SUPPORTING ASSET MANAGEMENT FOR INCIDENT MANAGEMENT USING GIS

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ABSTRACT

Currently, most of the incident management (IM) teams depend on paper maps and information sheets when traffic diversion is warranted in the presence of a major accident. These paper maps are not only difficult to use in the presence of an emergency situation, they are also difficult to maintain to ensure up-to-date information. A customized computer based system that takes advantage of Geographical Information Systems (GIS) is the best solution for accessing and maintaining these diversion maps and related other information. This paper describes a general framework and basic functions based on GIS for traffic incident management operations and long-term asset management of the equipment used for IM.

The proposed tool **T**raffic **I**ncident **M**anagement **S**ystem (**TIMS**) is developed using Visual Basic (VB) programming language and GeoMedia Pro[1], GIS software package. A major innovation of this application is the development of a VB based computer program that automates the efficient merging operations of multiple incident management plans for any complex transportation network. Response strategies implemented using this application include GIS based traffic diversion plans, assignment of static and dynamic variable message signs to diversion points, and database of capabilities of responding agencies. The application offers "intelligent electronic maps" that can present the user the related diversion route and variable message sign locations along with the list of messages and agencies to be contacted, when the accident link of interest is identified on the GIS map. Diversion routes and other information can also be easily updated through the same Graphical User Interface (GUI), which has user-friendly data editing properties. Message signs are efficiently attached to electronic information data sheets that can be accessed and updated by the user through the same interface. Therefore, the application not only provides real time traffic incident management information to the traffic operators through a GIS based GUI but allows him to maintain an accurate database. The paper aims to demonstrate the utility of dynamic diversion maps and visual elements to ensure incident preparedness, and assist transportation agencies and also public safety agencies with an innovative asset and information management tool that facilitates the deployment of effective traffic incident management strategies. This tool is hoped to obviate the need for paper maps and manuals that can contain obsolete information that is difficult to update in a timely manner.

Key Words: Asset Management, Incident Management, GIS, electronic maps

[1] www.intergraph.com

INTRODUCTION

This paper examines the use of GIS as a mechanism of asset management to automate resource tracking, resource allocation and resource dispatching within a centralized system, TIMS. A major challenge to the success of asset management is how it is to be integrated into overall transportation decision-making. This paper proposes, for three reasons, that the use of GIS may be appropriate for meeting this challenge. First, GIS and Asset Management (AM) can be systematized using compatible data. Second, GIS-AM integration appears to offer significantly practical benefits. And third, both GIS and AM are relatively emerging initiatives, with institutional structures that are not yet fully fixed for these both systems and are therefore capable of adapting them for more integrated approaches.

Asset management can be viewed as "a set of guiding principles and best practice methods for making informed transportation resource allocation decisions, and improving accountability for these decisions"(1). A more ambitious view of asset management is that it is a set of techniques and methods for integrating decision-making using GIS for maximizing the physical performance of capital assets, such as pavement management systems, bridge management systems, maintenance management systems, and so forth. The latter view represents the need for leveraged information from various individual systems so that better, more informed decisions in resource allocation and utilization could be made. In addition to maximizing the physical performance of capital assets, this view also incorporates considerations of the operational performance of capital assets, and technical, managerial financial and political factors.

MOTIVATION AND BACKGROUND

This paper is motivated by the need of responding the prevailing traffic conditions caused by various incidents. "Incident" refers to any event that degrades safety and slows traffic, including disabled vehicles, traffic accidents and crashes, maintenance activities, adverse weather conditions, special events and so forth. Incident-related traffic congestion (including secondary impacts) detrimentally affects normal traffic flow. Thus, Incident Management is the coordinated and pre-planned approach used to restore freeway traffic to normal operation as quickly as possible after an incident has occurred.

The goal of TIMS is improving the "quality" of the response to incidents. TIMS will help all relevant parts of the transportation department to operate jointly on to minimize the effects of an incident, determine who is responsible for implementing each action, and managing resources in the best possible way. Incident management strategies may be categorized into four basic techniques; Detection, Verification, Response and Clearance, and Driver Information. TIMS is the combination of techniques of Incident Response and Driver Information.

The proposed system maintains the goal of diverting the traffic to available routes with enough capacity to absorb the incident traffic, and adjusting the signal timing plans, providing resources like message signs, etc. to accommodate efficient operation of traffic flow in the selected alternate routes. In TIMS with well-prepared diversion routes, the primary benefits from incident management seem to accrue not from diversion but from effective response, and timely clearance of incidents.

Ozbay and Noyan (3) proposed **G**eographical **I**nformation **S**ystems (GIS) based **M**anagement **I**nformation **S**ystem (GISMIS) tool for the New Jersey Department of Transportation (NJDOT). The proposed tool provided capabilities for the NJDOT professionals to digitize right of way (ROW) maps or plan files, and keep them in a digital format. This ensured effective management and retrieval of requested documents from this very large scanned digital document database. This paper first described the development efforts of GISMIS tool, and then presented overall application functionality from different perspectives of systems design and various GIS aspects of the developed tool. Ozbay and Noyan (4) also proposed a series of IM Decision Support functions based on Bayesian Networks (BNs). The paper described the

integration of BNs to estimate total clearance time for emergency management. They also presented the method to create dynamic estimation trees that are extracted in the presence of an incident, enabling operators to create case-specific incident management strategies. Ozbay and Kachroo (5) suggested the use of decision trees for duration estimation to enable better incident management practice.

