

EVALUATION AND DEVELOPMENT OF MIS INTERFACE

FINAL REPORT

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ABSTRACT

NJDOT has been working on creating a digital database of its roadway plans and Right-of-Way (ROW) maps by scanning them to allow easy access to all prospective users. The scanned documents are location specific, and can be referenced to a specific geographical location on the New Jersey highway system. The best and most efficient way to search for these documents is clearly through their geographical locations. Thus, it is quite natural to develop a system that integrates the digitized document database with a Geographical Information System (GIS)-based highway database. The main goal of the prototype GIS-Based Information System (GISMIS) is to provide an intelligent and easy to use computer tool to process this large database of digital roadway plans and ROW maps. GISMIS tool is connected to a third party product namely, Falcon/DMS, that is used to manage this large database of digital roadway plans and ROW maps. The user can easily identify his/her new location on the GIS map and then search the database for the scanned roadway plans and ROW maps associated with the location identified on the GIS map.

INTRODUCTION

GENERAL

The main motivation behind this project is to make use of the powerful GIS capabilities by effectively integrating transportation related data sources for creating “accessible, reliable, useful and affordable” information presented in a simple yet innovative way to the end users. It is that the very large digital document database of roadway plans and ROW maps generated for each state road sections ever built in New Jersey can be effectively maintained, managed and used on a day to day basis with the help of an effective information technology tool similar to GISMIS. There is also the need to geographically reference these files to the current New Jersey road network to ensure better access by the users. The solution proposed for NJDOT is to digitize these documents, and keep them in a digital format, and then to develop a GISMIS application that ensures effective management and retrieval of requested documents from the very large scanned digital document database.

The physical process of scanning roadway plans and ROW maps was not part of this project. CAIT researchers used already scanned documents obtained from NJDOT. CAIT subcontracted tsaADVET to develop a custom module in which the route information, start and end mileposts of the selected road segment is passed to Falcon/Document Management System (DMS) that was already being used by NJDOT for the retrieval of the scanned documents.

The responsibilities of three parties in their interaction in this project are shown below:

CAIT

- The custom command NJ.dll developed by CAIT generates a temporary file named FalconGeoNJDOT.txt

- FalconGeoNJDOT.txt file contains the related information for the last selected road segment

TsaADVET

- TsaADVET developed FalconGeoNJDOT module and tested integration with NJ.dll

NJDOT

- NJDOT professionals populated Falcon/DMS released document vault. The Falcon/SVP web module was installed and was made operational. IIS web server was available for the installation of the CGI program and also some html template files

PURPOSE AND OBJECTIVES OF THE PROJECT

The main objective of GISMIS application was to produce a customized GIS-based management information system prototype that can demonstrate the following:

- Bringing GIS-based New Jersey transportation network data into unified data management environment, which is capable of integrating digital roadway plans and ROW maps residing in NJDOT databases in order to generate valuable and useful information for the end users
- Employing visual and geographical analysis capabilities of GIS along with efficient implementation of various database operations such as automated data analysis, querying processing and presentation
- Enabling a range of users in NJDOT with different requirements and capabilities to gain easy access to this very large digital document database of the roadway plans and ROW maps
- Integrating a powerful third party product namely, Falcon/DMS, which has already been employed at NJDOT prior to this project, with various capabilities of GIS

GISMIS APPLICATION OVERVIEW

GISMIS application presents a unique solution for a unique problem that requires management, maintenance and access of large document databases that have to be arranged in such a way that the user can retrieve the required documents for specific geographic location through the use of a GIS-based user interface.

Development of this custom application for NJDOT enables the creation of a unified platform for integrating several software tools and controls to provide capabilities that can respond to all of the potential users' needs. GISMIS design is in fact based on the unique needs of NJDOT for utilizing several tools and databases in a single application. The key to the system is the effective access to data stored in several databases via GIS Mapping Window with full range of analysis capabilities offered by GeoMedia Professional (GMPPro).

Currently, the databases that contain scanned roadway plans and ROW maps generated for each state road sections in New Jersey are managed and maintained using Falcon/DMS. One of the most important tasks of GISMIS is the integration of GIS side of the application with this existing document viewing and management tool.

Figure 1 shows the overall framework of the application. Figure 2 is a screenshot of the application, and Figure 3 presents the system application design. As the user clicks on the link on any highway shown on the GIS map, our application retrieves the link information from the GIS database including milepost start, milepost end and route number using the queries embedded in the VB program, and then writes it on a text file that is then accessed by Falcon/DMS to identify the corresponding digital files. Once Falcon/DMS reads the related link information from this dynamic text file, it launches a special query to identify corresponding digital files from a released document vault, where each scanned document was added, and then indexed in the Web Server. A list of these file names are then shown in a different window to the end user who can go ahead and review each digitized roadway plan or ROW map by simply clicking on a name in that list.

