INTRODUCTION

The Advanced Transportation Management System (ATMS) developed by the Texas Department of Transportation (TxDOT) is a critical tool in transportation management centers (TMCs) across Texas. Acceptance of a software system often depends on the perception of the ease of use and legibility and an understanding of the user interface (UI) provided with the system. Additionally, on the average nearly 50 percent of software system's code is devoted to the UI (*1*).

User interface design falls under the Human Computer Interaction (HCI) specialty in Computer Science. HCI emphasizes the importance of good user interfaces and the relationship between good interface design and effective human interaction with computers. UI design is an art as well as an engineering and science discipline. The UI design and development involves an understanding of human thought and cognition, graphical screen layout and design, and creativity in designing metaphors and mappings between system functionality and the tasks and goals the user is trying to accomplish by using the software system.

This letter report presents the results of the UI evaluation of the ATMS product.

EVALUATION CRITERIA

In evaluating the ATMS UI, a set of criteria that is widely agreed upon and accepted in the HCI literature was adopted (*2,3,4*). The criteria selected includes but is not limited to:

- visibility,
- feedback,
- mappings,
- cues and affordances,
- minimize user memory load,
- consistency,
- clearly marked exits,
- good error messages,
- shortcuts, and
- help and documentation.

Visibility

Visibility of a UI is determined by how easily and directly a user can see what can be done and how to do it using the software system's UI. The functionality provided by a UI should be very visible and clearly match the user tasks in as natural a way as possible. The mapping between the system's functionality and the user's tasks should be almost one to one. The provision of

fewer controls to achieve the user's tasks results in a user interface that is complex and hard to navigate. On the other hand providing more than one way to accomplish the same task often ends up confusing the user. The ideal UI presents the user with only the right amount of information required to accomplish the task at hand.

User interfaces can be made more clear and visible by implementing proper graphical screen design and layout principles and techniques. For example, enclosing related data items within a frame, using bolder color or typeface to highlight objects, and presenting certain information first using the usual reading direction from left to right and from top to bottom in the English language are all techniques that can help the UI to prioritize the user's attention to certain information and consequently makes the path to follow in performing certain tasks more visible. Information must be presented to the user in a sequence that enables them to achieve their tasks and goals most effectively and productively.

Feedback

Feedback is a measure of how easily and quickly a system provides the user with information about the results of their actions and the system's state. A software system should continuously and promptly inform the user about its state and how it is interpreting actions in terms that are understood by the user, rather than in terms of the underlying system. Feedback becomes especially important in cases where a system has a long response time for certain operations. Instead of leaving the user guessing what the system is doing and whether it has crashed or is still operational, percent-done progress indicators are useful in such situations and assure the user that the system has not crashed. As a rule of thumb, percent-done progress indicators should be used to provide feedback to users for operations taking more than 10 seconds (*2*). In general, graphical progress-done indicators are preferred to text messages stating the expected remaining time.

Feedback can be loosely divided into four classes that include:

- Context information – which user is logged on currently;
- System's current state – is the system ready or not, or the current system mode;
- Conversation response – confirmation of closing, documents saved, or other important system tasks; and
- Immediate response – reaction from a button depression or some other expected action.

Mappings

Mappings describe the correspondence between the user's conceptual model of a system, i.e., the goals and tasks they would like to achieve by using the system, and the functionality and information provided by the system to accomplish these tasks. Designing good mappings is usually a very difficult task and requires a great deal of work on the part of the system designer to analyze user tasks and build an understanding of users and their domain.

Unfortunately, system designers often have a tendency to design systems with functionality that reflects the internal behavior or architecture of the system instead of needs of the users to which the system is catering. The main reasons for this are due to a lack of user interface skills on the system designers' part and/or a lack of interaction and input from the intended users of the system during the design and development phases of the system. Mappings will usually be poor if there are fewer controls in the UI than tasks the user is trying to achieve. Good mappings can contribute a great deal toward improving the visibility of a UI.

Cues and Affordances

A well-designed UI employs controls and components that utilize the user's existing experience and knowledge. A user's background provides hints about the way that items in the UI should be used. As an example, knowledge common to most UIs is that buttons perform actions when pressed and drop-down lists provide a number of available options.

Minimize User Memory Load

Research has shown that on average, a human being's short-term memory can hold up to six to eight items (*2*). This research shows that typically, people are not very good at *remembering* things. However, people are very good at *recognizing* things when presented with a list of items or options to choose from.

On the other hand, computers excel at remembering things. Therefore, UIs should always try to display dialog elements for users to select from or edit instead of asking users to enter the information from scratch. Menus, drop-down lists, checkboxes, and radio buttons are typical technologies used to achieve this goal It is also much easier for the user to modify information displayed by the computer than to have to generate all of the desired result from scratch.

For example, whenever a user wants to rename an object or file, most likely they want the new name to be very similar to the existing one. So, it makes sense to display the existing name in the edit field where the user is renaming the object and allow them to edit it rather than retyping the name from scratch and trying to remember it. Also, when users are asked to enter some input according to a specific format, the system should describe the required format and, if possible, provide an example of valid input like entering dates, phone numbers, etc.

Consistency

Consistency is very important when designing easy to use UIs. Consistency specifies that the same commands or actions always have the same effect. Also, the same information should be presented in the same location on all screens and dialog boxes, and it should always be formatted in the same way to facilitate recognition and avoid confusing the user.

Clearly Marked Exits

All dialog boxes and system states should have an Exit button, a Cancel button, or other escape facility to bring the user back to a previous state. Examples of escape facilities also include the Undo facility that allows users to return to a previous system state. It is important to make escape facilities very visible and accessible within the UI. The presence of escape facilities in a

UI encourages users to explore the system without being afraid of affecting the system irrevocably.

Good Error Messages

Error messages should be phrased in clear terms that a user can understand. Error messages should avoid obscure codes, be precise rather than vague and general, and be polite and not intimidate the user or assign blame. Error messages are most constructive when they help the user solve the problem they are facing. Multiple levels of messages may also be useful. A brief description can be given for the error with a button that the user can click for a more detailed message about the error.

Obviously, a UI designer should attempt to prevent errors from happening in the first place. However, when errors do occur, well-constructed error messages can provide a great deal of information to help solve the immediate problem.

Shortcuts

Shortcuts are very good tools to provide the user with quick access to repetitive tasks, especially expert users that have used the system for a while. Typical shortcuts and accelerators include abbreviations, function keys, toolbars, and command keys. Examples of shortcuts also include most recent opened files and most used commands on menus.

Help and Documentation

It has been stated that "When simple things need labels or instructions, the design has failed" (*1*). However, most software systems have enough features and functionality to warrant a paper manual or on-line help. On-line help is preferable for several reasons. Research has shown that on-line help systems have the potential to provide users with more precise and quick answers to their questions than paper manuals. This can be achieved through the use of index and overview maps, search and lookup capabilities, hyper-links, and context-sensitive help. Another important aspect of help systems, manual or on-line, is that technical writing rules should be utilized to ensure the readability of help documents.

