Pennsylvania
Department of Transportation

TASK 4 - SIMOS FEASIBILITY REPORT

Sign Inventory Management and Ordering System

Project No. 95-10

Gannett Fleming
ENGINEERS AND PLANNERS

in association with:

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December 1997

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

PB98-137805

2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
December 1997	Final - Task 4

4. TITLE AND SUBTITLE
Task 4 - SIMOS Feasibility Report
Sign Inventory Management and Ordering System
Project No. 95-10

5. FUNDING NUMBERS

6. AUTHOR(S)
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8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

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555 Walnut Street	228 Walnut Street, Rm. 558
Harrisburg, PA 17101	Harrisburg, PA 17101

Bureau of Highway Safety & Traffic Engineering

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
FHWA-PA-97-012 + 95-10

11. SUPPLEMENTARY NOTES
Project Team comprised of Gannett Fleming, Inc., Greenman-Pedersen, Inc., Fitzgerald & Halliday, Inc., Information Services Group, Inc., and Pennsylvania Department of Transportation.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Available from the National Technical Information Service, Springfield, VA.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)* The Sign Inventory Management and Ordering System (SIMOS) design is a merger of existing manually maintained information management systems married to PennDOT's GIS and department-wide mainframe database to form a logical connection for enhanced sign management. To minimize the development costs, consideration was given to utilize existing hardware, software, communication channel and applications.
The SIMOS project involved recommendations for reengineering the sign inventory/management procedures currently in place, and provides the technological solutions for effective statewide sign management. The key components to SIMOS include a suite of GeoMedia applications, Oracle database, and PennDOT's GIS. SIMOS completely automates the sign management process from; field data collection, work order generation, sign order generation, and maintaining a statewide sign database.
SIMOS will provide PennDOT with the tools to improve its services to the general public; safer roads through better signage, and more effective use of tax dollars. The direct benefits will include: *Effective solution for better decision making and maximizing available funding; *Increase operation efficiency - Reduce manhours; *Lower operation costs - Eliminate duplication of work; *Improve quality - Eliminate existing error-prone operations; *Reduce tort liability for sign-related lawsuits; and, *Reduce current sign review cycle from seven to two years.

14. SUBJECT TERMS
Sign Inventory System, Sign Management System
Signs and GIS

15. NUMBER OF PAGES
70

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

SIGN INVENTORY MANAGEMENT AND ORDERING SYSTEM
PROJECT NO. 95-10
TASK 4

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INTRODUCTION

The Pennsylvania Department of Transportation and the General Public will benefit greatly through the implementation of the proposed Sign Inventory Management and Ordering System (SIMOS). This report identifies the objective approach, components, methodology, schedule, and costs in great detail for a statewide SIMOS.

Included in this report is an Executive Summary, which describes in general terms the overall concept of the proposed SIMOS. A Cost Benefit Analysis is also included at the end of this report.

SIGN INFORMATION MANAGEMENT AND ORDERING SYSTEM OBJECTIVES

PennDOT will realize many benefits by implementing a statewide Sign Information Management and Ordering System (SIMOS). Additionally, the general public will benefit from this system through better maintained signage and more efficient use of tax dollars. The following objectives will be achieved for the implementation of a successful SIMOS:

- Enhance PennDOT's ability to improve signage on a statewide basis reducing tort liability;
- Reduce PennDOT's operating costs for managing signing activities by improving efficiency in the Engineering Districts, as well as in the Central Office;
- Provide enhanced information that will allow PennDOT to better allocate limited capital resources for the most critical signing needs. For example, prioritize the placement of signs based upon factors such as signage, type of sheeting, etc.;
- Develop uniform and efficient methods for data collection and post processing of data to be used by all of the Engineering Districts and counties;
- Completely automate the process of collecting field data, processing work orders, ordering signs, and maintaining inventory;
- When possible, incorporate the current inventory methods being utilized at the various Engineering Districts;
- Develop a comprehensive, centralized database that is accessible by the Engineering Districts, counties, and PennDOT Central Office;
- Utilize mainstream/non-proprietary software, that will operate on standard personal computers. Solution must be easy to learn and maintain;
- Graphically display signs and/or information in the spatially correct location on a "PennDOT Roads" type file. The relationship of signs to significant roadway features (bridges, RR crossings, etc.) would be helpful;
- Provide interface with other available databases at PennDOT. For example, accident data would be very useful in locating possible signing deficiencies; and
- Incorporate complaints and sign permit information to provide a comprehensive tool for evaluating sign replacement.