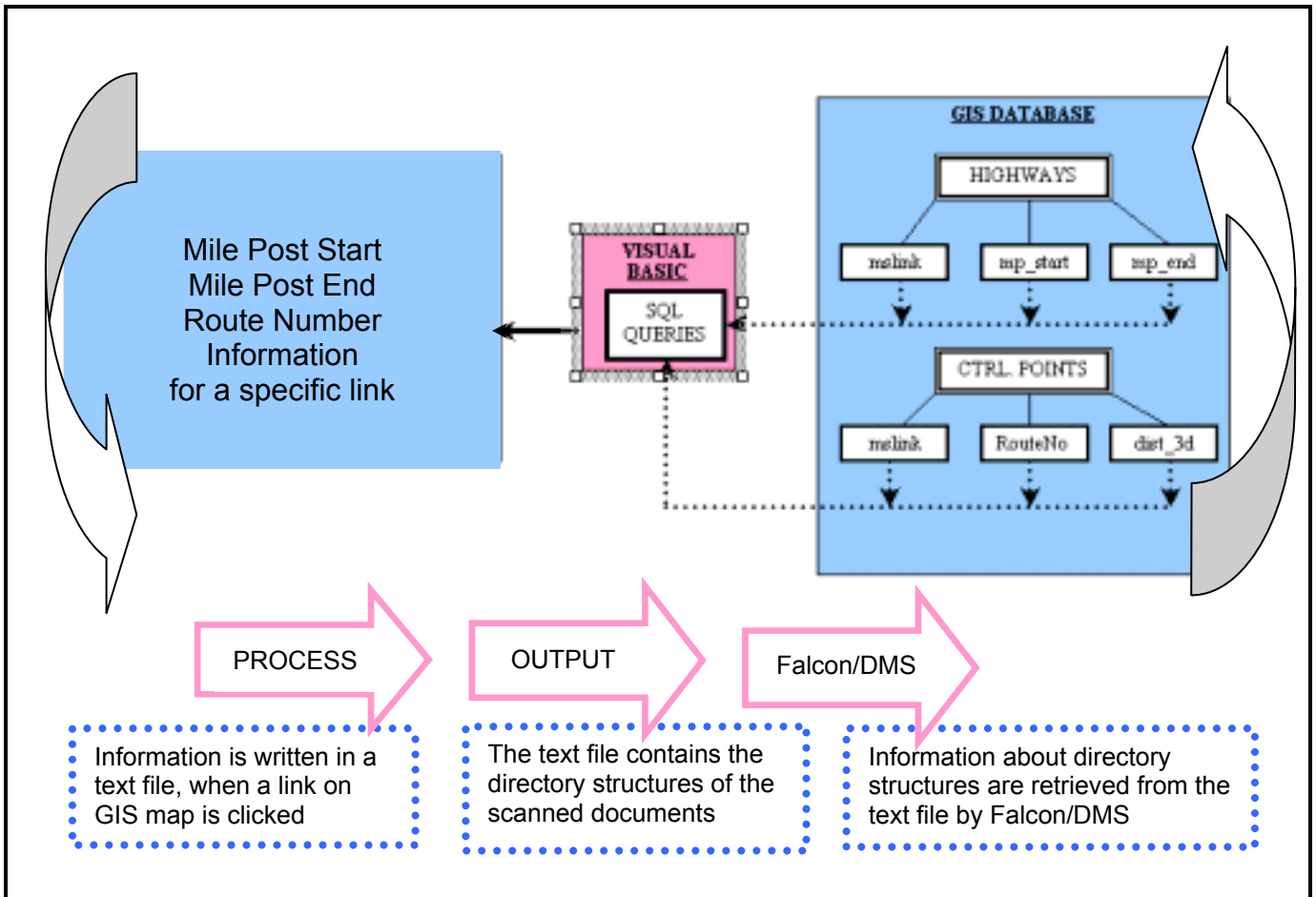


Figure 1 Overall Framework of GISMIS



Figure 2 Screenshot of the GISMIS Application

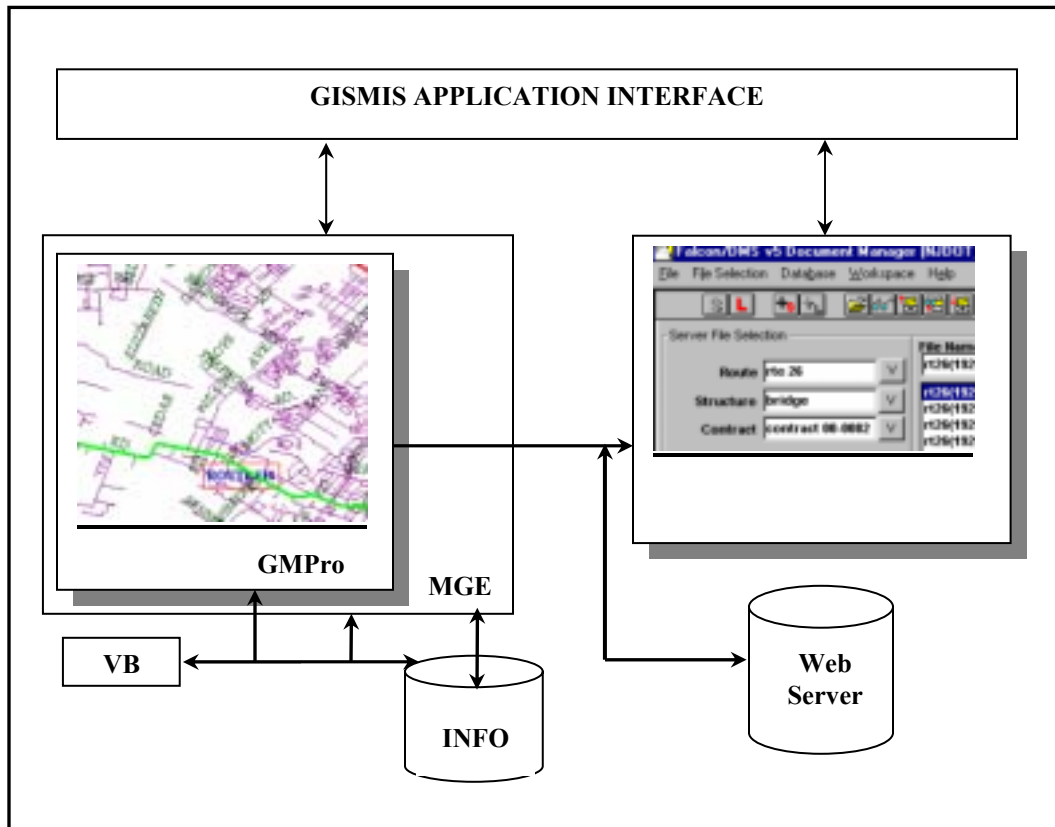


Figure 3 GISMIS Application Design

DESCRIPTION OF THE METHODOLOGY USED FOR THE APPLICATION DEVELOPMENT

DEVELOPMENT OF SYSTEM ARCHITECTURE

GISMIS application and its proposed functions were designed to help NJDOT professionals access various databases through the desired GIS functionality. GMPPro is used as a software development environment, and as the main desktop and a viewing and analysis tool. Originally GMPPro was going to be used as the only GIS platform to develop a customized application in conjunction with Falcon/DMS. Due to new requirements of NJDOT for accessing roadway plans and ROW maps in a more efficient way, and to remedy inconsistencies that existed between the digital scanned files and the existing NJDOT GIS map, dynamic segmentation was needed to narrow down the number of related documents identified by the search process. This was only possible if the links originally coded into NJDOT road network were automatically modified to reflect the milepost information of roadway plans and ROW maps. In general, these scanned documents cover distances much smaller than the original link lengths in the GIS database used by NJDOT. Dynamic segmentation was used to modify the links on GIS map as to reflect smaller lengths covered by related documentation. Dynamic segmentation feature is not available in GMPPro. Thus, it was decided to change the work plan to employ MGE and MicroStation, along with GMPPro, and modify the original NJDOT GIS map using dynamic segmentation feature available as part of these new tools.

GISMIS uses MGE as its primary GIS platform. MGE is an environment highlighting the complete spectrum of spatial information capture, processing and management. MGE Basic Nucleus (MGNUC) is the platform and prerequisite front-end setup application for MGE. MGE and its applications are based on MicroStation, and it combines MicroStation graphics for mapping, and MS Access for database applications. It has a structure that allows the user to access common utilities including software tools, graphic data and the database system in an efficient workflow. MGE Basic Administrator (MGAD) enables the developer to define the structure of the database. MGE Segment Manager (MGSM) data server provides the capabilities to display and to analyze data stored in distributed attribute tables in GMPPro. Open Database Connectivity (ODBC) integrates all the tools used in the application by creating interface to MS Access Databases and the MGSM project file. Due to its full compliance with ODBC standards, the system is supported by the Application Programming Interface (API) for database access, and thus Standard Querying Language (SQL) can be used as its database access language.

GISMIS is seamlessly connected with Falcon/DMS, which is a general document management solution for the MicroStation CAD community. "Falcon/DMS presents a comprehensive and flexible solution to provide advances in network technology. Falcon/DMS manages documents within the traditional client/server architecture by making fast and reliable transfer of data available to more users." ⁽³⁾

GISMIS is developed inside a VB programming structure, because of VB's ability to incorporate add-in technologies, which make our application efficient and scalable. Software functionality and interfaces among VB, MGE, GMPro, Falcon products and data files are shown in Figure 5. While VB controls the whole application, MGE ensures the integration of data files with GIS-based user interface application namely, GMPro, which displays the map to the users. As shown in Figure 4, any client running MS Operating System and GMPro can use GISMIS application with full access to the document files and functionality of our application. Due to security reasons, outside users cannot be given access to the Web Server at NJDOT, thus the access is only limited to users within NJDOT.