ATMS UI EVALUATION

In evaluating the ATMS UI, the researchers applied the criteria listed in the previous section to the screens that comprise each ATMS subsystem installed at TransLink, namely the ATMS Client and the ATMS Data Entry subsystems. The overall results of the evaluation process revealed that the ATMS Client subsystem screens are very well designed and met almost all the evaluation criteria, while the screens that make up the ATMS Data Entry subsystem need to be simplified and require a few modifications to meet the evaluation criteria. The following sections provide the results of evaluating both subsystems.

ATMS Client Subsystem Evaluation

ATMS Client v.2 Main Screen

The ATMS Client software main screen met all the evaluation criteria except for minor problems in the Consistency, Mappings, and Help and Documentation criteria. The main screen provides the user with good feedback as to whether the Client is ready or not, the status of keyboard keys like NUMLOCK, and hints about the functionality of each icon when the user moves the mouse over the icons. It also provides the user with clearly marked exits to quit the application through the File/Exit menu, provides shortcuts to repetitive tasks through the toolbar icons, and finally uses cues and affordances to indicate very easily the functionality of some of the toolbar icons.

Consistency: The ATMS client software main screen provides two methods to access the new incident, new maintenance, new road closure, freeway lane control signal (LCS) plans, and the system configuration functions. The first method is through the Edit menu (Figure 1), while the second method of access is through a toolbar (Figure 2). The order of the functions listed in the Edit menu from top to bottom is not consistent with the order of the same options on the toolbar. In UI design it is highly recommended that same functionality or information be presented to users in the same order and in the same place if it is repeated on different screens.

Mappings and Cues: Some of the icons used on the toolbar are very intuitive like the level of service (LOS) icon, the camera icon, and the LCS icon. The functionality of these icons can be immediately recognized by users either because of the imagery that is being used with the icon like the camera icon, the text used on the icon like the level of service display, or both imagery and text used with the icon like the lane control signal icon. On the other hand, some of the other icons such as the incident report, list of incidents, maintenance report, maintenance list, road closure report, and the road closure list are not as obvious. Text and imagery can be used to make the functionality associated with these icons more easily recognized.

Help and Documentation: The ATMS system has a paper manual that provides users with basic help in terms of installing the system, describing the general system architecture, and guiding the user through the system functionality and screens data entry. The ATMS system provides no on-line help.

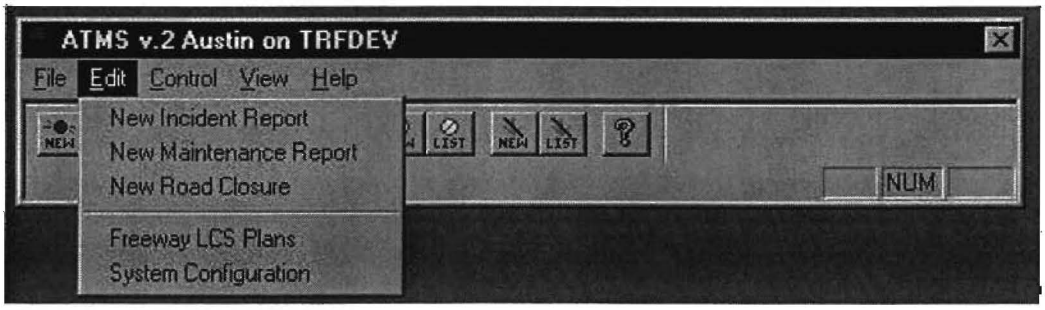

Figure 1. ATMS Client's Edit Menu.

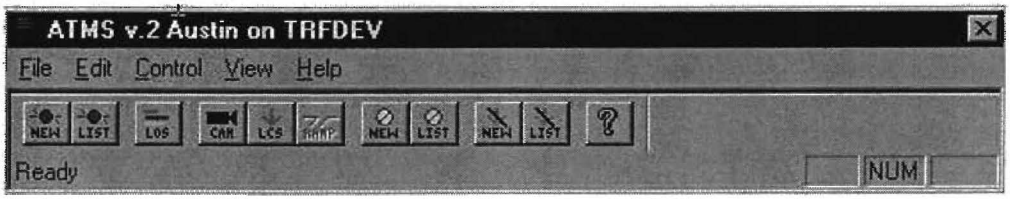

Figure 2. ATMS Client Main Screen.

New Incident, New Maintenance, and New Road Closure Report Screens

The new incident (Figures 3 and 4), maintenance (Figure 5), and road closure (Figure 6) report screens conform very closely to the UI evaluation criteria. Graphical screen design principles and techniques like blocking related data items within a frame, as well as colored hints and labels, are used effectively to highlight important data items and guide the user through the logical data entry sequence of elements presented on the screens.

The usage of UI controls and techniques contributes to a great extent toward preventing users from committing errors. Items such as drop-down lists, checkboxes, radio buttons, and disabling certain components and screen pages until other data entry conditions are met reduces the burden on the user's short-term memory. It puts the burden on the application, which can easily store and retrieve all of the various options.

The screens also provide users with helpful and useful error messages when they try to bypass the data entry sequence, clearly marked exits on each page through a Cancel button, and good textual and graphical feedback when the user selects certain options on the LCS control page in the new incident report.

The overall design of the new incident, maintenance, and road closure report screens is very visible, clear, and friendly.