The **I**ntegrated **I**ncident **M**anagement **S**ystem **(IIMS)** (6) is a real-time incident management system that enables the communication of critical information between the incident and emergency managers at operations centers and responder personnel at the incident scene. The proposed system enabled responders to dispatch appropriate emergency equipment to the scene more quickly and restore normal transportation operations faster.

Anderson and Souleyrette (7) proposed a system to provide real-time information for agencies to improve traffic flow through changeable message signs/traffic signals, and for travelers to alter routes based on the pre-trip information such as cable television and websites. The proposed methodology deployed a GIS interface between Tranplan and Corsim for a test case in a medium sized urban area, Iowa. Burchfield (8) proposed a research that was designed to identify efficient uses of geospatial technologies, namely GIS and GPS, for wildfire management. The research team discovered through its observations and interviews that geospatial technologies offer a series of benefits to fire suppression operations.

Guler et al. (9) proposed railway asset management system for defining georeferenced locations, storing attribute data, and displaying data on maps. In the case of accidents or disasters, the assessment of damage and reconstruction, proposed GIS determined the location of an event or asset and its relationship or proximity to another event or asset, which may be the critical factor leading to a decision about design, construction, or maintenance.

Switzer and McNeil (10) presented a research road map for transportation asset management to identify research needs and provide significant milestones along better asset management practices. The road map included specific projects in the areas of policy goals and objectives and performance measures, planning and programming, program delivery, and systems monitoring and performance results. The goal of this paper was to facilitate the widespread adoption of the asset management concept and the continued enhancement of tools and processes. Ochia (11) presented a study with an extensive focus on the roles of engineers and planners in the delivery of traffic calming public works projects. The paper was important to understand the service contributions of engineers, planners and so forth in a realization of the public project.

Asset Management and TIMS

Asset management represents a comprehensive view of system management and performance for making more effective resource allocation decisions. Resource allocation decisions are based on a well-defined set of goals. These goals reflect desired system condition, level of service, and safety, mobility and reliability provided to drivers. The most important factor is that agency-specific output measures are needed to supplement user-oriented outcome measures, since performance in operations-related areas (mobility, travel delay, reliability, safety, etc.) will be affected by many factors outside of the control of an individual transportation agency. TIMS utilizes a central system of resource tracking and dispatching, and taking effective response to accomplish this task in the asset management strategies. Inventories of physical and system operations components are stored in the system, with updates to utilize asset management integrating the operation in all individual parts of the transportation system. Figure 1 presents the physical integration of TIMS into the asset management strategies.

Figure 1. Asset Management and TIMS-Systemized Framework

DATA AND METHODOLOGY

The proposed set of techniques and methods in TIMS are designed to help traffic operators access related information about their tasks in undertaking of the required response. Microstation was used to analyze the design files for roadway maps, and used as CAD data for creating maps. GMPro is used as a software development environment integrated with VB, and as the main desktop and a viewing and analysis tool. In VB, GM objects were used to enable proposed functionalities, and two different codes for edit and display modes were installed in two dynamic link libraries (dll). These dlls were registered in GMPro as customized buttons to enable the function of editing and displaying information through an interactive map.

Data consists of design files and access databases for the regions that the TIMS was created to present the proposed set of techniques and workflow.

Data was obtained from PASDA (Pennsylvania Spatial Data Access). “PASDA is the official public access geospatial data clearinghouse for the Commonwealth of Pennsylvania and Pennsylvania's node on the National Spatial Data Infrastructure, Geospatial One-Stop, and National Biological Information Infrastructure” (2).