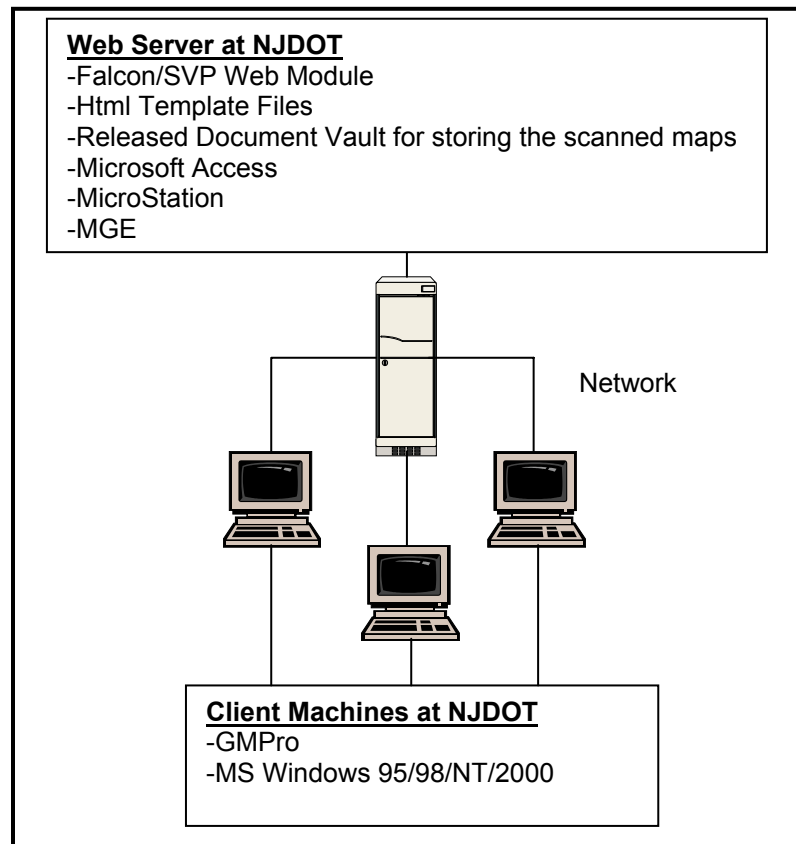


Figure 4 Application Architecture

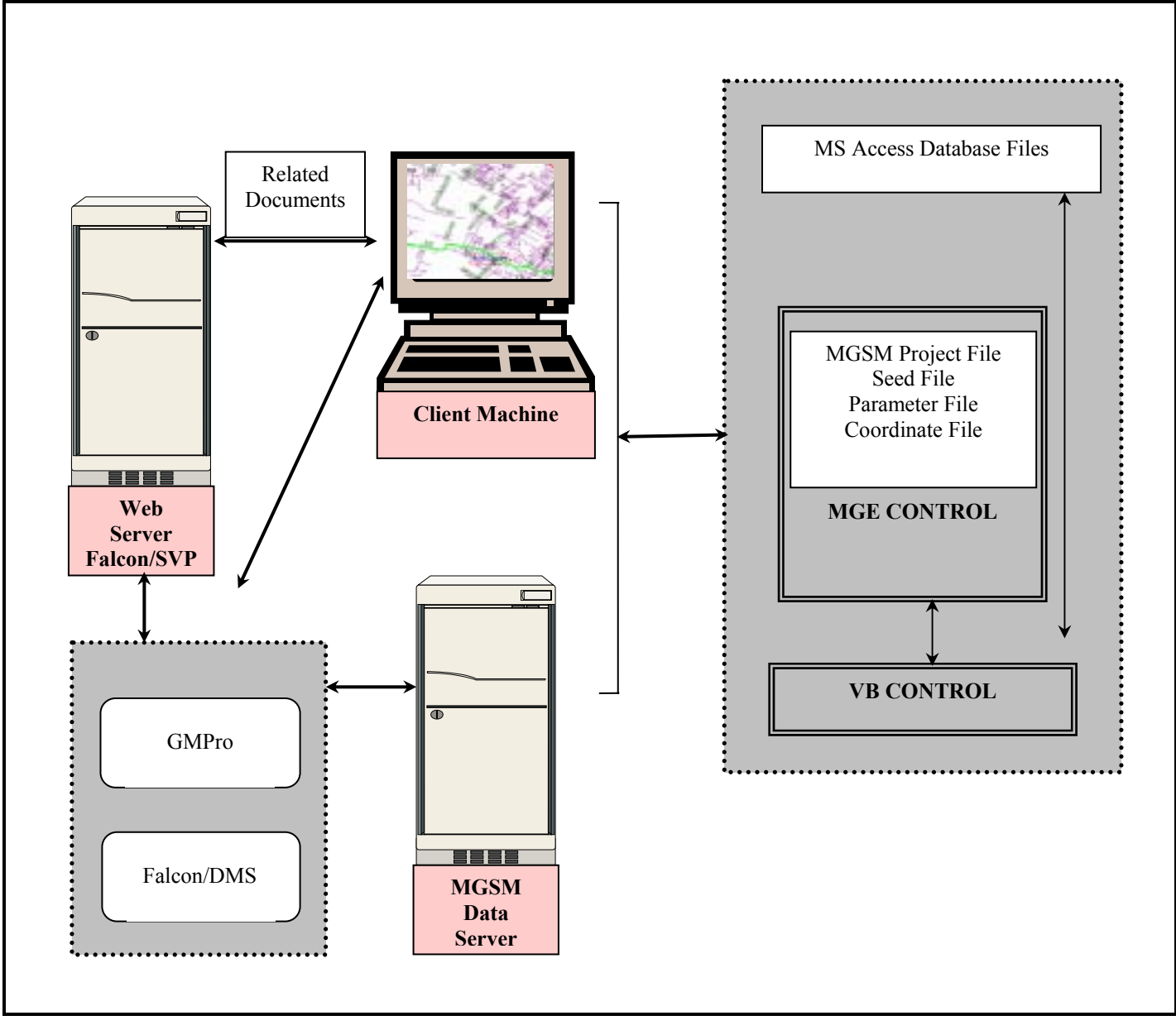


Figure 5 Interfaces between Different Software Tools for the Creation of an Integrated Application

IMPLEMENTATION OF THE PROTOTYPE APPLICATION

SOFTWARE TOOLS IN GISMIS

Software tools that are used for the implementation of the prototype GISMIS application are listed in Table 1.

Table 1 Software Tools Used in System Development

| |
|---|
| <p><u>GeoMedia Professional (GMPPro)</u></p> <ul style="list-style-type: none">▪ Software development environment▪ Main desktop, and a viewing and analysis tool▪ GIS data from different sources and in different formats are integrated into a single unified workspace environment |
| <p><u>Modular GIS Environment (MGE)</u></p> <ul style="list-style-type: none">▪ Primary GIS platform▪ Environment for the spatial information capture, processing and management▪ MGE and its applications are based on <u>MicroStation</u>, and it combines MicroStation graphics for mapping, and <u>MS Access</u> for database applications |
| <p><u>Visual Basic (VB)</u></p> <ul style="list-style-type: none">▪ GISMIS is developed inside VB's programming structure▪ Incorporates add-in technologies which make GISMIS efficient and scalable |
| <p><u>Falcon/Document Management System (Falcon/DMS)</u></p> <ul style="list-style-type: none">▪ Manages documents within the traditional client/server architecture by making fast and reliable transfer of data |

Below a brief description of each tool is given:

GeoMedia Professional

GeoMedia Professional (GMPPro) provides a viewing and analysis tool to combine geographic data from different sources in different formats into a single environment. Using GMPPro, queries on spatial and attribute data from various sources can be performed, and views for maps can be displayed in a single GeoWorkspace. GMPPro is also a software development environment, which can be customized with Windows-development tools like Visual Basic (VB) ⁽¹⁾. GMPPro requires the components explained below for its workflow:

GeoWorkspaces

The first thing the user does in GMPPro is to create a GeoWorkspace, or open an existing GeoWorkspace, since it is the container for all the work in this product. It can be configured to suit the user's needs like selecting the coordinate-system

properties, or properties of legends. After saving the GeoWorkspace, it can be reopened with the restored configurations ⁽¹⁾.

Warehouses

Data viewed by the user are stored in warehouses. Feature geometries and attribute data are displayed in a GeoWorkspace through connections to warehouses. Access to data is performed creating connections from the GeoWorkspace to one or more warehouses. Warehouse stores can be both geometric (graphic) and attribute (non-graphic) information. After connecting to at least one warehouse, related data can be displayed and analyzed in a single GeoWorkspace ⁽¹⁾.

Coordinate Systems

Data is displayed using the coordinate system defined for the GeoWorkspace. Features with different coordinate systems are transformed and displayed through a single GeoWorkspace using its selected coordinate systems ⁽¹⁾.

Map Window

In its interface, GMPRO environment consists of a series of windows within windows. Map windows display graphic data like geographic or other map objects. Each map window contains a legend ⁽¹⁾.

Legends

Legends provide control for displaying characteristics of the features, like their style and display property. User defines the content and design of each map window through its legend, simply controlling what is displayed to the user, and how it looks ⁽¹⁾.

Data Window

Data windows display the attribute data associated with the geographic objects (geometries) in the Map Window. Data windows contain non-graphic attributes of a single feature class or query. Map and data windows are linked so that changes made in one window are reflected in the other ⁽¹⁾.

MGE

MGE Basic Nucleus (MGNUC) is the platform and prerequisite front-end set-up application for MGE and other GIS applications based on MicroStation. MGE is responsible for the creation and maintenance of GIS databases. It provides the user a flexible set of tools for both production and planning GIS environment where several software tools function to create a single, efficient and user-friendly application.

MGE combines MicroStation graphics for mapping and relational databases, such as MS Access used in GISMIS, and runs on the operating system such as Windows NT. Figure 6 illustrates the architecture of MGE system used in GISMIS.