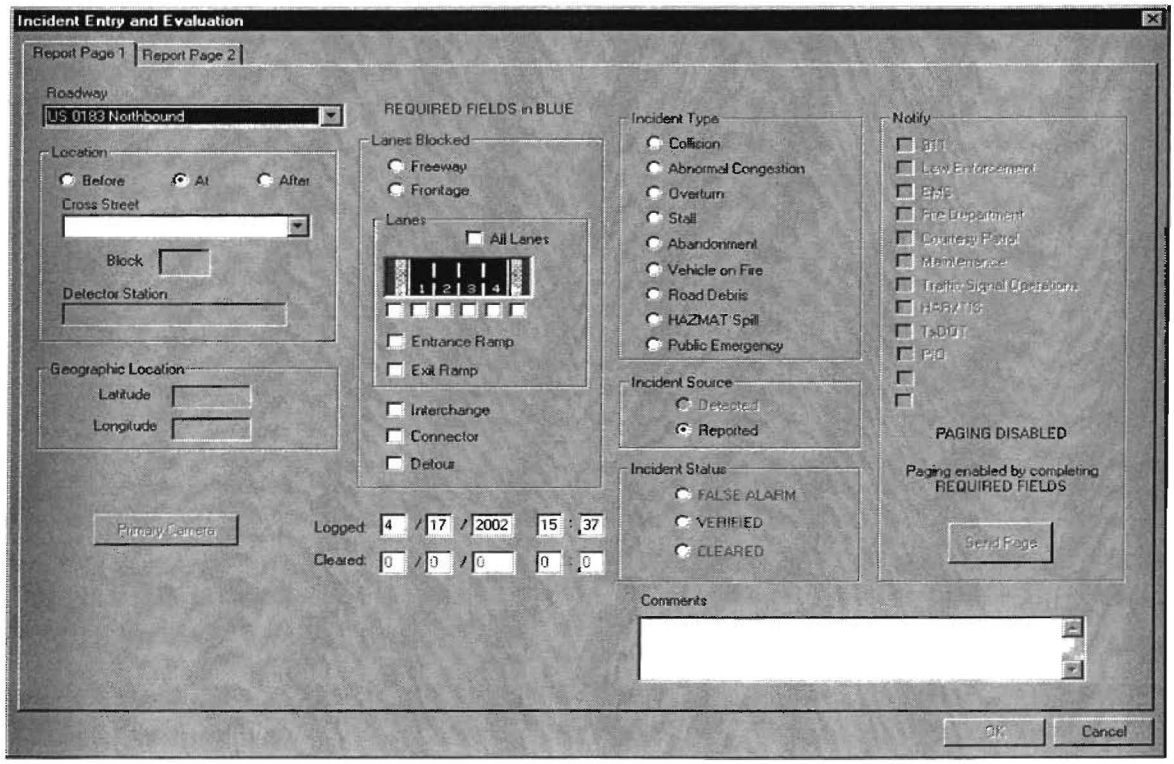

Figure 3. First Screen of the New Incident Report.

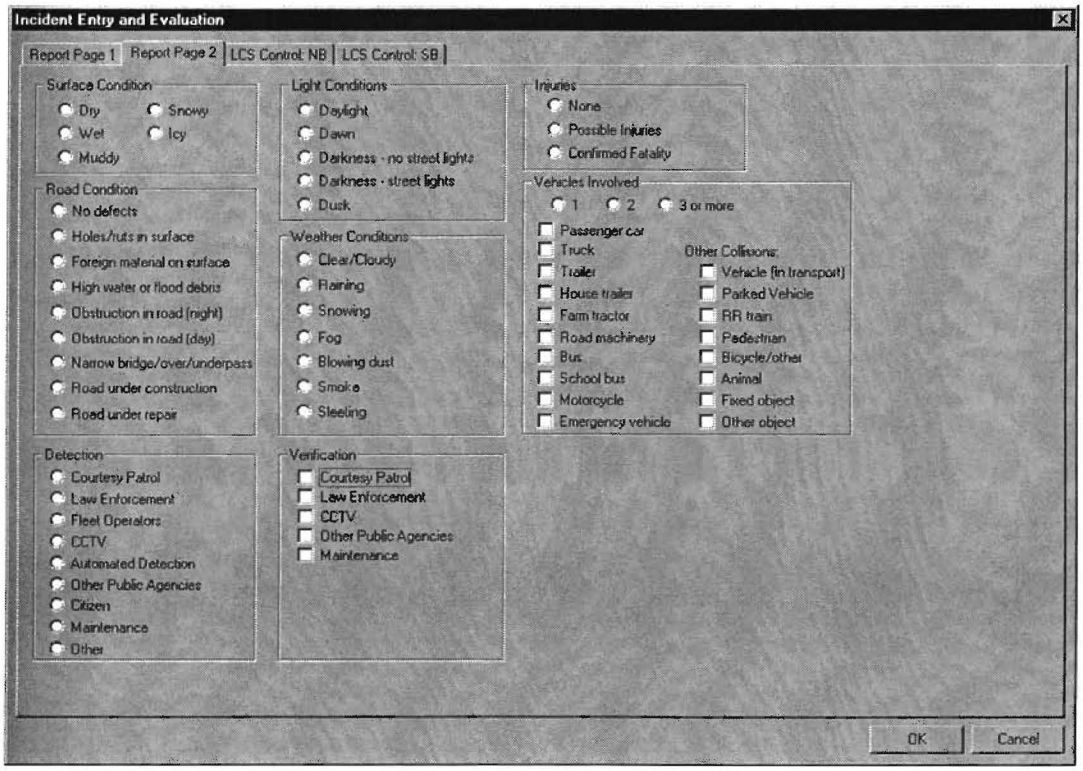

Figure 4. Second Screen of the New Incident Report.

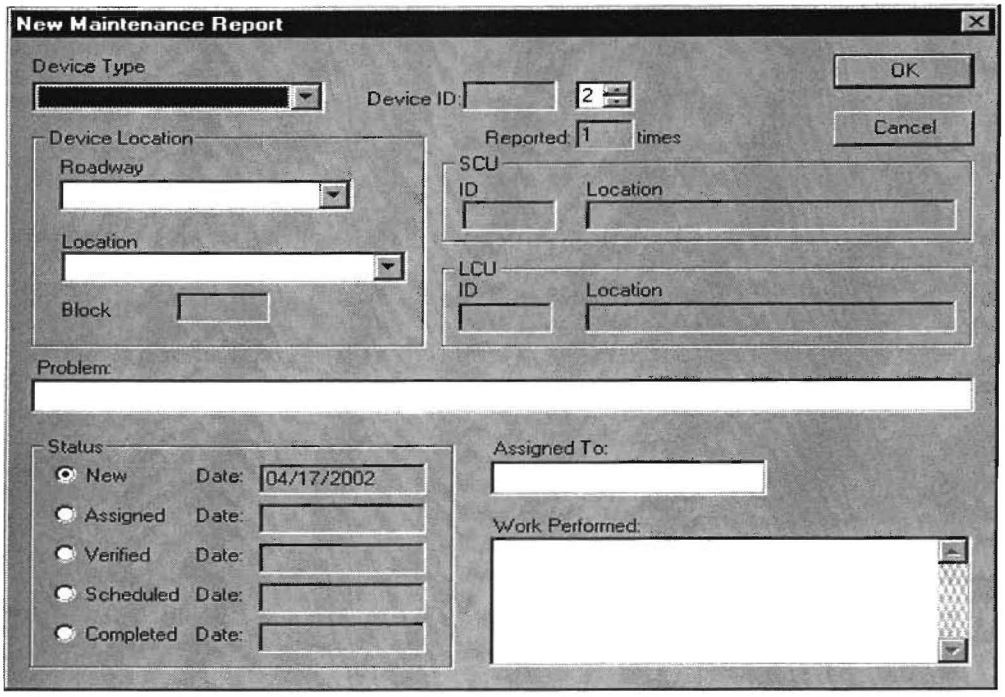

Figure 5. New Maintenance Report.