VALUE ADDING MANAGEMENT SESSION

Following the initial proposed SIMOS solution, a Value Adding Management (VAM) Session was held to evaluate the sign replacement process. The results of this session shifted the responsibility for sign management from the districts to the counties. The following objectives were determined through the VAM Session. These were included with the previous objectives for the development of SIMOS.

1. Shift responsibilities for sign maintenance (e.g., deteriorated faces, poor retroreflectivity, knockdowns, etc.) from the districts to the counties. Review cycle to be part of annual work plan.

2. Continue with the development of a statewide, in-place sign inventory.

3. When a county's in-place sign inventory is prepared, it would be given to the county to use in the field. Each county would update the inventory as signs are replaced.

4. When traffic studies require new types of signs, or the removal or relocation of existing signs, the District Traffic Units would issue a work order. The sign inventory would also require updating to reflect the changes.

5. Provide training for the sign foremen and ACMMs on identifying sign deficiencies, and quality assurance procedures.

6. Have the sign foremen reduce the inventory of signs by controlling the ordering process. Except critical signs, which should always be stocked at the counties, order signs for "just-in-time" delivery.

7. Have the Central Office establish an optional contract with a private carrier for 1- or 2-day delivery of signs to supplement the "pony express."

8. Emphasize the importance of dedicated sign crews.

9. Redesign MORIS to develop a user-friendly order screen, and to provide a back order system.

10. Develop incentives for the counties to reduce excess sign inventory, e.g., give credit for the return of usable high-intensity signs, and allow the counties to sell non-usable signs for scrap.

NOTE: Items 1 to 5 effectively eliminate the existing Sign Upgrade Program (SUP).

SIGN INFORMATION MANAGEMENT AND ORDERING SYSTEM (SIMOS)
EXECUTIVE SUMMARY
(Conceptual Design)

Introduction

The SIMOS functional and operational design is a merger of existing, manually maintained information systems married to PennDOT's GIS and Department-wide mainframe database to form a logical connection for enhanced decision-making. This Executive Summary provides the general concepts for SIMOS. A detailed discussion on these concepts follows in this report.

There are five major stakeholders in a successful statewide Sign Information Management and Ordering System (SIMOS) for Pennsylvania. These include Engineering District Offices (EDO), Traffic Engineering and Operations Division (TEOD), county work crews, the Sign Shop, and the general public. The general public will benefit from a SIMOS through better signage and lower costs to maintain signage on a statewide basis. The stakeholders within PennDOT each have their own unique needs and communication requirements. The conceptual design for SIMOS has been developed to accommodate these unique needs with the flexibility to take advantage of anticipated technology enhancements to be incorporated at PennDOT.

The initial concept of a statewide Sign Information Management and Ordering System concentrated on improving the existing sign management processes in the Engineering District Offices and the PennDOT Central office, with the counties maintaining their role installing the signs. Following the Gannett Fleming recommendations for the initial concept, PennDOT held a Value Added Management (VAM) Session to reengineer the sign replacement process. The result of the VAM session was to shift the bulk of the sign maintenance responsibility from the district to the county. By necessity, this resulted in Gannett Fleming revisiting their original findings and recommendations.

Engineering District 1-0 was selected as the Pilot District to reevaluate a statewide SIMOS solution under the new concept. Gannett Fleming revisited the Engineering District and performed a Needs Assessment for each county in the District (Crawford, Erie, Forest, Mercer, Venango, and Warren). The results of this reevaluation on the statewide SIMOS solution have been incorporated into the previous concept and outlined in this document.

The proposed statewide SIMOS design leverages existing hardware, software, communication channels, and applications that are currently utilized at PennDOT to minimize the development costs. Utilizing the existing processes will also facilitate the maintenance of the system. **Figure 1** depicts the overall conceptual design for a statewide SIMOS. The statewide SIMOS data will reside on the Oracle data base that is maintained by Bureau of Planning and Research (BPR). The staff of TEOD/Safety will use BPR computers and GIS software for any required analysis and mapping.