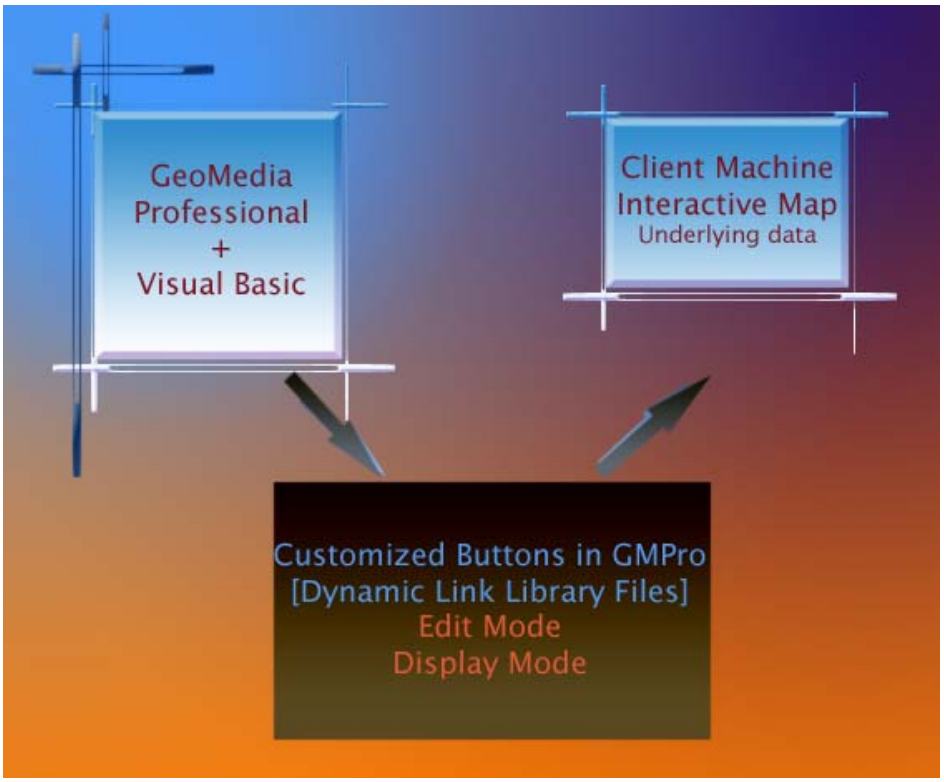

Figure 2. Tools Interaction/Integration in TIMS

Coordinate system information is regularized for all the data structures to be used in creation of the map, using the metadata information given by PASDA. Coordinate System File is created and loaded in GMPro to coordinate data from various sources in a consistent manner, using projection as the coordinate system type, cylindrical
equirectangular as the projection space, geodetic datum as North American 1983. Data inscribed in the interactive maps include State routes, Local Roads, Counties, Cities, Boroughs, Cities, and so forth. The interactive map is created using GMPro for the customized control manipulated by VB code. The section for "TIMS workflow" show the result map after data analysis and integration, also present the steps of asset management.

The application was achieved after an exciting brainstorming phase, and adding all the possible functionalities to the proposed tool. The functionalities were controlled by the reference number associated with each link in the databases. There are several links constituting a roadway. Therefore, one route is a collection of different reference numbers. The main challenge was to click to any point on the map and retrieve the related information, differentiate the user's task type, and update the information. The following is some of the milestones in the succession of the application:

- to manipulate and control all the possible tasks using only reference link number and clicking event
- to retrieve the reference number for the link that is clicked by the user, detour routes for the clicked point, resource locations, text files for detour plans and so forth

- to create interfaces between VB forms and GMPro, and to add data access through these GUIs in addition to data access through the interactive map.
- to advance editing capabilities:

    - giving the user to select the accident route using only start and end segments of the accident route
    - giving the user to select the detour route using the select tool, instead of one by one selection
    - giving the user to choose the direction and to update/activate this direction for display
    - to adjust the application in a way for the user to make sure in his/her steps of editing giving information about the underlying process to continue or not
    - to enable the user to clear all the update/change in the edit mode for one session of the user
    - to differentiate the selection type of routes (for example, in the editing mode of the application, the user first selects the accident route and then selects the detour routes), and to enable updates/changes in the database according to the selection type
    - to differentiate the assignment type which is assigning detour routes or resources, and enable the update

- to advance display capabilities:

    - using only the click event, retrieving and displaying all the related information about the selected point of interest,
    - retrieving the resource locations for the selected accident route and displaying these locations using pictures for user-friendly interface (i.e. DMS pictures, and so forth)
    - to click on the device, retrieving the reference number for the link that DMS belongs to, and displaying all the related information, i.e. device specifics, detour plans for that specific location
    - to update the resource plans through VB forms
    - to update information using WildEdit one-at-a-time for all the text files, for example, if the certain part of I-99 is assigned an “Alert Route”, after incident clearance, this information can be changed to “Normal Conditions” and updated one-at-time for all the text files. This is a crucial task, since there might be many accident routes where this part of I-99 was assigned as their detour route. When there is a notice of “Alert Route” on the associated text file, the editor is informed with a warning and directed to choose another detour route. Since, the update can be achieved with a simple one-at-a-time change using VB and WildEdit interface, the change from “Alert Route” to “Normal Conditions” will cancel the need for the warnings, and enable the roadway to be assigned as an available detour route.

TIMS LOGIC

In this section, we offer the workflow of TIMS to present the proposed functionalities. The workflow starts with Function 1: Edit Mode, where the authorized user goes through the provided steps of updating/changing information in this asset management tool. The workflow continues with Function 2: Display Mode, where the user can retrieve and analyze the updated information and take the immediate action according to the given resource plans.

Function 1:Edit Mode - Interactive Editing of New and Existing Accident and Corresponding Diversion Route and DMS Information

Function 1 is automated through GMPro, and the main goal is to take the user through the steps of the editing capabilities. It should be noted that information edited dynamically using these electronic maps are immediately updated in the database. The user is also informed about the current conditions of the diversion routes that might be assigned to specific accident routes as their detour routes. For example, if there is a construction/maintenance work in one of the diversion routes, the editor is warned about the current condition of the roadway, and advised to choose another detour route. The following presents the steps for the edit mode of the proposed tool:

1 Diversion route is selected, choose "assign diversion and accident route" to continue with the selection of the accident route

Figure 3. Edit Mode-Step1

2 Accident Route is selected by choosing the start and end points of the accident route. After the selection of the start and end segments the user is informed that the segments are successfully located for the accident route