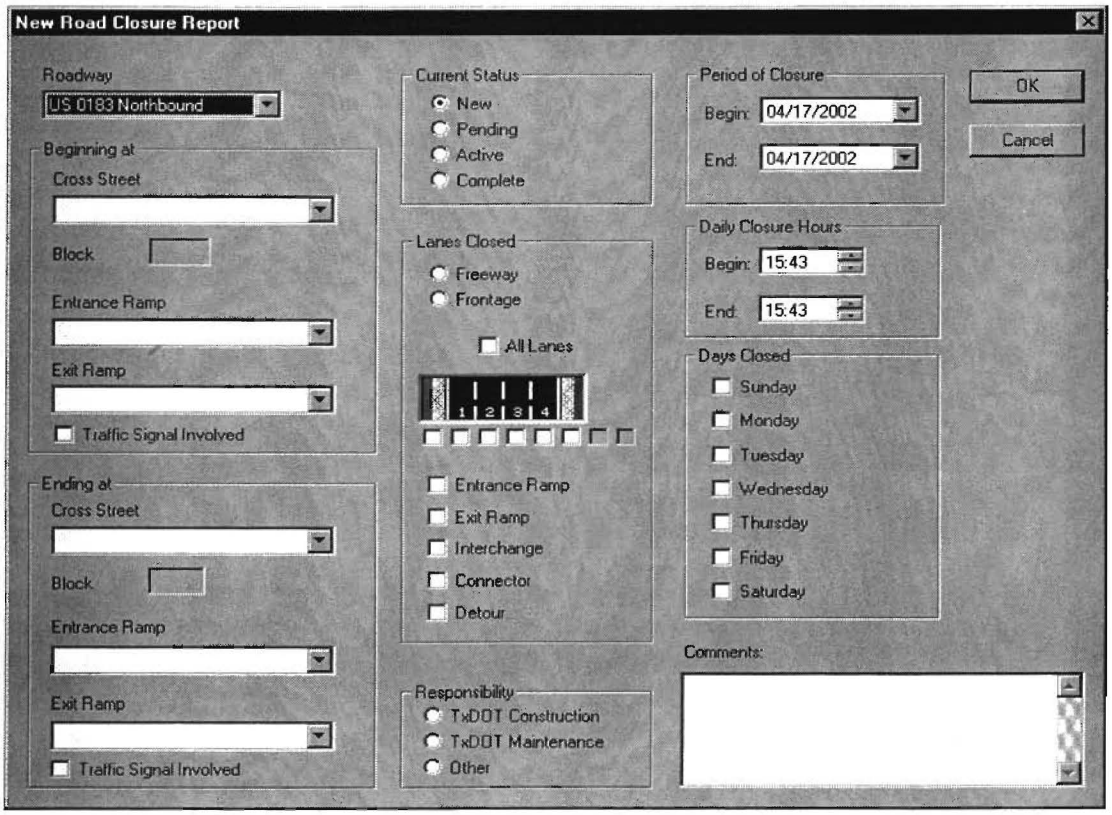

Figure 6. New Road Closure Report.

Lists of Incidents, Maintenance, and Road Closure Reports

The current incidents (Figure 7), current maintenance (Figure 8), and current road closure (Figure 9) report screens provide the user with the status of reports currently in the system. The screens representing these lists take advantage of color to give the user a quick cue about the status of each report in the list. Another useful feature provided in the lists is the ability of the user to double-click on a report in the list to view and edit the contents of the report. Such convenient features reduce the users' memory load by not requiring them to remember which report is needed and then enter the information somewhere else to view the contents. All the list screens provide the user with clearly marked exits except the list of incidents screen.

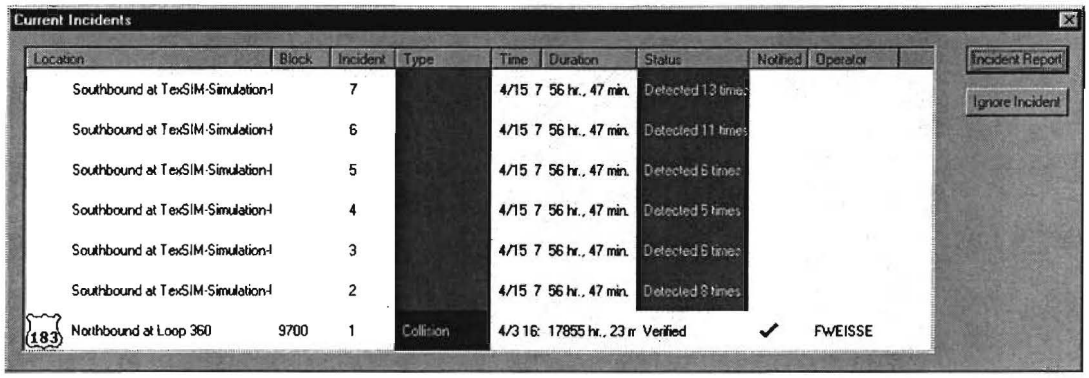

Figure 7. List of Incidents.

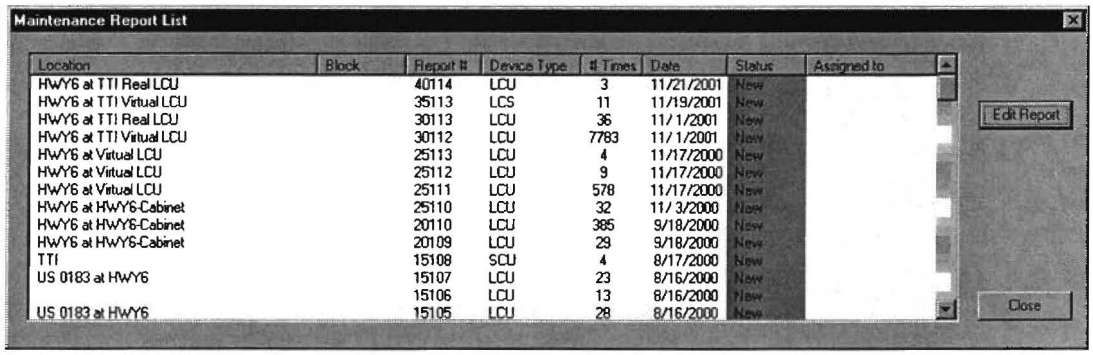

Figure 8. List of Maintenance Reports.