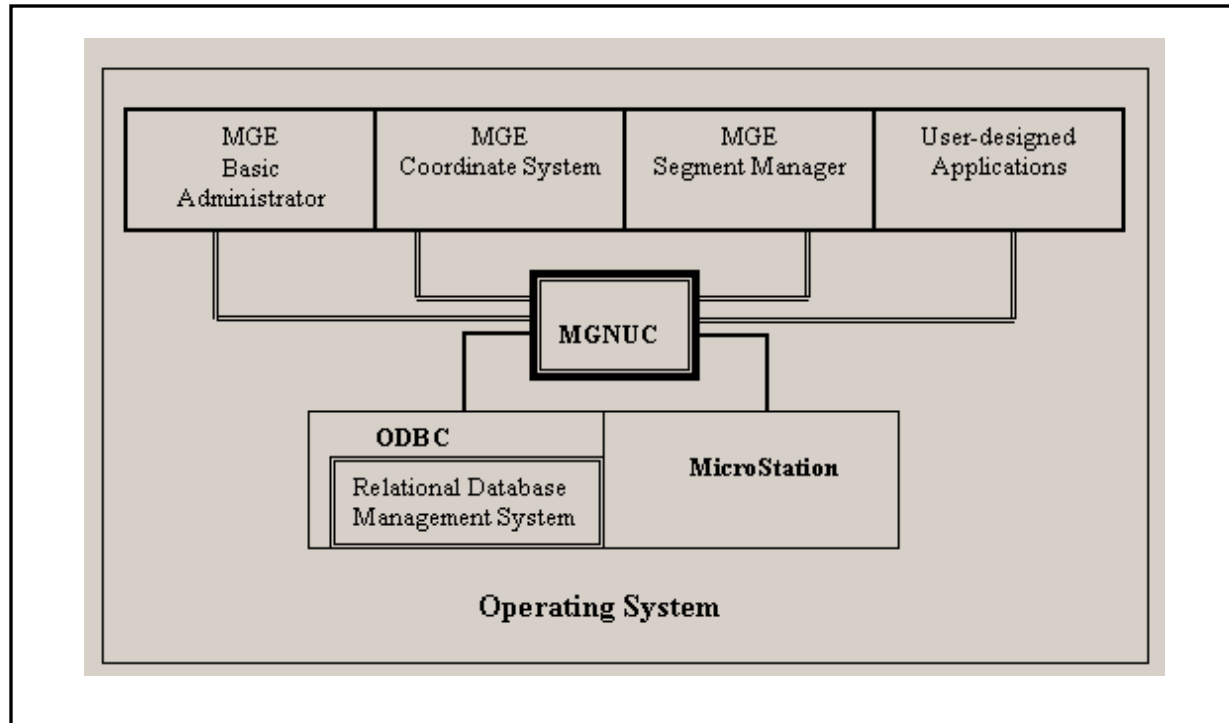


Figure 6 Modular GIS Environment Platform

Visual Basic

VB application developed as part of this project establishes the MGSM warehouse connection with MGE that is then used to define linear network queries to enable user to select a link on the NJ highway map. MGSM is an MGE application that stores distributed attributes that are linearly referenced to highways in the NJ Network. To connect to MGSM data, the MGSM project, parameter, seed, and coordinate files were identified in a VB custom command to define a reference for the GeoWorkspace to determine properties of the database to get connected.

“Open Database Connectivity (ODBC) is a database interface standard, which provides a single interface between front-end applications and back-end databases, and enables the access to MGSM warehouses through the identification of the file, file name and file type, which is processed through ODBC.”⁽¹⁾

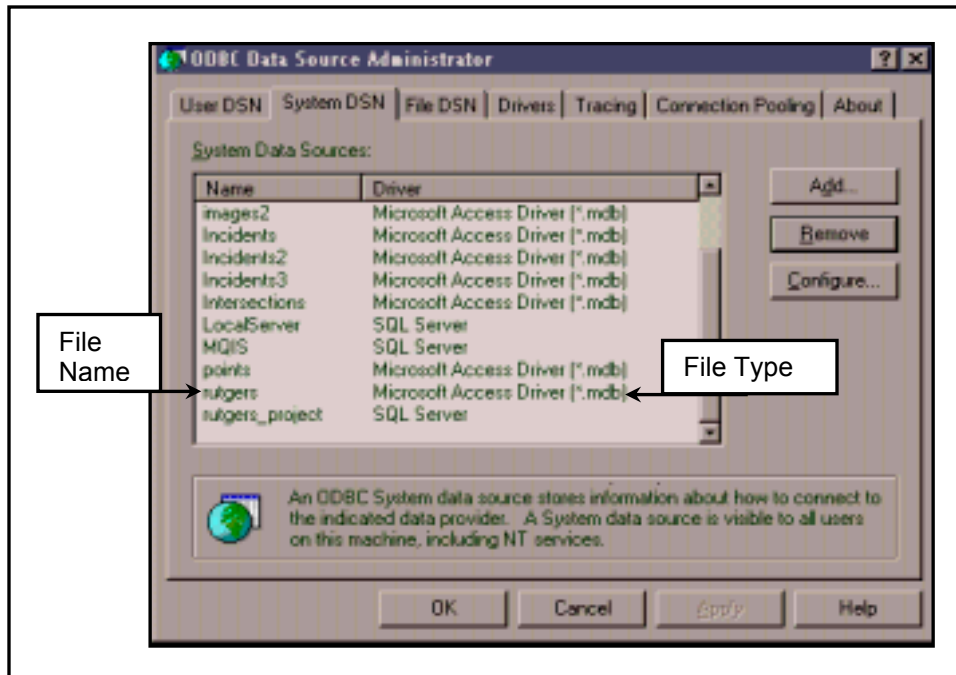


Figure 7 Creating a Data Source to access GIS data files through ODBC

Use of VB was of prime importance since it provided the basic programming and customizing tools for MGE and GMPro. In the existing version of GMPro, due to compatibility issues, VB 5.0 had to be used instead of VB 6.0. Prior to the tool development, the project team sought out the information about the objects, properties and methods available in GMPro. The customized button which was named and created by GM Command Wizard, and which visually stands for the GM Command itself initiates the process. GM Command encapsulates the programming code written in VB 5.0. It then initiates and completes the application process using the capabilities provided by the objects, methods, and properties of VB and GMPro.

Falcon/DMS

Falcon/DMS is an engineering document management system developed by tsaADVET Advanced Enterprise Technologies. Falcon/DMS is an integral part of GISMS, where it offers a complete, comprehensive and flexible solution to document management with easy implementation, configuration, and usage for any WAN/LAN or web-based automation effort. ⁽³⁾

Another product that was already installed, but partly used in the project by tsaADVET was Falcon/SVP. It includes tools for configuring and managing web-based Falcon implementation. Requiring only a Web browser, Falcon/SVP provides users with 'view only' access to documents by allowing them to enter criteria on a search form that, upon submission, produces a result of matching database records. This search results form is configured to pull key information from each document's record, and allows the user to view the corresponding scanned documents through Falcon/DMS tool on a client machine ⁽³⁾.

DATABASE IMPLEMENTATION

MS Access Database Files

MS Access Database files are *MGE_GIS_Export.mdb* and *DYNSEG.mdb*. The *MGE_GIS_Export.mdb* file, which is provided by NJDOT, creates the basis for the GIS map. The *DYNSEG.mdb* file is a custom-made database used to display segmentation of data on the NJ Highways Map. These two databases, as presented in Figure 8, contain *Highways* and *Control Points* tables where crucial data to perform the application is stored in.

The *Control Points* and *Highways* tables shown in Figures 9 and 10 are distributed attribute tables. Distributed attribute tables contain information that allows geometry to be generated by dynamic segmentation. Distributed attribute values apply only to particular distances along Network Linear Feature (NLF). The distances are identified by start and end points on the NLF. The MGSM data server provides the capabilities to display and to analyze data stored in these distributed attribute tables. For the *Control Points* table, distance-from-origin values on control points in a control network are the key attributes for dynamic segmentation. Control point data represents a known position on a Network Linear Feature from which “distributed attribute” information can be referenced. The *Highways* table includes important information such as route number and milepost start and end data ⁽¹⁾.

For the *Highways* table, distributed attributes and their start and end point data originate as records in the custom-made database for dynamic segmentation process namely, *DYNSEG.mdb*. The columns of the *Highways* table in *DYNSEG.mdb* including route number, *sri*, link identification number, *mmlink* are used as the distributed attributes to be applied on the linear feature. The column *mmlink* is used as the primary unique key for all database-linked features.