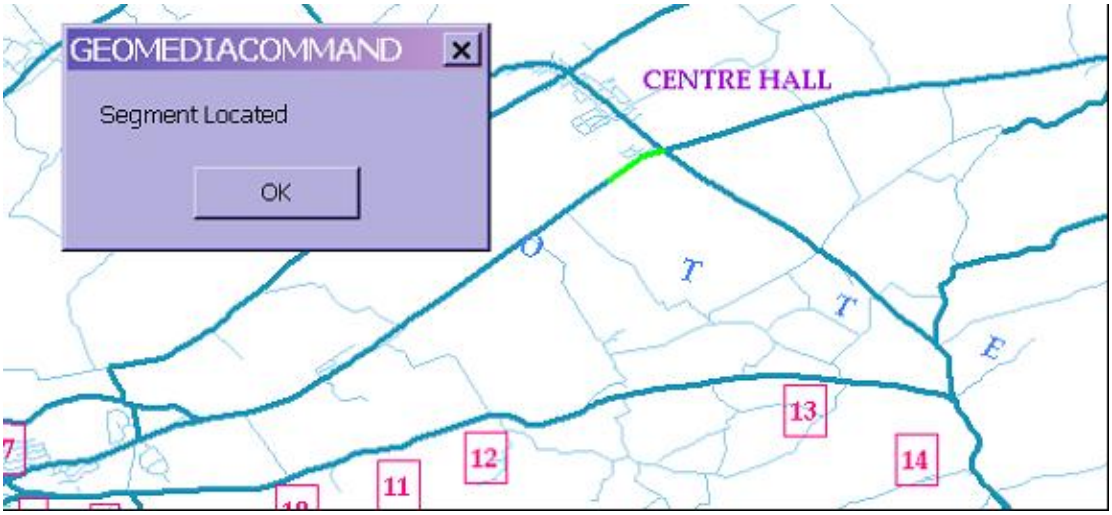

Figure 4. Edit Mode-Step 2

3 User is given an option of choosing the direction for the accident route. Direction will be also updated in the database, and the updated information for the direction will be displayed on the map.

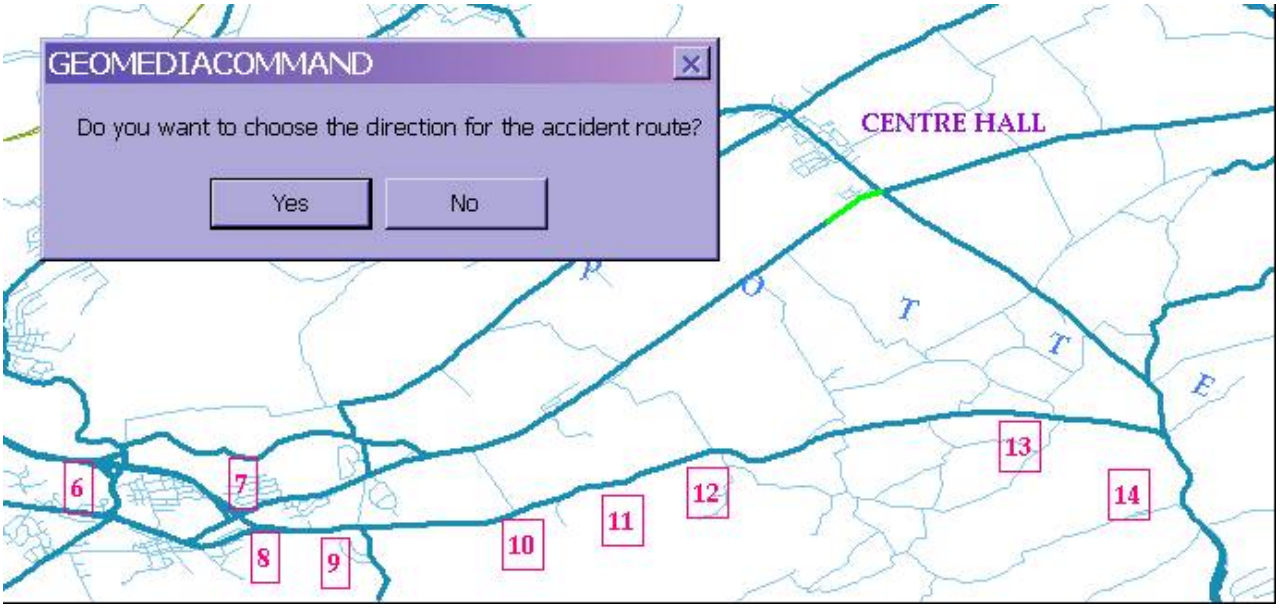

Figure 5. Edit Mode-Step 3

4 Direction is selected by the user through the Graphical User Interface

Figure 6. Edit Mode-Step 4

5 First, if the user desires to see the diversion and accident routes without the direction information, edited information that has just entered by the user will be displayed. Accident routes are displayed in read and diversion routes in green.