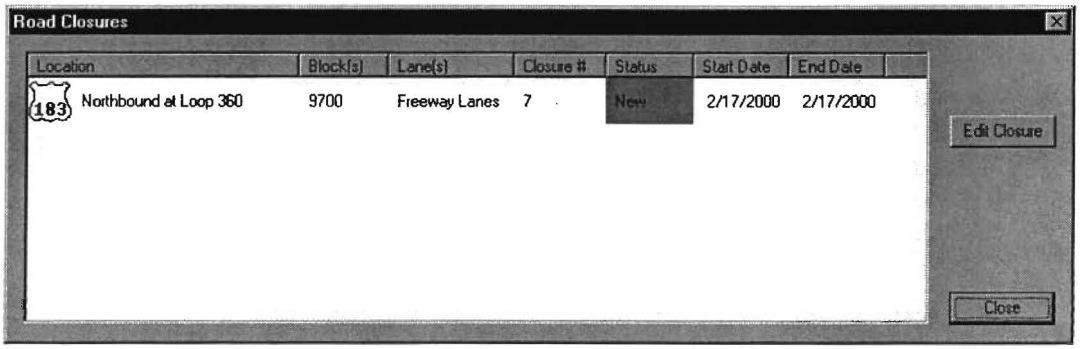

Figure 9. List of Road Closure Reports.

System Configuration Screen

The system configuration screen (Figure 10) enables the user to view and edit general system settings. The screen highlights related settings and information by enclosing them within a frame. Checkboxes, radio buttons, and drop-down lists are provided whenever applicable to get user input. Finally, a clearly marked Cancel button is provided to allow the user to revert to previous settings without saving the changes made.

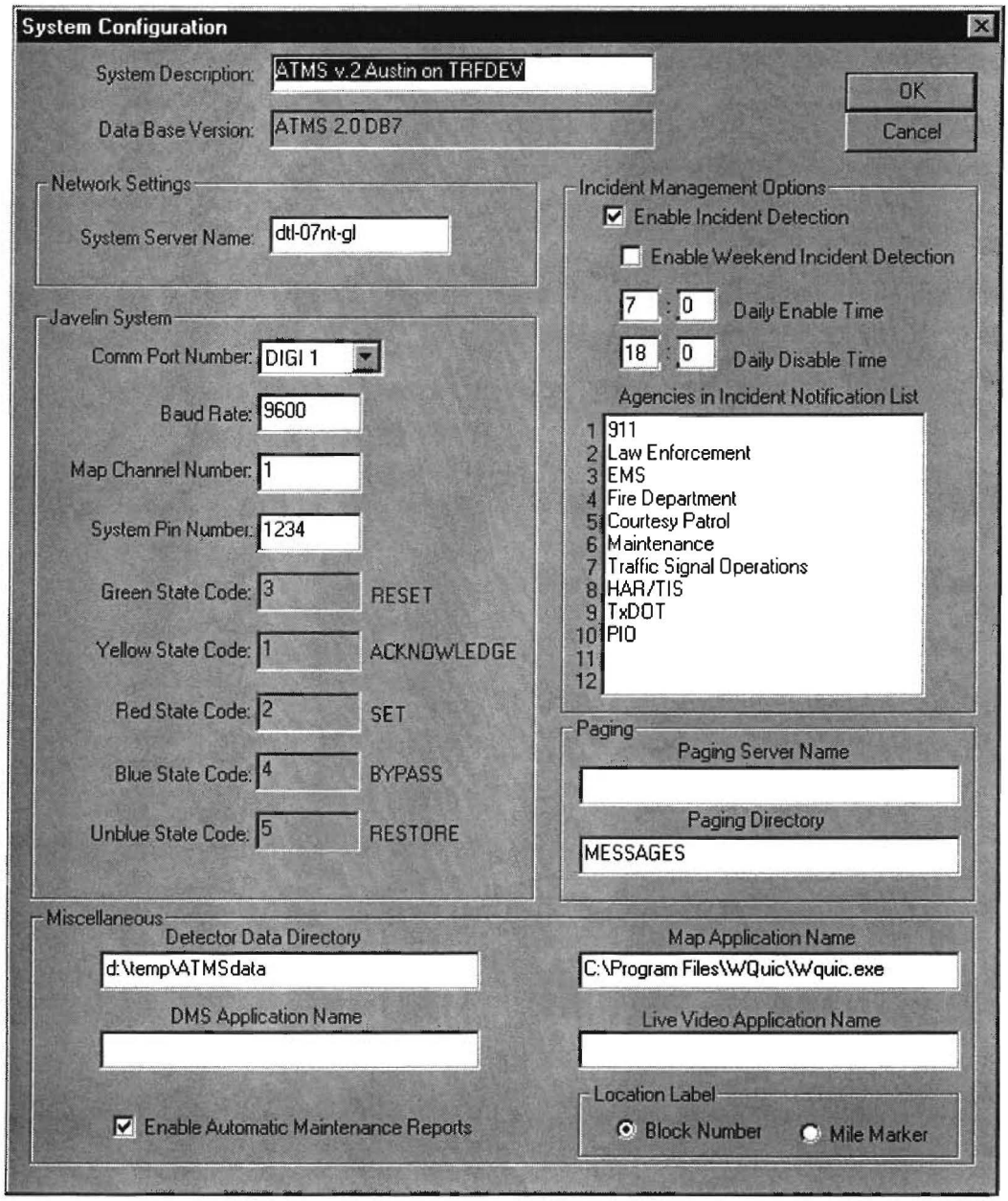

Figure 10. ATMS Client Configuration Screen.

Level of Service and Lane Control Signal Screens

The LOS and LCS screens (Figures 11 through 13) use graphics and text to provide real-time feedback to users. The LOS screen effectively conveys information about the level of service at selected locations, while the LCS screen effectively details that status of lane control signals at a particular location.

Color is used to provide the user with cues about the current LOS at a freeway location by using red for congested and green for free-flow. The cues use the existing knowledge of users as to how these colors are used in other areas of traffic and correlate it to the LOS on a freeway. The red X and green arrow symbols are also used in the same way on the LCS screens to provide LCS status.

On both screens, graphical feedback is also augmented with real-time textual feedback, especially on the LOS screens, to give the user up to the minute real-time updates on traffic conditions at a selected site. The screens also provide users with clearly marked exits and lists of known sites to the system for the user to select from instead of requiring them to remember all the possible sites and enter the site information from memory.