PennDOT Sign Inventory Management and Ordering System

Conceptual Design

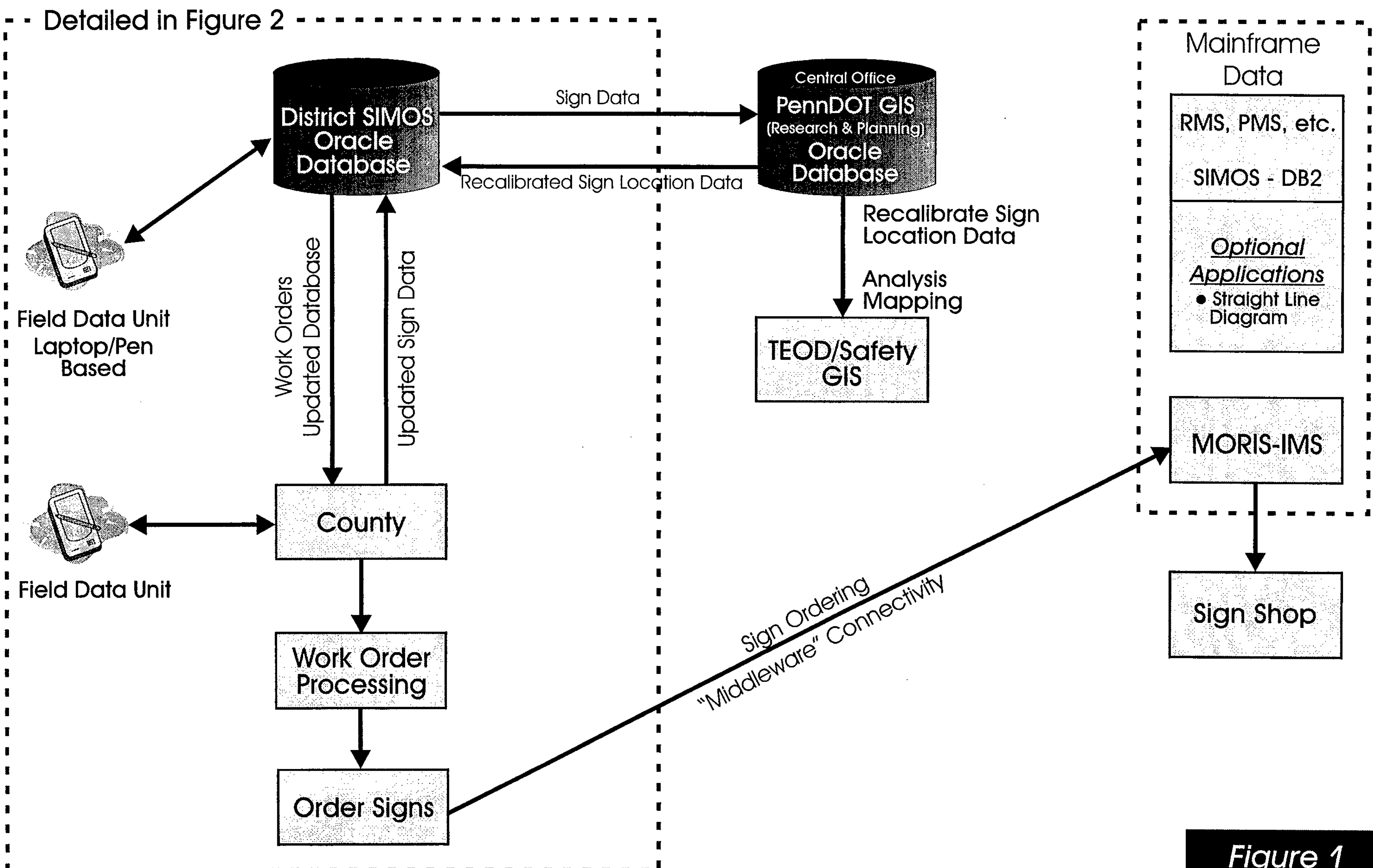


Figure 1

One of the key components of SIMOS is the ability to graphically display signs in a spatially correct orientation. This will be accomplished by utilizing the PennDOT Roads Files that are maintained by the Bureau of Planning and Research. Signs will maintain locational accuracy through the use of the mainframe recalibration program (ARS), which has been ported over to the PC. This program will be modified and used to recalibrate the sign location data.

The Engineering District Offices (EDO) will maintain the database for all signs in their district. This will allow them to perform analysis and generate mapping on all signs within their district. The district SIMOS will utilize the Oracle database being installed in each EDO for GIS. The EDO will be responsible to maintain the districtwide database by: 1) review and process work orders submitted by the counties and update the database with the latest sign information; and 2) upload the latest sign information to Central Office for TEOD/Safety use and recalibration of sign data, and download the latest recalibrated sign location data.

Figure 2 depicts the County/Engineering District Office relationship. All responsibility for work order processing, sign ordering and sign installation will reside with the county staff. Although it is not a requirement of the proposed solution, the counties and the districts will be primarily responsible for developing the sign inventory database and the counties will be responsible for maintaining the sign inventory for their respective counties. A brief outline of the process for SIMOS at the county level follows.