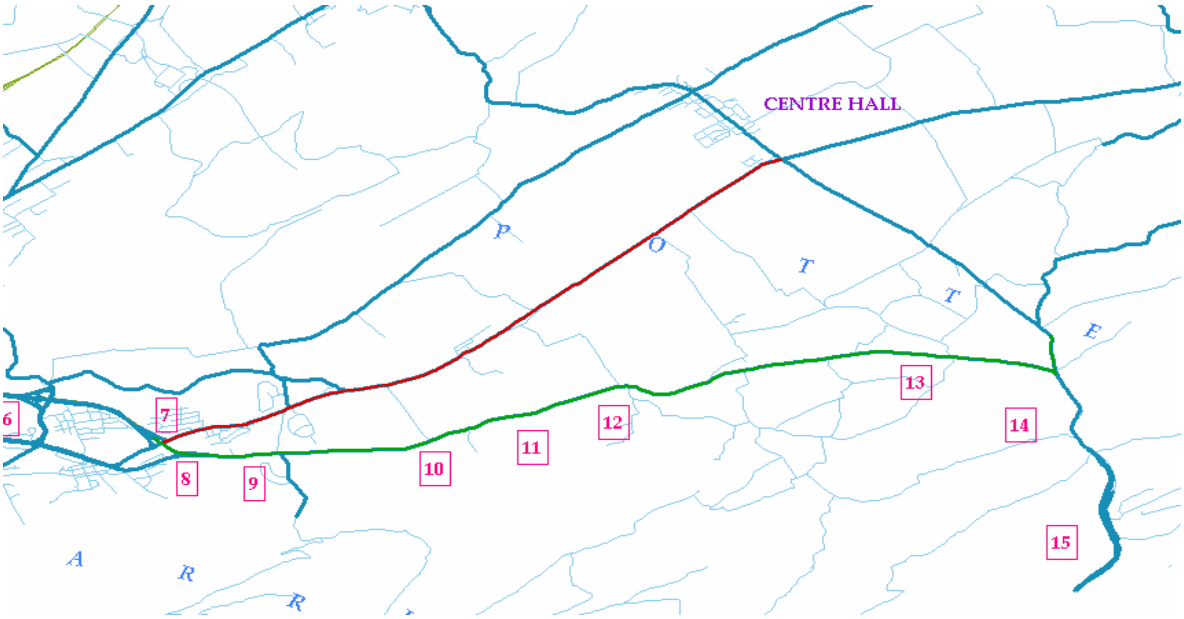

Figure 7. Edit Mode-Step 5

6 The display can be cleared if desired, or the user can simply continue the editing process. The map display will be updated for each selection process. Therefore, there will be a single accident route and corresponding diversion route, DMS location information displayed.

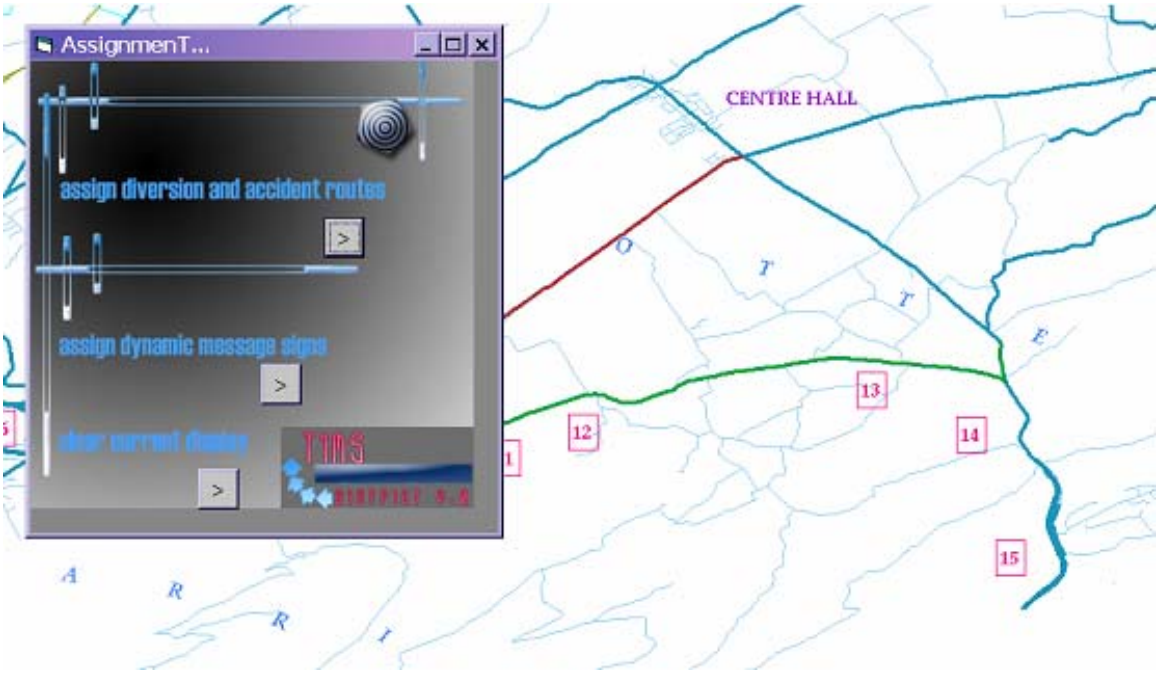

Figure 8. Edit Mode-Step 6

7 The process of DMS location selection for the corresponding Accident Route selection is similar to the process of selecting the diversion route for the corresponding accident route selection. First, DMS segments are selected, and user selects “assign dynamic message signs” through GUI and follows the selection process used in the selection for the diversion routes.