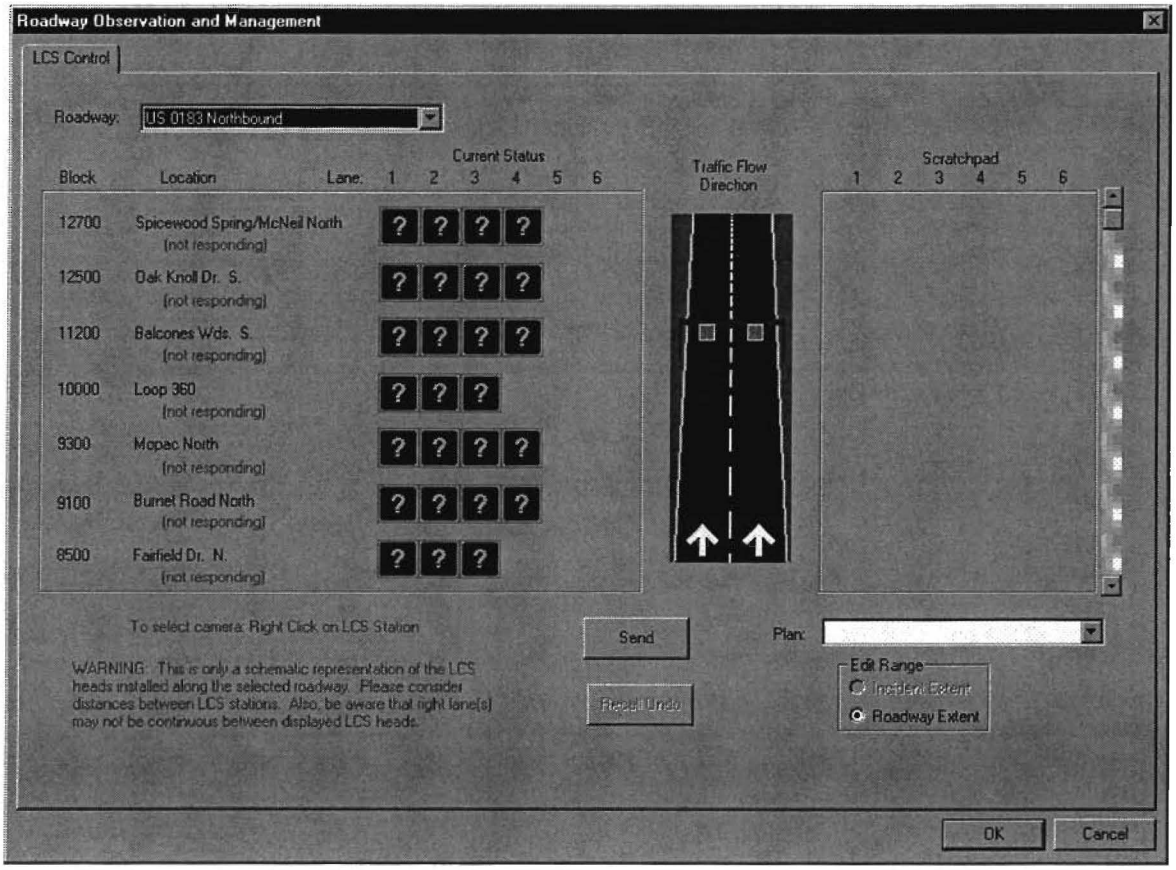

Figure 11. LCS Observation and Management Screen.

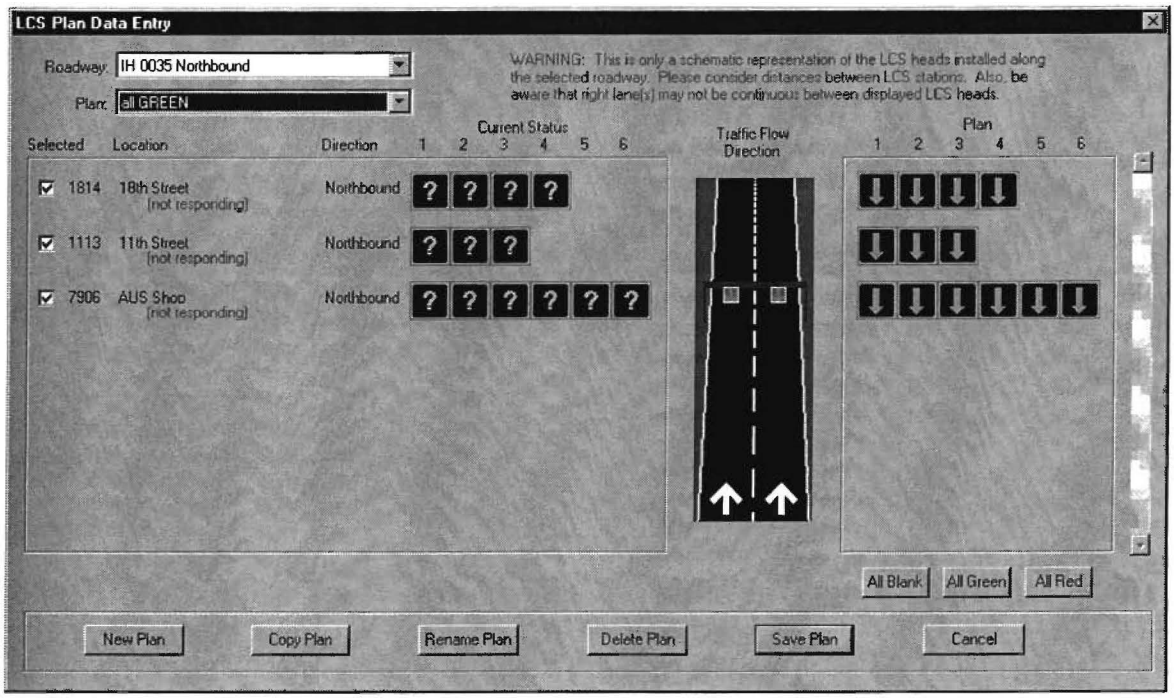

Figure 12. LCS Control Screen.