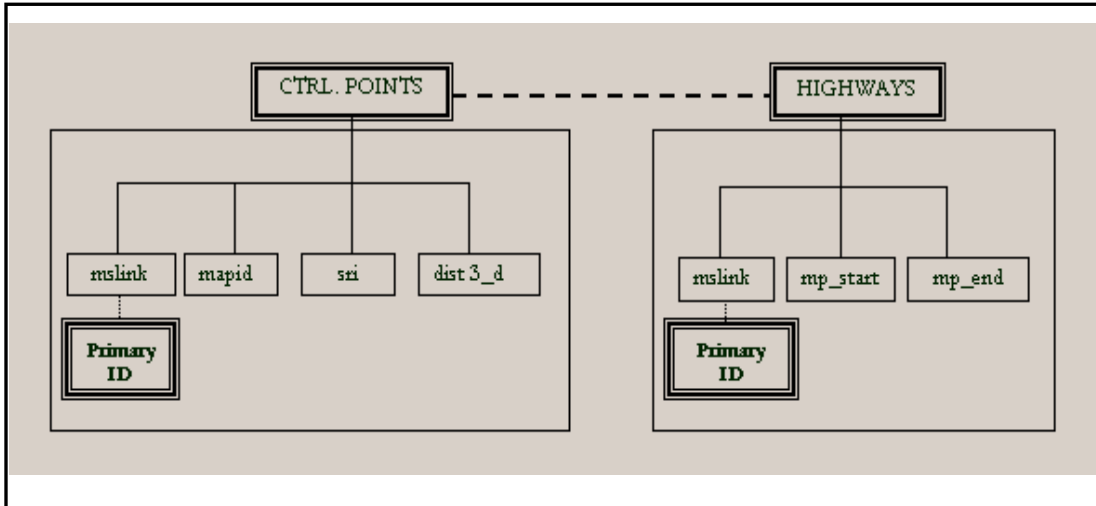


Figure 8 Basic Fields in Control Points and Highways Tables in MGE_GIS_Export.mdb and DYNSEG.mdb

Table 2 Column Descriptions for Highways and Control Points Tables

| | |
|--------------------|---|
| <i>mslink</i> (PK) | Link identification number (Primary ID) |
| <i>mapid</i> | ID of the entire map |
| <i>sri</i> | Route number |
| <i>dist_3d</i> | Length of the segments that will be used for the dynamic segmentation |
| <i>mp_start</i> | The starting point of milepost of the link. |
| <i>mp_end</i> | The end point of mile post of the link |
| <i>sld_name</i> | Route Name |

| sri | sld_name | mp_start | mp_end | mslink |
|-----------|---------------|----------|--------|--------|
| 00000446 | ATLANTIC CITY | 0 | 29.5 | 1 |
| 02000017 | COUNTY 17 | 1.54 | 2.03 | 2 |
| 16000601 | COUNTY 601 | 0.27 | 6.61 | 3 |
| 00000444 | GARDEN STAT | 37.23 | 48.94 | 4 |
| 00000444 | GARDEN STAT | 153.73 | 158.24 | 5 |
| 00000195 | I-195 | 8.54 | 16.71 | 6 |
| 00000280 | I-280 | 0 | 3.32 | 7 |
| 00000287 | I-287 | 0 | 10.25 | 8 |
| 00000287 | I-287 | 30.17 | 44.96 | 9 |
| 00000078 | I-78 | 26.71 | 42.74 | 10 |
| 00000080 | I-80 | 37.63 | 48.4 | 11 |
| 00000095 | I-95 | 23.4 | 50.65 | 12 |
| 00000095 | I-95 | 70.06 | 77.96 | 13 |
| 00000445 | PALISADES IN | 0 | 11.06 | 14 |
| 020001242 | RIVER ROAD | 0.23 | 0.53 | 15 |
| 00000001 | US1 | 11.97 | 38.34 | 16 |

Figure 9 Highways Table

| mslink | mapid | sri | dist_3d |
|--------|-------|----------|---------|
| 1446 | | 00000446 | 0 |
| 1449 | | 00000446 | 29.5 |
| 1450 | | 00000446 | 42.85 |
| 1451 | | 00000446 | 44.19 |
| 1452 | | 02000017 | 1.54 |
| 1453 | | 02000017 | 2.03 |
| 1454 | | 02000017 | 7.87 |
| 1455 | | 02000017 | 8.07 |
| 1456 | | 02000017 | 10.05 |
| 1457 | | 02000017 | 13.55 |
| 1458 | | 16000601 | 0.27 |
| 1459 | | 16000601 | 6.61 |
| 1460 | | 00000444 | 0 |

Figure 10 Control Points Table

Parameter File

The parameter file is used to determine the structure of database tables and column names to generate the MGSM inputs to perform dynamic segmentation. It contains data of network linear features, control points, and distributed attributes. The parameter file is created and maintained in the Modular GIS Environment as presented in Figure 11.



Figure 11 Working with Parameter File Builder

Coordinate File

The coordinate file contains the ordered information of all the coordinates of every vertex of every element in the network linear features. The input files are Universal List Files (ULF) with linear element and control point information as well as the parameter file to create ordered information as mentioned in the output coordinate file.

Seed File

The seed file is a design file in MicroStation format, which contains proper projection and data transformation definitions to specify the coordinate system, and to enable the display of NJ Highway map to the user.

MGSM Project File

The MGSM Project file (.mge) provides an attributed basis to link the graphics and database tables. GMPPro knows about the needed MGE files by means of the MGE project name. A control network, which consists of Network Linear Features and control points, is a set of geographic data that has been structured for dynamic segmentation. The control network was built by selecting feature and attribute data from MGE project data set and from the relational database tables. Figure 12 presents the environment for the MGE file. With different components of MGE, several applications were processed in the Rutgers.mge file, like dynamic segmentation, creating coordinate and parameter files.

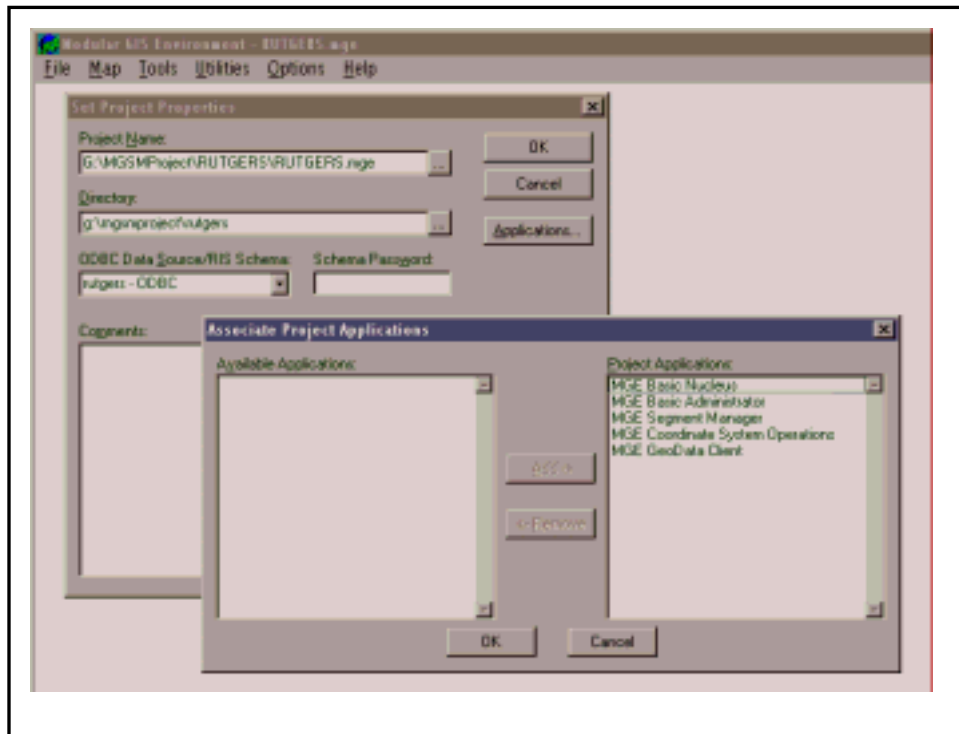


Figure 12 Working with Rutgers.mge

Rutgers folder, which essentially has the data, files for the project, other than the .mdb files has the folder structure presented in Figure 13. Figure 13 also presents the relationship between those files associated with this project and the subdirectories. These files should be considered as input to process the application, and are provided by NJDOT. When a project is created, these subdirectories are also created automatically. These directory and subdirectory structures are needed for the components of MGE to define the project and to manage data with a workflow for the geographic and thematic nature of the data ⁽¹⁾.