1. The county work crew utilizes a field data unit (FDU) to collect sign information, and identify sign maintenance requirements. This information will be collected from a vehicle with the FDU, through an easy-to-use menu system.

2. The inventory data and maintenance activities identified in the field with the FDU are downloaded into an existing PC in the county office. This information resides in a queue in the computer for future processing.

3. When the county work crews identify the need to order more signs to be installed, they will process the pending work that has been sitting in the queue and create a work order. There will be total flexibility to select the number, type, and location of the signs for a particular work order. This will allow sign orders to accommodate high priority sign replacements. Because the signs are graphically depicted on the roadway mapping, sign maintenance activities could be grouped by geographical location. This will maximize the counties ability to order signs based upon their ability to install signs.

4. The next step will be to process the work order that has been created (step 3) and automatically generate a sign order. The sign order will be submitted to the sign shop through MORIS. Sign orders will be automatically submitted to MORIS through several available options pending the availability of a WAN.

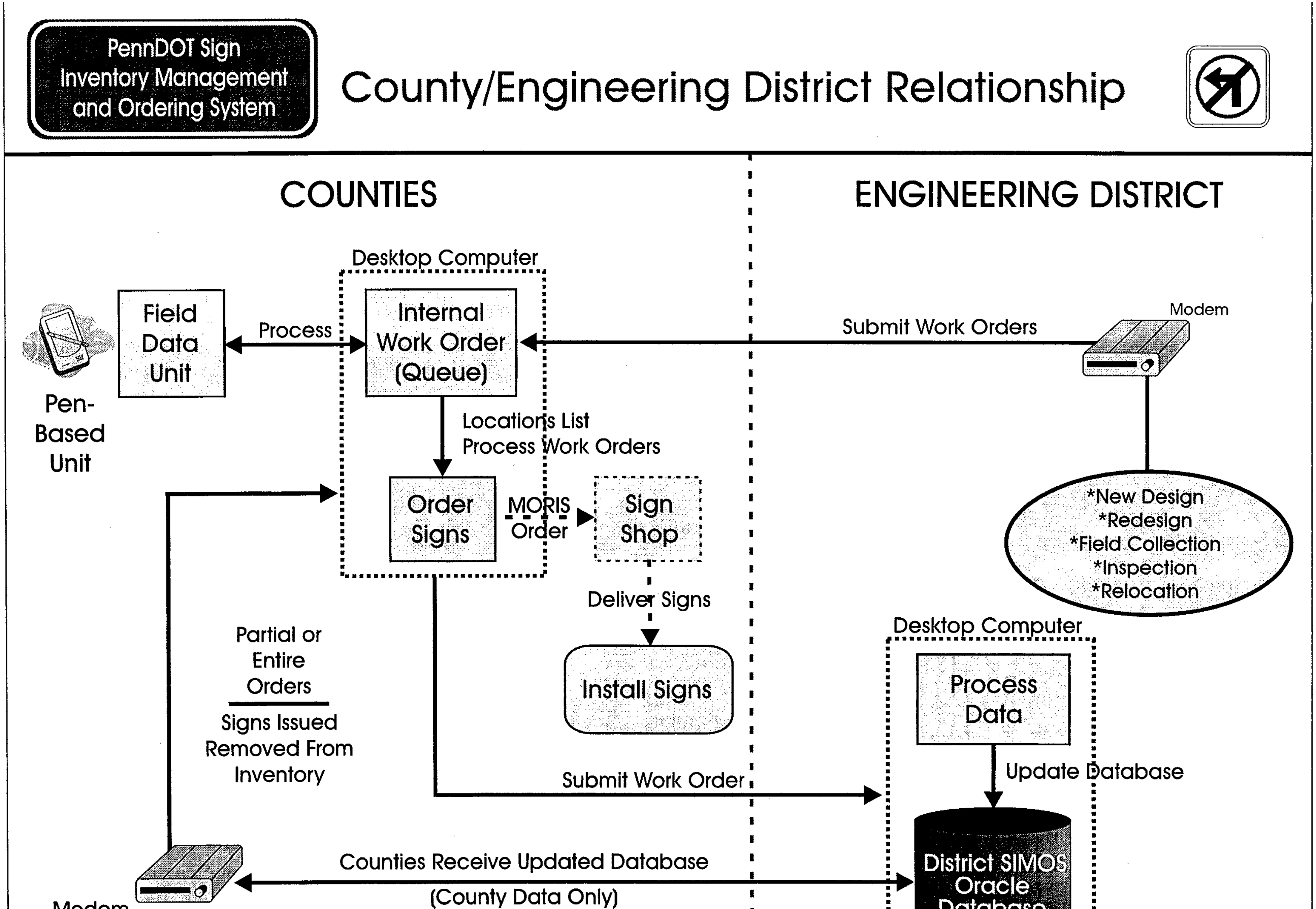

PennDOT Sign
Inventory Management
and Ordering System
County/Engineering District Relationship
COUNTIES
ENGINEERING DISTRICT
Desktop Computer
Field
Data
Unit
Process
Internal
Work Order
(Queue)
Submit Work Orders
Modem
Pen-
Based
Unit
Locations List
Process Work Orders
Order
Signs
MORIS
Order
Sign
Shop
*New Design
*Redesign
*Field Collection
*Inspection
*Relocation
Deliver Signs
Partial or
Entire
Orders
Signs Issued
Removed From
Inventory
Install Signs
Desktop Computer
Process
Data
Update Database
Submit Work Order
District SIMOS
Oracle
Database
Counties Receive Updated Database
(County Data Only)
Modem

Figure 2

5. After the signs have been installed, the county work crew will process the work order on the PC in the county office, for the work that has been completed. This information will be submitted (uploaded) to the EDO via modem (until better communication are in place). After the information has been submitted, the latest database information, for a particular county, will be downloaded during the same modem session. A modem will be an effective mode of communication due to the small size of the information to be uploaded and downloaded.

6. The EDOs will be able to submit work orders, via modem, to the county offices. This information will be stored in the queue with the rest of the pending work.

The following discussion identifies the fundamental components and functionality of the proposed solution. A more detailed analysis of the SIMOS components, software requirements, and communication needs are discussed following the Executive Summary section.

Field Data Collection

Existing

There are a variety of methods currently used by the Counties/Districts for collecting data during the field inspection process. The methods in each County/District were developed to make the process as efficient as possible within the limitations of the existing staff and the availability of computer hardware and software technology. The typical approach follows:

- Significant manual effort in collecting a wide variety of required information for the field inspection;
- Manually collecting sign information during the field inspection, on paper forms or maps;