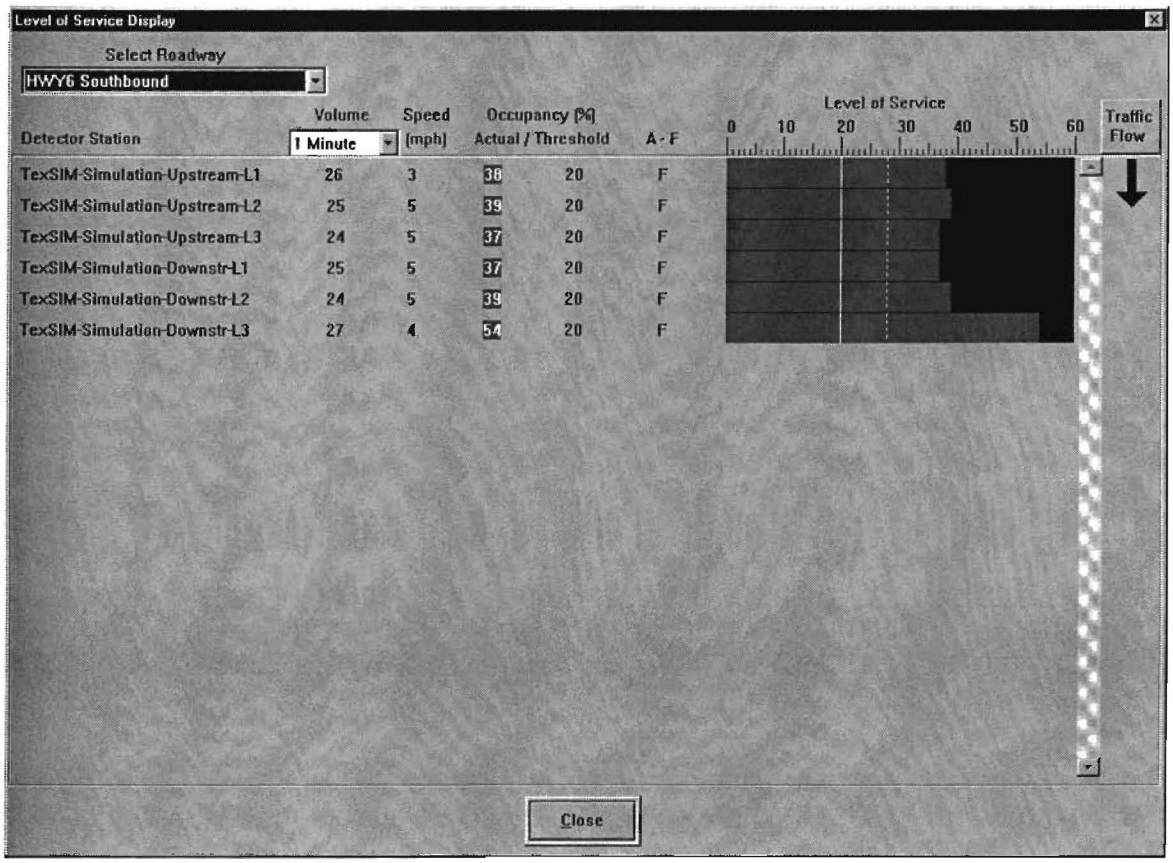

Figure 13. Level of Service Display.

LCU Maintenance, SCU Maintenance, and Monitor Detectors Screens

The LCU maintenance, SCU maintenance, and monitor detectors screens (Figures 14 through 16) provide the user with utilities to communicate, monitor, and control field equipment. The user interface provides effective feedback including timely and helpful messages about the success or failure of actions it performed on behalf of the user. The screens minimize the possibility of errors and lessen the burden on user's memory by using drop-down lists to provide users with lists of existing field equipment to select from. The three screens also provide very clearly marked exits.

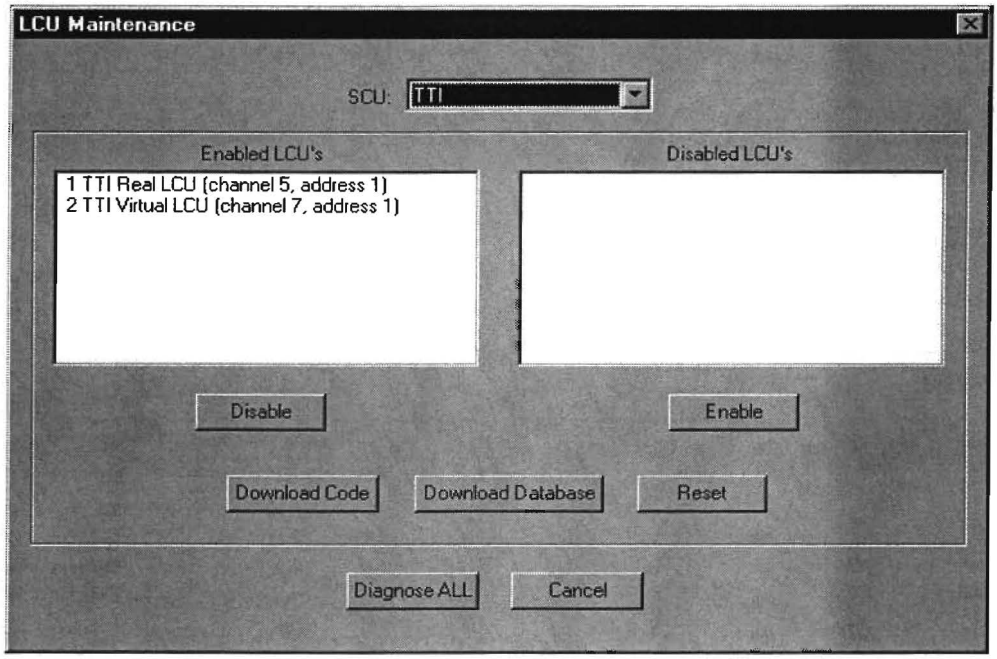

Figure 14. LCU Maintenance Screen.

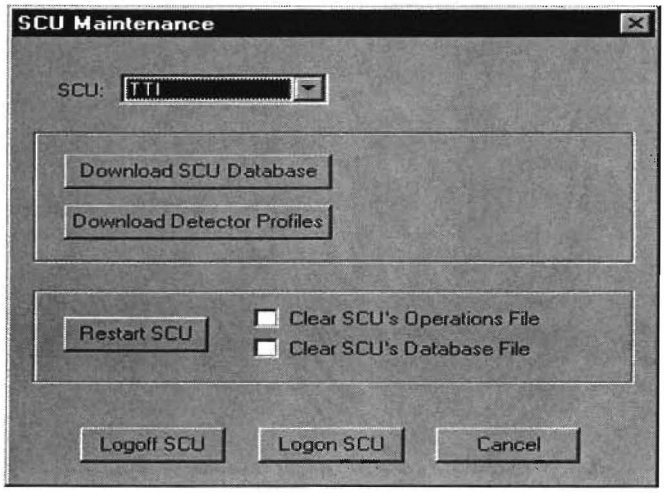

Figure 15. SCU Maintenance Screen.