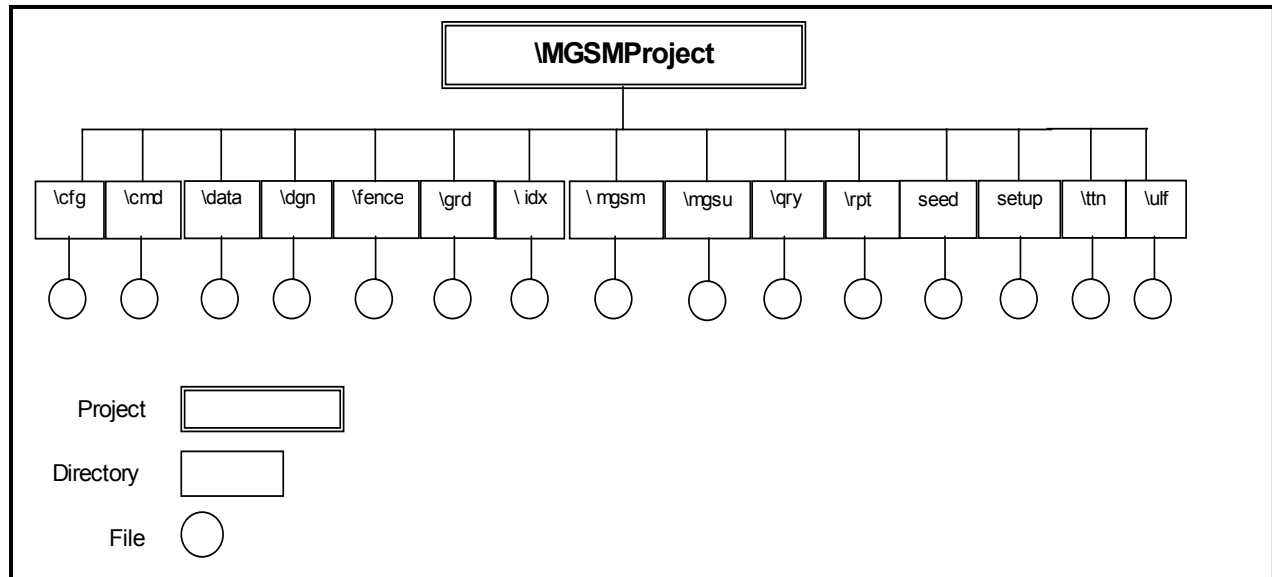


Figure 13 Relationships between the Directory and Subdirectory Structures of the Project

FALCON INTEGRATION

GISMIS was integrated with Falcon/DMS at CAIT Laboratory on a pilot computer. An unpublished API that links GMPPro, MGE and Falcon products, which was already developed by tsaADVET, was modified for the project. The technical aspects of data exchange between GISMIS and Falcon/DMS was resolved using solutions developed by the two development teams.

The focus of the integration studies, which were done on site to enable Falcon/DMS to retrieve the text file created by CAIT with the information for the selected link, and to show the related scanned documents in the Falcon/DMS user interface. The integration was accomplished by following the installation procedure described in site implementation.

Milepost information and the route number for each selected link is stored in a dynamic text file in the following format:

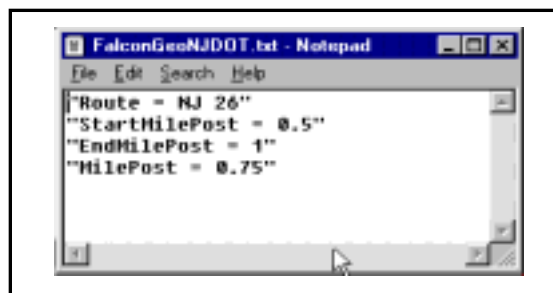


Figure 14 Dynamic File

The FalconGeoNJDOT module processes this information, and reaches a list of related digital files stored in web server in NJDOT displayed in Falcon/DMS to the user. The custom FalconGeoNJDOT module depends on a standard Falcon/DMS installation running with the Windows modules and the Falcon/SVP module. NJDOT have already built a document vault for storing the scanned engineering documents. Each new engineering document is scanned, added to the Falcon/DMS vault and then indexed. The first three system keywords in Falcon/DMS were configured to have the labels Route Number, Start MP, and End MP ⁽²⁾.

For each document added to Falcon/DMS, these three fields must be filled in to make the document available for user's search:

- *Route Number* - The *Route Number* is mapped to keyword 1 in Falcon/DMS. The route number should only contain a route number. For example "route 26" should be entered as just "26" in this field
- *Start MP* - The *start milepost* field is mapped to keyword 2 in Falcon/DMS. The *start milepost* must be entered with a format of ###.### for the search to work properly. For example, if the milepost is 1.5, it must be entered as 001.500 for the search to work properly
- *End MP* - The *end milepost* field is mapped to keyword 3 in Falcon/DMS. The *end milepost* must again be entered with a format of ###.### for the search to work properly

DYNAMIC SEGMENTATION

One of the major problems with standard linear maps similar to the one provided by NJDOT for document management applications, is that standard highway links are most of the time too long, and the information associated with each standard link can be much more than the user needs. Most of the time user is interested in a smaller portion of these links, but without using dynamic Segmentation, it is not possible to subdivide these standard links into smaller links that will enable the user to better focus to his/her area of interest. GISMIS enhances the management of this information over a standard linear GIS network by taking advantage of the dynamic segmentation capability of MGE toolbox. An MGE tool, MGSM, accomplishes dynamic segmentation by eliminating manual operations required to break linear networks into smaller segments. Dynamic segmentation has the capability of displaying and analyzing any portion of a linear feature without modifying the base map. MGSM facilitates creating, validating and maintaining control network segmentation integrating map coordinates with LRS, where the spatial characteristics of a feature is described using positions along a linear network ⁽⁴⁾.

However, for performing dynamic segmentation process as required in this application, a new database was created by sub-dividing each link in equal lengths, which is specified as 0.5 mile by NJDOT. Unfortunately, MGE does not have an automated function readily available for the creation of this new database.

However, automatic processing of the link information for the creation of a new database that contains sub-divided link information is a very important requirement to eliminate the manual manipulations that can be excessively time-consuming due to the very large size of the NJ link database. Current NJ highway database includes 943 links, and for accomplishing dynamic segmentation 10491 sub-links in total had to be created using a MATLAB code written by CAIT researchers by automatically sub-dividing all the links according to a specified length. MATLAB code developed as part of this project creates a new database that contains appropriate information for each sub-link. MATLAB code complies with the specifications of the database component of the main application. It also provides the flexibility to enhance the application by allowing NJDOT to modify the lengths of sub-links for their future needs, and thus creates different types of network solutions without making any changes to the rest of the application.

DESCRIPTION OF THE USAGE OF THE APPLICATION

Usage of the application is presented using screen shots shown below:

Step 1: Initialize application with NJ command

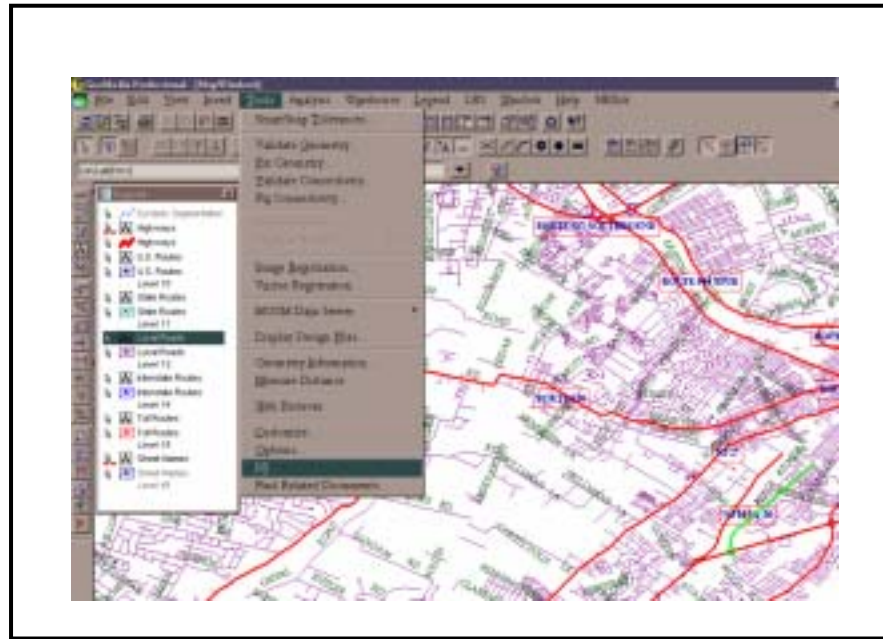


Figure 15 Initialization of the Application with NJ Command

Step 2: Display information about the link clicked on GIS map



Figure 16 Display of Link Information

Step 3: Activate Find Related Documents command to reach the documents associated with the selected link