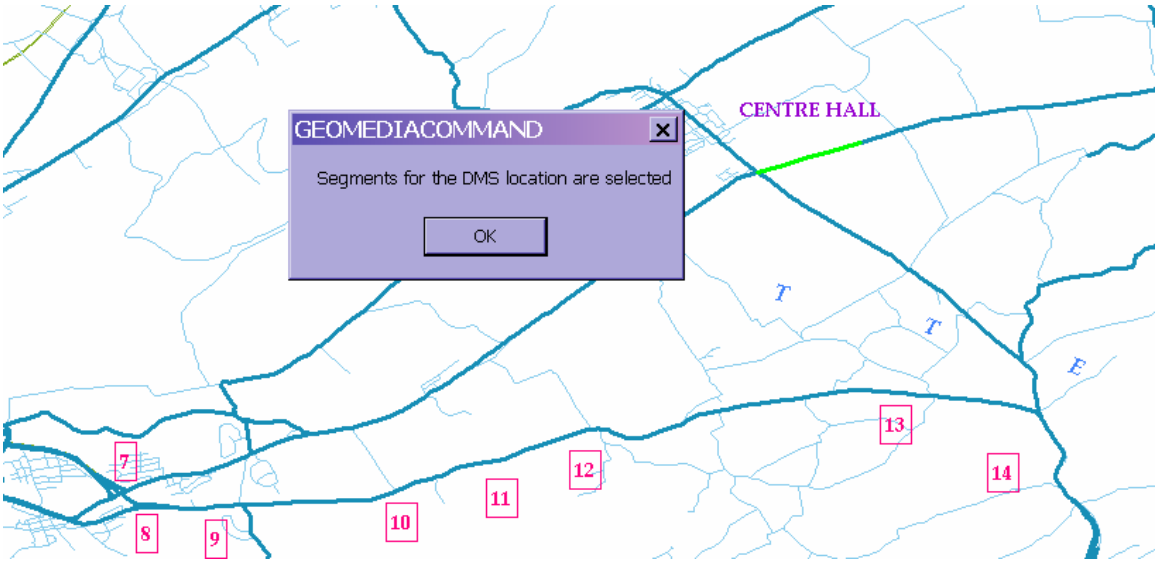

Figure 9. Edit Mode-Step 7

8 DMS locations and related accident route is selected.

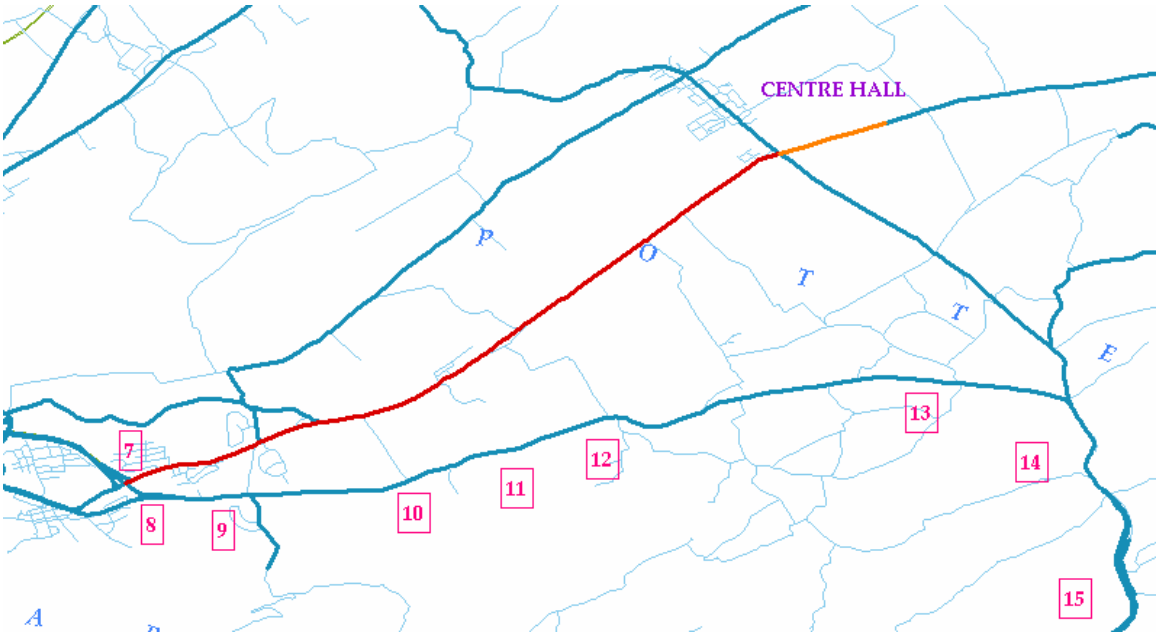

Figure 10. Edit Mode-Step 8

Function 2:Display Mode - Displaying Accident Routes, Detour Routes and DMS locations on the GIS map

Function 2 is automated through GMPro, and the objective is to display accident routes, detour routes and resource locations on the GIS map for the response agencies. All the assets/resources information can be accessed through the GIS map. The resource plans can be viewed in text, and the authorized user can update and change the information. Design Files can be viewed by site engineers in detail within an interface between GMPro and Microstation. User can browse through the data records, if desired. Authorized users can write reports and email these reports through user-friendly VB forms integrated in GIS Map. Also using WildEdit[2], any change in the text forms for diversion plans, which include information about the current condition of the road, resource specifics, contact information, and so forth. Let us assume the traffic operator for that specific road has changed, using the interface created between WildEdit and GMPro, this contact information can be changed for all of the text forms that exist in TIMS for practical managerial purposes.

The following presents the steps for the display mode of the proposed tool:

1 User clicks on the routes on the display map, and he or she is presented with the diversion route and DMS location information related to the clicked accident route on the map. User is presented with the recent updated information for the accident route, diversion route, DMS location information.