- Identifying maintenance activities through non-standardized action codes;
- Data collection team typically involves two people, a driver and data collector.

Proposed

The proposed solution utilizes a Field Data Unit (FDU) for collecting sign inventory data as well as identifying maintenance activities. The FDU will be comprised of a laptop or pen-based computer that will be carried into the field. (While both devices will work, we are recommending the pen-based computers for use in the vehicle.) The FDU will display sign locations on a "PennDOT-roads" type map on the monitor. The operator will be able to click on any sign and have access to the database information linked to that sign. The operator will be able to update incorrect information and identify any action item (maintenance activity) that will be necessary. The FDU will also allow the operator to add new signs to the database. An easy-to-use menu system (GUI) will be developed to make the FDU easy to use with most operations requiring a choice of a stylus or mouse. The action codes will be standardized on a statewide basis. The FDU will allow inventory/inspection to occur by one person in a vehicle.

The FDU will only have to contain the roadway and sign information for one county. This is significant, as the new pen-based computers will have sufficient capacity to hold all of the required information for the entire county. This eliminates the burden of the county work crews downloading portions of the data depending on the geographic area they will be working on.

After the inventory/inspection process is complete, the operator will process and download the information into a computer located in the county office. This computer will also have the county road data residing on an Oracle database. The download of data from the FDU to the computer will be easily accomplished by plugging a cable between the FDU and the computer and pressing a button. The information that is being downloaded from the FDU will contain the maintenance activities and inventory updates identified during the field view. This information will sit in a queue awaiting further processing into a work order. Offsite downloads of data could easily be incorporated into this solution.

SIMOS Oracle Database

The SIMOS Oracle databases, located in the counties, the Engineering Districts, and the Central Office, will be designed identically. This will facilitate replication of data between these groups. Each county will be responsible to maintain its own data. Each Engineering District will be responsible for collecting and processing sign data from the counties in their district. They will also be responsible for maintaining the latest PennDOT roads file and sign relocation data for their district. The Engineering Districts will be required to upload the latest county sign data to the Central Office on a regular basis. As part of the process the Engineering District will be able to download the latest PennDOT roads data and recalibrated sign location information. Through the process the most current sign information for each district will be maintained on the district's SIMOS Oracle database.

Central Office will receive sign data for each Engineering District. This information will be recalibrated to account for recent modifications to roadway alignments and made available to the districts. As a result of these activities, the Central Office Oracle database will contain statewide sign information. This will provide TEOD/Safety the data for comprehensive statewide sign management.