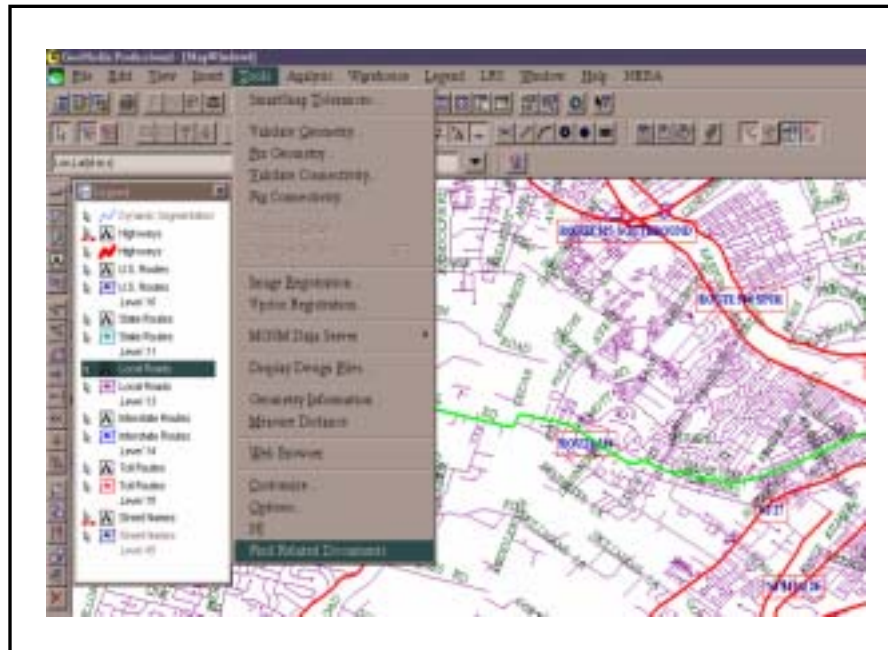


Figure 17 Search for Related Documents

Step 4: Read and display to the user, the folder for the related documents, which resides in NJDOT web server

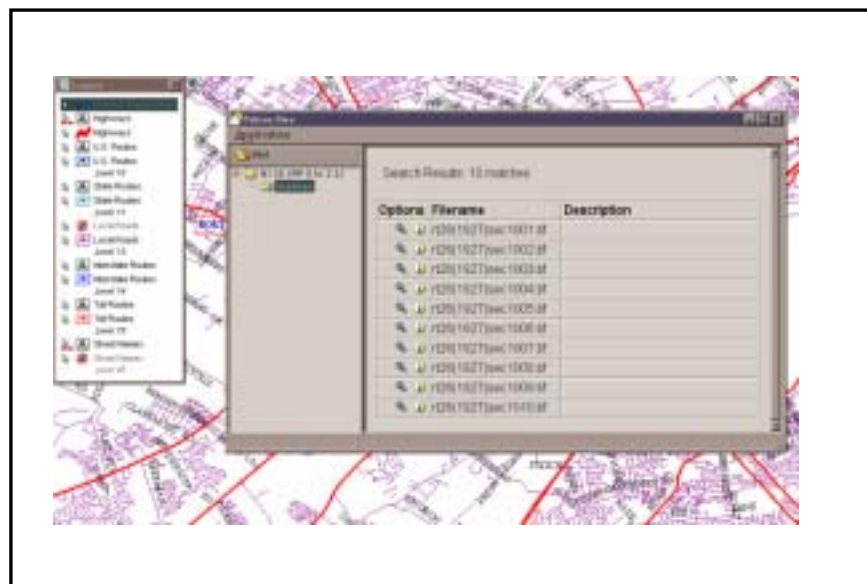


Figure 18 Related Documents Folder

Step 5: Display related documents for only the selected segment of the link with Falcon/Geo user interface

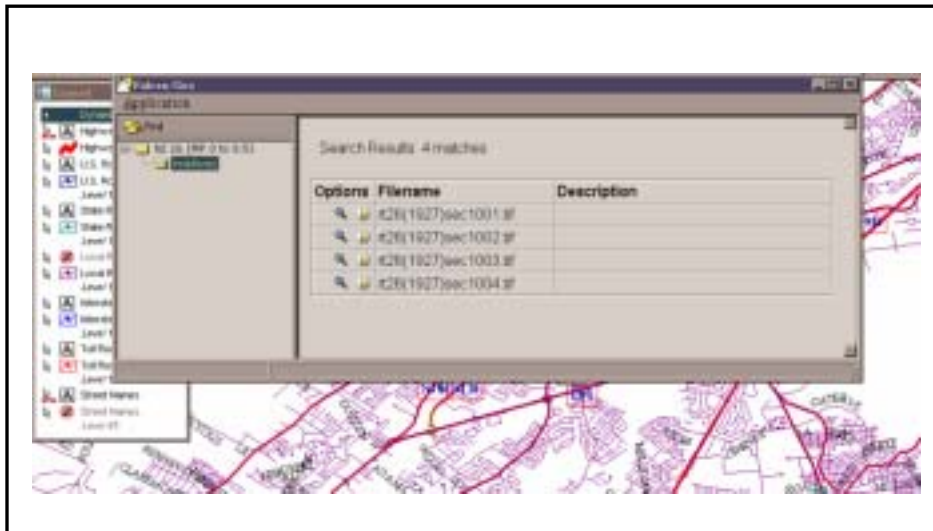


Figure 19 Falcon/Geo Interface for one segment of the Selected Link after Dynamic Segmentation

Step 6: Display typical documentation information through Falcon/DMS user interface

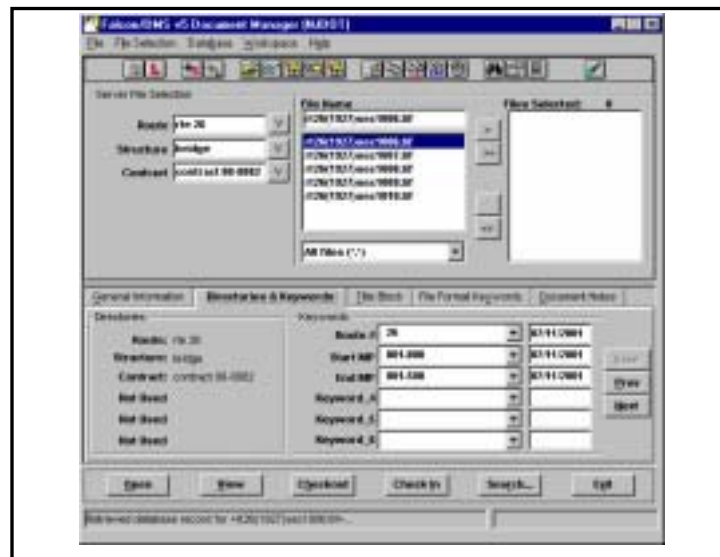


Figure 20 List of ROW Maps

SITE IMPLEMENTATION

Site implementation was accomplished with the collaboration of CAIT researchers and tsaADVET.

Installation procedure performed during the site visit is illustrated as follows:

1. Install GMPPro 4.0
2. Install MGE Products MGNUC, MGAD and MGSM in the respective order
3. Save MGSMProject main project directory to a drive in the computer which has the following:
 - *MGE_Gis_Export.mdb* → Main Database
 - *Rutgers.mge* → Modular GIS Environment Project File
 - *Njdot.prm* → Parameter File
 - *Njdot.crd* → Coordinate File
 - *Seed83.dgn* → Coordinate System File in Microstation Design File Format
4. Save the following MS Access Database Files to a directory in the computer
 - *Gist.mdb* → For Displaying Highways
 - *DYNSEG.mdb* → For Dynamic Segmentation
5. Install Custom Web CGI program
 - Copy the Web CGI programs *dmsGeoNJ.exe* and *dmsGeoWebs.exe* to your Falcon/SVP web directory `\inetpub\scripts\falcon`
6. Install HTML Template Files
 - Copy the html template files *FalconGeoBuildTreeView.htm* and *FalconGeoSelectContract.htm* to your Falcon/SVP web directory `\inetpub\wwwroot\falcon`
7. Install Custom FalconGeo components and GISMIS components on GIS client machine by setting two environmental variables
 - *MGSM_DIR* to the directory which include MGSMProject main project folder
 - *MGSM_HttpServer* to point to the Web Server
8. Create two ODBC Connections to *DYNSEG.mdb* using data source name, “dynamic_converter”, and to *MGE_Gis_Export.mdb* using data source name “Rutgers”
9. Place the *nj.dll* and *nj.ini* file in the `/Geomedia Professional/Program` directory of the computer, and install the user command to Geomedia Professional using the following command:

Installusrcmd /prod "Geomedia Professional" nj.dll nj.ini

- install the user command to Geomedia Professional using the following command:
Installusrcmd /prod "Geomedia Professional" nj.dll nj.ini
- Proceed with the message "User Command Installed Successfully"

10. Place FalconGeoNJDOT.exe, FalconGeoNJDOT.dll, and FindRelatedDocs.ini file to /Geomedia Professional/Program directory of the computer:

- Install the user command to Geomedia Professional using the following command:
Installusrcmd /prod "Geomedia Professional" FalconGeoNJDOT.dll FindRelatedDocs.ini
- Proceed with the message "User Command Installed Successfully"

11. Open an already created GeoWorkspace, which already has all the connections to all database objects, and design files with a user-friendly interface

Creating a GeoWorkspace

1. Customize the command Button in GMPro User Interface:

- Go to Geomedia Professional and open a blank GeoWorkspace
- In the menu bar, go to Tools, and select Customize in the pull-down menu items
- Select Custom from the Toolbar or the Menubar Tab
- Click on the custom command visible (It is displayed by its command name)
- Drag it outside to place it as a button on the interface or add it inside a pull-down menu
- Close the Customize dialog box
- Click on the Tool Button or the Menu Item to activate the command

2. Create connections to design files according to the segment size to display on top of the base map

3. Select legend properties for the display of different levels on NJ Highway map for easy visualization purposes

The levels were selected optimizing the visualization advantages with the level of information needed by the user.