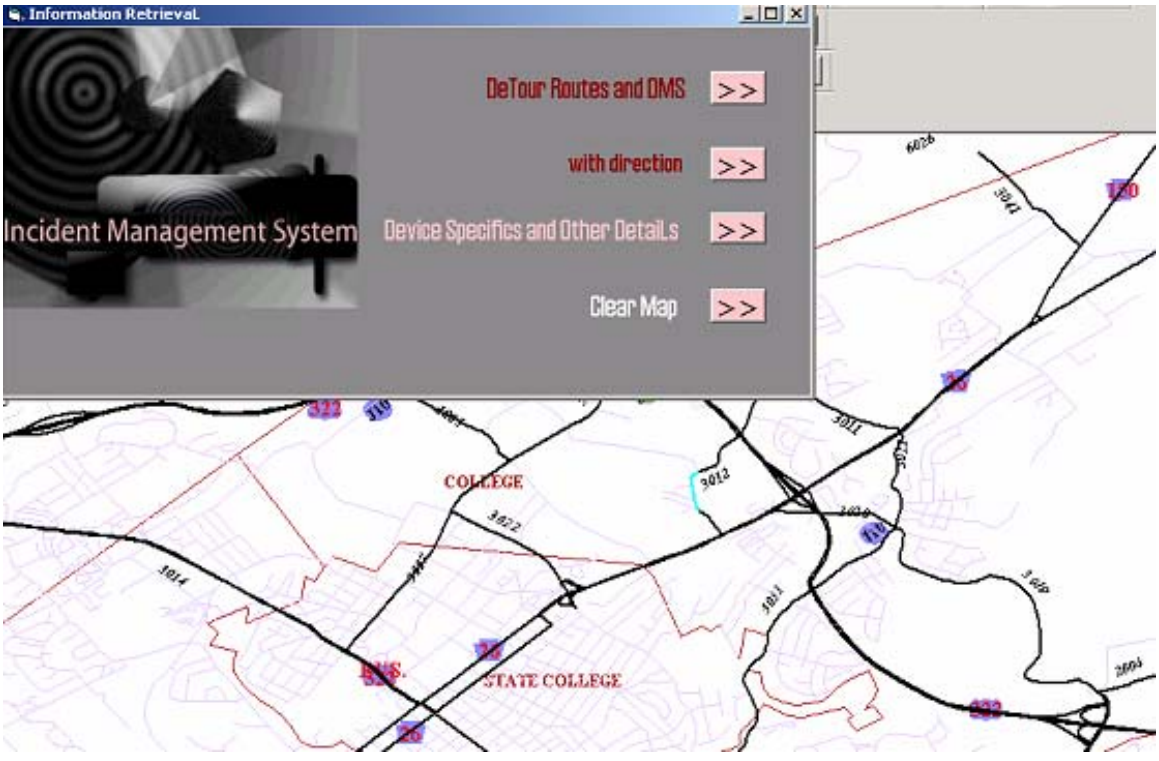

Figure 11. Display Mode-Step 1

[2] www.textpad.com

2 Detour Routes and DMS locations are represented for the related accident route.

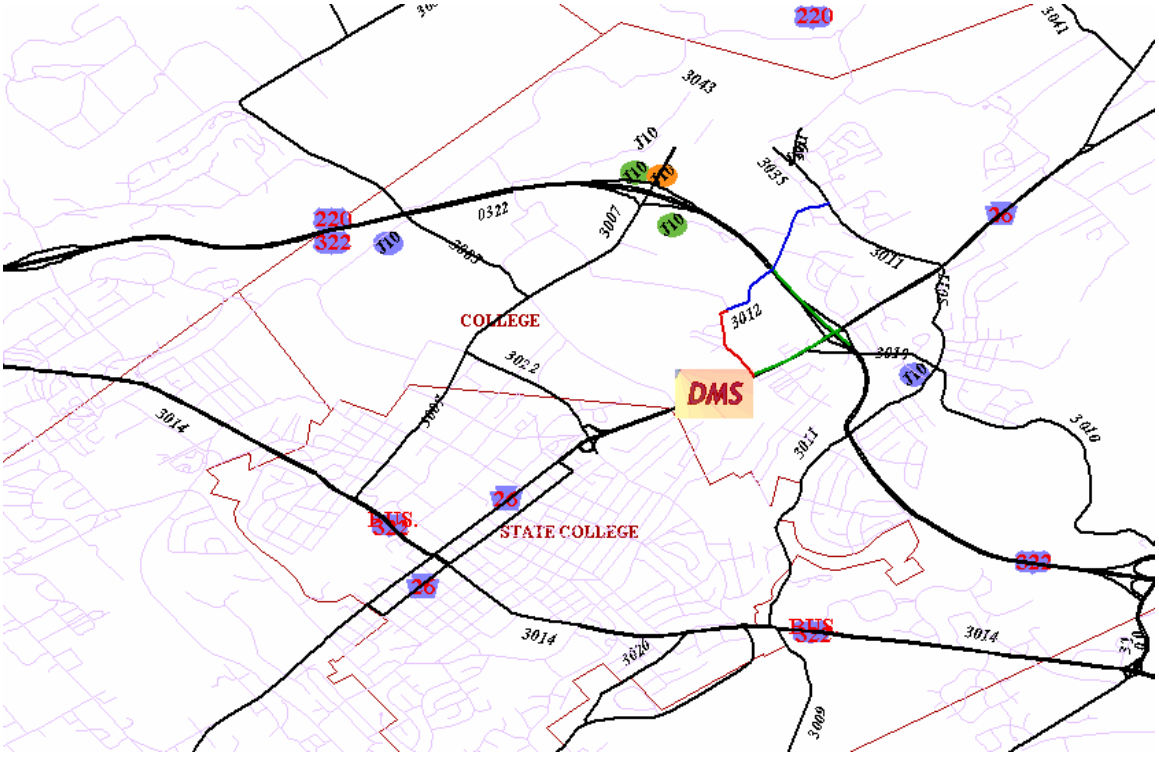

Figure 12. Display Mode-Step 2

3 User can click on DMS sign to see the related information specific to that DMS. He is also presented with other options. He can write a report, access the folder for diversion plans, he can analyze design files in detail, or he can access all the related information about the selected segment, like the street name, route number, etc.