Work Order and Sign Order Generation

Existing

The current methods for processing information collected in the field, at the Engineering Districts, to generate work orders and sign orders are inefficient and prone to errors. These methods typically involve several staff members and significant duplication of effort. A typical scenario follows:

- Data is collected in the field by manually writing information on a paper form or drawing;
- In the office, this information is manually reviewed and summarized, based upon action codes, to obtain the necessary information for a work order;
- A sign order form is then manually completed from the information on the work order;
- Sign orders are then manually entered into MORIS through a mainframe terminal connection. This operation is prone to errors due to entering 40-digit sign codes. This results in wrong signs frequently being ordered.

Proposed

The proposed SIMOS solution will completely automate the process of generating work orders, sign orders, and submitting sign requests to MORIS. This will be accomplished through a suite of "user-friendly applications" that will perform all of the complex computer processing that will be required. These applications will be customized so that most computer operations will be executed with the push of a button. We will work with the county staff to develop and organize these applications to best meet their needs. Some of the key applications that will be developed include:

Work Order Generation: This application will generate a work order from the queue of "work to be done" that will reside on the PC in the county office. This queue is a result of all the work that has been identified in the field review or from the Engineering District. The application will provide the user complete flexibility on the development of the work order. The user will be able to prioritize sign maintenance activities for the work order based upon the date the problem was identified, route, type of sign or problem, or geographic location. The latter will be accomplished through GIS. The user will be able to display all work pending in queue over the PennDOT Roads file, and graphically select signs to be included in the work order by drawing a shape around the particular area he/she will want to work.

Sign Order Generation: This application will process the work order and organize all information related to the ordering of new signs. This information will automatically be formatted and include all of the codes required for submission to MORIS.

MORIS Interface: This application will submit the sign order to MORIS for subsequent manufacturing of signs by the Sign Shop.

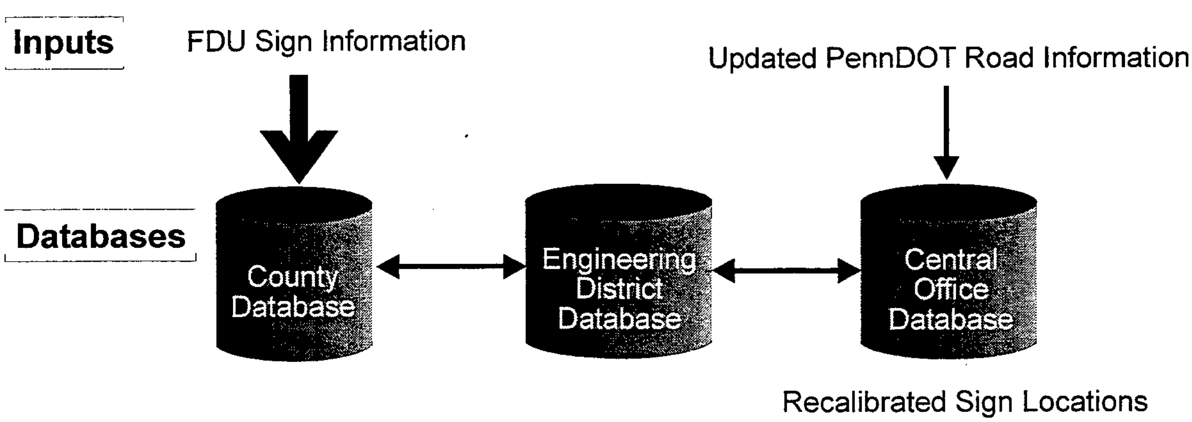
Database Editing, Querying, and Report Development: A suite of applications will be developed, with input from PennDOT staff, to assist the user in editing the database, and generating formatted reports or maps. These applications will provide the user access to all information in the SIMOS database including the mapping. Over time, as users become familiar with the system, it is likely that many applications will be developed to improve decision making related to sign management.

Database Interface/Update: There are four primary databases in the SIMOS solution. One that resides on each FDU. One that resides in the county offices containing county data only, one that resides in the Engineering Districts containing districtwide information, and one that resides in the Central Office containing statewide SIMOS data. We are recommending using the same Oracle database in each location to facilitate the communication of data. Applications will be developed to automate the uploading and downloading of data between the databases, maintaining the latest information, and storing historical data.