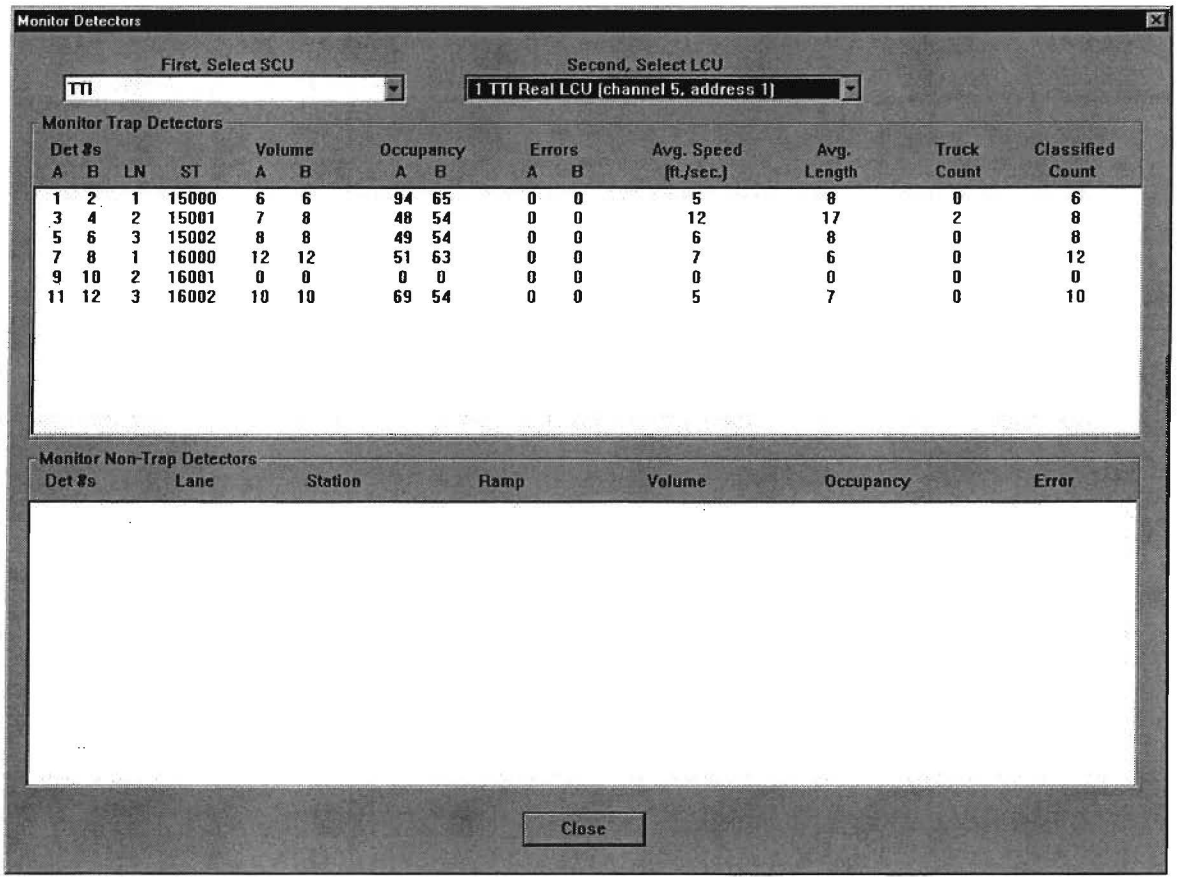

Figure 16. Monitor Detectors Screen.

ATMS Data Entry Screens

The screens that comprise the ATMS Data Entry subsystem suffer from four common problems, as detailed below.

Poor Mappings

As described earlier, good mappings refer to the intuitiveness of the correspondence between the system's functionality and the user's tasks. The smaller the gap between these two views, the more efficient and productive the user would be in using the system to accomplish the required tasks. The functionality and screens provided by the ATMS Data Entry subsystem reflect more closely the system's internal architecture, i.e., the various database tables the system uses to store the system data, rather than the tasks the users want to accomplish, like entering and defining trap detectors or lane control signals.

Too Much Information Per Screen

The majority of the ATMS data entry subsystem screens provide the user with more information per screen than necessary. This has the effect of overwhelming the user, especially, novices. In addition, most of the screens provide the user with a number of actions that are available at the

same time, which adds to the confusion. Although some of these actions can be disabled by default, their presence contributes to the information overload on the data entry screens.

No Visible Sequence of Data Entry on Screens

As mentioned in the previous section, most of the ATMS data entry screens provide the user access to a number of actions at the same time. This usually confuses users, especially novice users. Graphical screen design techniques can be used to highlight a data entry sequence to the user based on the functionality provided by the screen.

Error Messages

The error messages provided by the ATMS Data Entry screens are not very helpful or useful. They reflect more of the internal system architecture, especially the database table design, than the task the user is trying to accomplish. Error messages should avoid obscure codes, be precise rather than vague, and be constructive in helping the user solve the problem he is facing. Some examples of error messages are shown in Figures 17 through 19. Again, the error messages here reflect more of the internal system architecture rather than the tasks the user is trying to accomplish.

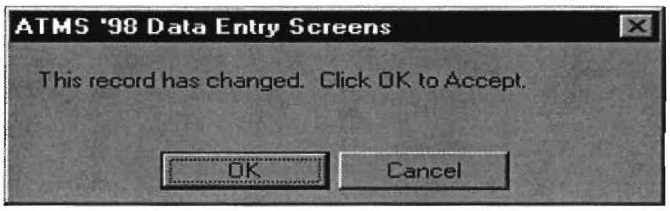

Figure 17. ATMS Data Entry Sample Error Message.

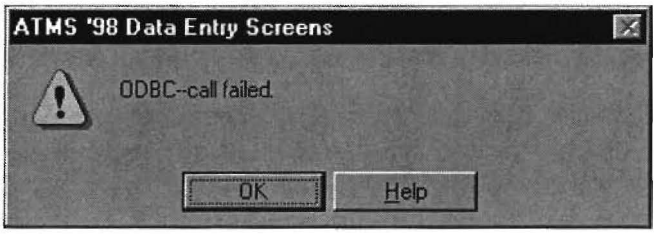

Figure 18. ATMS Data Entry Sample Error Message.

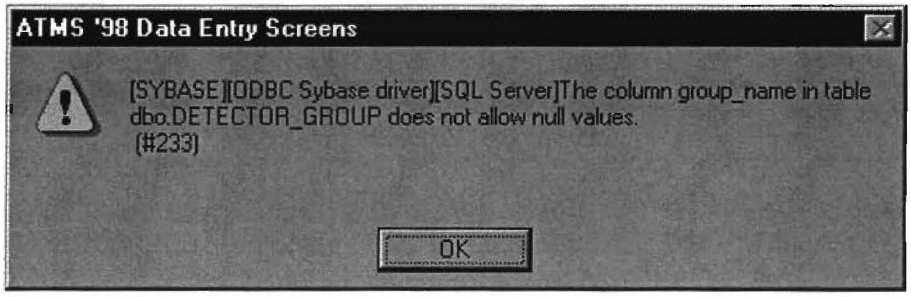

Figure 19. ATMS Data Entry Sample Error Message.

CONCLUSIONS

In general, the ATMS client screens conform well to accepted design principles for user interfaces. While slight problems were identified at a number of locations, the overall user interface is excellent and provides an operator with the ability to quickly enter information and examine the status of the roadway and field devices.

In comparison, the ATMS data entry screens were not as polished and suffer from a number of common user interface problems that lead to confusion. This confusion could lead to incorrect data entry and incorrect configuration of the ATMS product. It is recommended that the data entry screens undergo a thorough evaluation to examine the relationship of form and function, and how the user interface can be improved.

REFERENCES

1. Norman, Don. *The Psychology of Everyday Things*. Basic Books, New York, NY, 1988.

2. Nielson, Jakob. *Usability Engineering*. Academic Press, Boston, MA, 1993.

3. Mullet, Kevin, and Darrel Sano. *Designing Visual Interfaces: Communication Oriented Techniques*. SunSoft Press, Englewood Cliffs, NJ, 1955.

4. Zetie, Carl. *Practical User Interface Design: Making GUIs Work*. McGraw-Hill Book Co., New York, NY, 1995.