Below are the selected levels for the created GeoWorkspace:

- Level 10 – U.S. Routes

- Level 11 – State Routes
 - Level 13 – Local Roads
 - Level 14 – Interstate Routes
 - Level 15 – Toll Routes
 - Level 45 – Street Names
4. Perform dynamic segmentation adding the already created layer on top of the GIS map (This step is alternative considering the segment size desired by the user)
 5. Save the GeoWorkspace, which contains all the work done for that specific GeoWorkspace. It can be considered as a scratch paper where the user works and erases continuously and tracks (views) all the work she/he has done.

MODIFICATIONS FOR GISMIS PROTOTYPE

The improvements and modifications determined as a result of the feedback obtained from NJDOT professionals were implemented. A survey was prepared and submitted to users for further improvements. tsaADVET has participated in this over the phone for guidance of Falcon/DMS installation and connection to Web Server. The questionnaire is shown in Appendix B. Overall, the prototype software was received well, and its capabilities were rated excellent.

Based on this survey and other inputs, we have also created a sample GeoWorkspace, which contains the optimized requirements for the user's work. GeoWorkspace is created based on the considerations as mentioned under "Creating A GeoWorkspace". The sample GeoWorkspace was saved during installation to accentuate the efficiency and ease of workflow in GMPro.

TRAINING FOR GISMIS PROTOTYPE

The developed GISMIS prototype implemented with minor modifications and improvements were installed at NJDOT. The environment variable is incorporated in GISMIS to enable driver independence for data. Training started with introducing the system to the users. As an introduction, concise training and user's manual for GISMIS was also prepared. A sample GeoWorkspace was created showing the basic flow of the application to the users on October 18, 2002. The designated user worked on the program experimenting with it until he felt comfortable with the product. Future training can involve all the possible users of the system.

CONCLUSIONS AND RECOMMENDATIONS

GIS-Based Management System was a success with regard to the original criteria, which was to develop a user-friendly graphic interface for retrieval of roadway plans and ROW maps. However, due to constraints of the software used in this project, which require all users to own a copy of the GeoMedia Professional in order to use the prototype, this current solution does not appear to be the most efficient one, if NJDOT plans to pursue the development of the prototype on a large scale. In addition to the software requirements, hardware requirements can also be a problem due to demanding CPU and memory requirements of the current software application. CAIT researchers will continue to use and evaluate the application on a small scale and pursue more efficient solutions, as they become available including web based applications. Following recommendations are made to enhance the prototype:

- Explore new web-based techniques that will obviate the use of the existing desktop set-up
- Study safety, security and other maintenance implications of using web-based solutions
- Implement an enhanced version of the GIS-based prototype using GeMedia Web Map which became available recently

- Explore the applicability of GeoMedia Transportation package to simplify the use of dynamic segmentation feature


```

    rte_lgis_new(j+1) = rte_gis(i);
    geometry_sk_new(j+1) = geometry_sk(i);
    km_start_new(j+1) = km_start(i); % should be changed
    km_end_new(j+1) = km_end(i); % should be changed
j=j+1;
    k=k+1;
    end
% last value of the Mile Post End for each record
mp_end_new(j) = mp_end(i);
% dividing map_length, sri_length and map_sri_diff by the count
map_length_new((j-k+1):j) = map_length(i)/k;
sri_length_new((j-k+1):j) = sri_length(i)/k;
map_sri_diff_new((j-k+1):j) = map_sri_diff(i)/k;
j=j+1;
k=1;
end
total_count=j-1;
% writing new variables to the output file and creating the text file
for j=1:total_count,
    % segmented (i.e. output) file
    fprintf(fid,'%s\t',char(sri_new(j)));
    fprintf(fid,'%s\t',char(sld_name_new(j)));
    fprintf(fid,'%0.3ft',mp_start_new(j));
    fprintf(fid,'%0.3ft',mp_end_new(j));
    fprintf(fid,'%d\t',char(mslink_new(j)));
    fprintf(fid,'%d\t',char(mapid_new(j)));
    fprintf(fid,'%0.8ft',map_length_new(j));
    fprintf(fid,'%0.8ft',sri_length_new(j));
    fprintf(fid,'%0.8ft',map_sri_diff_new(j));
    fprintf(fid,'%s\t',char(rte_lgis_new(j)));
    fprintf(fid,'%0.3ft',km_start_new(j));
    fprintf(fid,'%0.3ft',km_end_new(j));
    fprintf(fid,'%s\r\n',char(geometry_sk_new(j)));
    fprintf(fid3,'%d\t',j);
    fprintf(fid3,'%0.3ft',mp_start_new(j));
    fprintf(fid3,'%0.3ft',mp_end_new(j));
    fprintf(fid3,'%s\t',char(sld_name_new(j)));
    fprintf(fid3,'%s\r\n','c:\neba');
    end
fclose(fid);
fclose(fid3);
delete(finname2);

```

APPENDIX B

| |
|---|
| <p>EVALUATION OF GIS-BASED MANAGEMENT INFORMATION SYSTEMS FOR NJDOT HIGHWAY NETWORKS</p> <p>Questionnaire by CAIT</p> |
|---|

| | |
|--|---|
| <p>1. Are you familiar with Geographical Information Systems?</p> | <p>Yes</p> |
| <p>2. Are you familiar with Geomedia/Geomedia Professional?</p> | <p>No</p> |
| <p>3. Do you think GIS is effectively incorporated to this prototype, namely GEMINI?</p> | <p>Yes</p> |
| <p>4. Does GEMINI have any particularly innovative features that you would like to mention?</p> | <p>Yes. The ability to turn on/off features within the legend (Road Names).</p> |
| <p>5. To your opinion, is GEMINI efficiently integrated with the fundamental components of Falcon/DMS?</p> | <p>Yes. Software packages work well together.</p> |
| <p>6. Is the system user-friendly?</p> | <p>Yes. For the average end user, there may be too much displayed on the screen. Tool bars, buttons, etc. could become a disadvantage</p> |

| | |
|--|--|
| <p>7. Is the system efficient in your practice of work in the following aspects?</p> <ul style="list-style-type: none"> ▪ starting the system ▪ querying data ▪ displaying data ▪ visualization and geographic representation ▪ ease-in-use <p>others, please specify</p> | <p>Yes</p> <p>Easy as any windows-based program</p> <p>Quick as your machine will respond</p> <p>Excellent with the right viewer</p> <p>Excellent</p> <p>Excellent</p> |
| <p>8. Is the user manual for GEMINI meaningful, easy to understand, and current?</p> | <p>Yes</p> |
| <p>9. Do you have any suggestions/comments for future improvements of GEMINI?</p> | <p>More of an easier looking display, just the map area (New Jersey). No Tools or buttons.</p> <p>This gives the user less of a chance for errors.</p> |

APPENDIX C

ROW = Right-Of-Map

NJDOT = New Jersey Department of Transportation

GIS = Geographical Information Systems

GISMIS = GIS-Based Management Information System

CAIT = Center for Advanced Infrastructure and Transportation

MGE = Modular GIS Environment

MGSM = MGE Segment Manager

MGNUC = MGE Basic Nucleus

MGAD = MGE Basic Administrator

GM = GeoMedia

GMPro = GM Professional

VB = Visual Basic

DMS = Database Management Systems

MIS = Management Information Systems

EDMS = Electronic Document Management System

ODBC = Open Database Connectivity

API = Application-programming Interface

SQL = Structured Query Language

NLF = Network Linear Feature

ULF = Universal List File

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