Analysis and Mapping

Because the Department currently has a well-developed GIS system, we recommend that the SIMOS database be integrated into the existing Department's GIS. Having the SIMOS in a GIS environment will also allow maps to be produced using a real geometry representation of the roadway with a graphical representation of the sign to be shown at its true location. In addition, the output map can contain labels derived from any data fields in the database. The application we will develop for the FDU will have GIS capability. This will significantly increase the functionality of sign management. It will also eliminate the need for Straight Line Diagrams (SLD) to be generated on the mainframe.

Communications



Databases

There are two primary inputs of information into the SIMOS solution. 1) The FDU inputs collected sign information. This will occur at the county level. 2) Central Office will recalibrate sign locations and provide updated road information. Regularly scheduled uploads and downloads of information between the county, EDO, and Central Office will be required. While not a requirement the availability of a WAN will facilitate these communications.

FDU to County Database

The FDU will download, information collected in the field, to the county database with a direct connection. The operator will connect FDU to a PC (containing database) with a wire link. The operator will execute and command to automatically download data. Remote downloads via modem could easily be incorporated if desired.

County Database to Engineering District Database

As work orders are completed by the county work crews, the new sign information, as well as any sign inventory updates, will be uploaded to the EDOs database via a modem connection. The amount of data submitted will be small enough for a successful modem solution. After the upload is complete, the county will download any sign or roadway information that had been revised since the last communication during the same transaction.

EDO Database to Central Office Database

It is a necessity that the Engineering Districts' Oracle database can send and receive data from the Central Office's Oracle database located in the Planning and Research Department. The SIMOS data must be sent to the Central Office to maintain a statewide sign inventory database, which will be necessary for statewide sign management and planning. This process of uploading data from the Engineering District Offices will be on a regularly scheduled bi-weekly or monthly basis. The amount of data moved during these processes is relatively small and will have little impact on existing processes. Sign data will not change that often, so scheduling one district per day on a bi-weekly or monthly basis will be sufficient.

The Engineering Districts are responsible to maintain a districtwide SIMOS database. They must regularly update the sign location information which is continually changing in the Roadway Management System (RMS) due to roadway realignments. It is anticipated that updating this information on a monthly or bi-weekly basis will be acceptable. The Engineering Districts will download the sign location information from the Central Office Oracle database. In most cases, downloading the latest sign location information will occur during the same modem connection used to upload data. The sign location records are a small component of the SIMOS database. The amount of data needed to be transmitted during this process is small and will have little impact on existing processes and the future WAN.

It is anticipated that the wide area network that will be in place in the near future will make communication between the Oracle servers an efficient process. Until the wide area network is operational, transferring data via modem will be an effective means of communication.

MORIS Connection

Sign orders will be submitted to MORIS by the counties, through existing lines of communication. The SIMOS workstation in each county office will be configured with a network card and software to facilitate a connection to the mainframe through an existing network line. The use of middleware software will allow the connection to MORIS which is an IMS database. A detailed analysis on this is included in this report.

Central Office

PennDOT's Oracle GIS database, located in the Planning and Research Department, will maintain the statewide SIMOS data uploaded from all of the Engineering District Offices. There is sufficient capacity to easily accommodate the SIMOS data. It is anticipated that the approximate size of the statewide SIMOS database will approach 1.5 GB. The Planning and Research Department will recalibrate sign location data with an application that has been ported over from the mainframe. The recalibrated sign location data will be downloaded to the Engineering Districts along with the updated GIS information on a regularly scheduled basis.

The TEOD will use the GIS workstation located in the Bureau of Planning and Research (BPR) to perform statewide analysis, and generate necessary mapping and reports. Utilizing a GIS workstation will permit TEOD to access other critical information such as accident data along with the sign data to provide an effective statewide management tool. Applications will be developed to assist TEOD in data analysis and the generation of standard reports and maps.

Mainframe

The only interface to the mainframe for SIMOS will be to order signs through MORIS. There are two SIMOS approaches for sign ordering. Under Approach 1, the statewide WAN is not in place and the sign ordering process will require a MORIS update program. Sign order processing will be initiated by the user establishing a mainframe session in TSO, and selecting a client server function to post sign order data. The posting process transfers data to the mainframe using IBM transfer protocol, and then initiates a TSO CList to use the uploaded data to update MORIS sign order data. Approach 2 requires PennDOT's WAN to be in place. This approach will utilize a middleware software product for direct access to the MORIS IMS database. Refer to the Communications section for more detail.

Sign Shop

Under the proposed SIMOS solution the Sign Shop will continue to access MORIS for sign orders, as in the past. We have identified several inefficiencies in the way the Sign Shop processes sign orders. The current system only handles stocked signs. Forty digit codes must be manually entered for non-stocked signs. This is time consuming and prone to errors. Additionally, sign orders are not processed when the order cannot be completed due to insufficient sign stock. For example, if a work order requests 20 stop signs, and only 10 stop signs are in stock, the district will not receive any stop signs on that order.