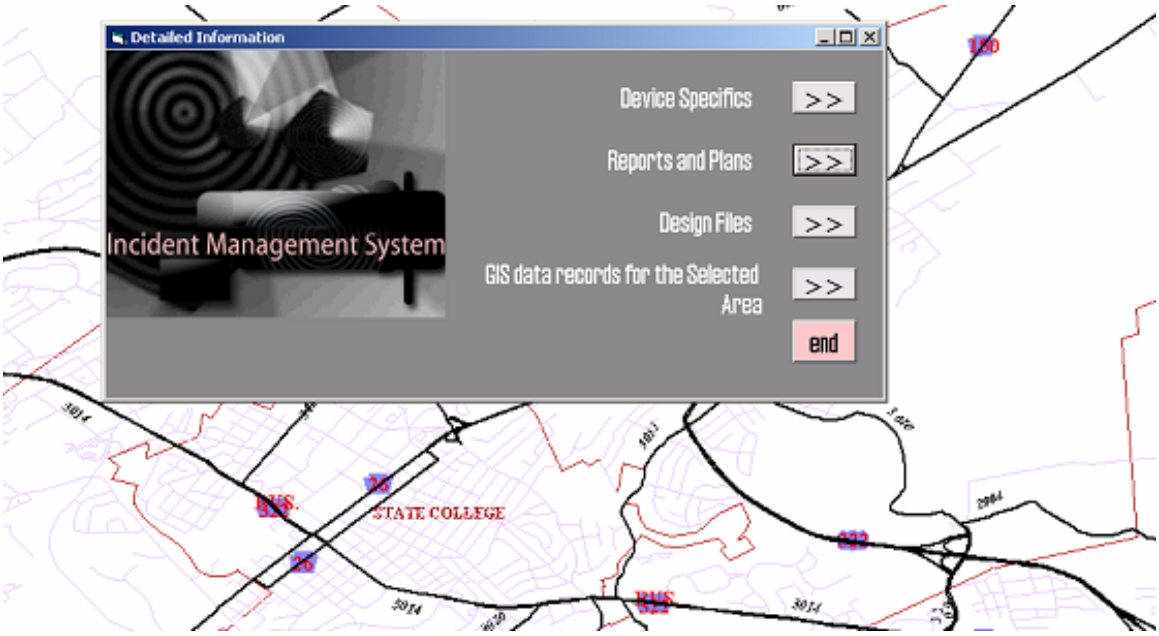

Figure 13. Display Mode-Step 3

4 User accesses a text file for all the related information about the selected DMS. He can make changes in the file and save these changes to update the recent information.

Figure 14. Display Mode-Step 4

CONCLUSIONS

TIMS can be a significantly beneficial GIS system for the transportation departments and their asset management strategies. Possible benefits are described throughout the paper. The cost of this implementation depends on the software installation for each client machine. Each client machine requires GMPro installed to edit and view interactive GIS maps. The future work aims improving TIMS using a cental server to overcome this problem. Therefore, the goal of the future work is the conversion of TIMS to an online real-time system. Since GM Web Map is selected for this task, minor effort is needed to overcome some technical issues of the conversion, rather than re-programming the functionalities which are already utilitized in TIMS.

The other future work is to keep track of all the operations in TIMS. For example, we believe that the number of times a roadway is selected as a detour route, the circumstances for this selection, and total time needed to restore normal traffic conditions in the presence of an incident should be recorded for planning purposes. This data might be useful for other incident management systems that will employ duration and delay estimation functions. Also, if a specific roadway is selected as a detour route for noticably large number of times during a certain period of time, the roadway capacity might need to be increased or other planning actions should be utilized.

There are some potential barriers, which have to be met in order to achieve deployability of TIMS as a real-time tool as part of a well-integrated asset management strategy. Some major issues are as follows:

- Develop managerial and practical strategies for updating data and maintaining system-wide consistent information on all parts of the transportation department

- Address inter-jurisdictional issues associated with notifying multiple agencies during an incident and having them to achieve a coordinated response through the effective asset management strategy.
- Identify and coordinate, where appropriate, the various asset management-related activities occurring in the agency
- Identify gaps in operational/technical and managerial support activities and develop strategies for filling these needs.

LIST OF FIGURES

REFERENCES

1. Transportation Asset Management Guide, prepared for the National Cooperative Highway Research Program (NCHRP) Project 20-24(11) by Cambridge Systematics, Inc. with Parsons Brinckerhoff Quade & Douglas, Inc., Roy Jorgensen Associates, Inc. and Paul D. Thompson, November 2002, AASHTO Publication RP-TAMG-1.
2. http://www.pasda.psu.edu/home.shtml
3. Ozbay, K. and Noyan, N. GISMIS-Based Management Information Systems. Presented at 83rd Annual Meeting of the Transportation Research Board, Washington, D.C., 2004.
4. Ozbay, K. and Noyan, N. Application of Bayesian Networks in Incident Management and Decision Making. To be presented at 85th Annual Meeting of the Transportation Research Board, Washington, D.C., 2005.
5. Ozbay, K., and P. Kachroo. Incident Management in Intelligent Transportation Systems. Artech House, Boston, MA, 1999.
6. http://www.dot.state.ny.us/ reg/r11/iims/
7. Anderson, D. A., and Souleyrette, R. Simulating traffic for incident management and ITS Investment Decisions
8. Burchfield, J.A., Miller, T.A., Queen, L., Frost, J., Alfright, D., DelSordo, and Goodman, S. Investigation of Geospatial Support of Incident Management Final Report, November 25, 2002
9. Guler, H., Akad, M. and Ergun, M. Railway Asset Management System in Turkey: A GIS Application. FIG, Athens, Greece, May 22-27, 2004
10. Switzer, A. and McNeil, S. Developing a Road Map for Transportation Asset Management Research Public Works Management Policy, Jan 2004; 8: 162 – 175.
11. Krys Ochia. Traffic Calming in Public Works: Agency Characteristics and Professional Staff Roles Public Works Management Policy, Jan 2001; 5: 240 - 246