Developing a solution for the Sign Shop is **not** included within the scope of this report. The PennDOT Sign Shop should however be an integral part of the SIMOS solution. The following requirements should be achieved for efficiently processing sign orders:

- The system must be able to eliminate any duplication of effort in the Sign Shop; 40 digit numbers should not have to be reentered.

- When an ordered sign is not available at the requested quantity, the order should be filled with the stocked quantity. A backorder system must be developed to automatically process the remaining ordered signs as the signs are stocked. The system must be able to notify the county and district which parts of the work order could not be processed completely. The work order, sign order, and backorder information must be linked together to assist in coordination.

Evaluation of Alternative Software

The Sign Inventory Management and Ordering System (SIMOS) is designed for PennDOT and the counties to facilitate sign management activities on a statewide basis. We have evaluated several options to the SIMOS solution. Most of the off-the-shelf software is designed either for general purpose usage (such as Access) or for specific purpose usage (such as SIGN*view*™). The general purpose software does not have user-friendly graphic user interface (GUI) and does not have a mapping component. We do not recommend SIMOS use general purpose software such as Access or Paradox because of these deficiencies. The specific purpose software does not have the flexibility for the required database structure and GUI designs. We also do not recommend SIMOS use specific purpose software such as SIGN*view*™ because the software cannot meet PennDOT's needs for the following reasons:

- The SIGN*view*™ database structure will not easily meet PennDOT's needs and cannot be modified to take advantage of PennDOT's existing databases. PennDOT's databases would have to be converted for use in SIGN*view*™. This conversion effort would be an on-going process as PennDOT continually updates their databases. An example would be that SIGN*view*™ uses a "link node" concept for their Linear Referencing System (LRS) to identify a specific route segment. PennDOT uses a route segment offset concept as their LRS. Significant effort would be required to continually maintain these two database structures.
- The mapping functions are poor and cannot read DGN file (PennDOT centerline file format); an alternative is to use ArcView to display maps, which requires purchase of ArcView software and the SIGN*view*™ for ArcView extension. (Mapping functions are essential for the SIMOS to easily locate the signs and for efficient routing of sign work).
- The GUI designs are not user-friendly, particularly for users with limited knowledge of Windows.
- It is not cost effective for organizational-wide implementation because each user has to buy a license at the same unit cost.

In general, we recommend the development of a customized system using GeoMedia and Visual Basic which provide seamless integration with PennDOT's GIS and sign inventory database and provides flexible and customized GUI designs.

Miscellaneous

Currently, county sign crews are having difficulty keeping up with all of the work orders. This is especially evident in District 6-0. With the proposed SIMOS in place, this situation will be eliminated as the counties will generate work orders based upon their ability to install signs.

The primary component of the data collection process will be the computer hardware and software used for inputting data into the system. This system can be taken into the field on a portable computer. If video logging is used, the same system will be used to transcribe information from the video tape at the district office. Therefore, the decision of whether to use video logging does not specifically apply to the computer hardware and software development for the SIMOS solution. However, video logging may provide a very effective tool for the actual data capture. The following section further identifies findings regarding video logging.

Video Logging

District 6-0 has totally integrated the video logging system and is in the process of ordering an eye witness video system used by the state police to enhance their video logging capability. They are very pleased with this system and are claiming significant savings in their sign inventory management. Currently, District 6-0 transcribes information from the video tape onto a paper straight line diagram (SLD). The information from the SLD is then manually inputted into the Lotus program. A SIMOS solution would eliminate the process of transcribing the information onto the paper SLD. The video tape information could be transcribed directly into the SIMOS workstation.

Video logging could be an excellent solution for collecting sign inventory information. Video logging has a significant safety advantage for sign inventory. This is especially true on roadways with high traffic volumes. The integration of data collection through video logging will only enhance the SIMOS whenever it is implemented.

Training

Training will be accomplished through a three-day initial training session and a full day follow-up training session. Personnel from each Engineering District and associated counties will be scheduled for an initial group training session at the Engineering District Office or Central Office. This translates into 11 initial training sessions of three days duration. A full day of follow-up training will take place in each county. This translates into 67 days of follow-up training. Two training crews will be required to meet the project schedule.

Schedule

It is estimated that a complete operational SIMOS for a pilot can be ready for system testing within 6 months. It is proposed that a pilot consist of one Engineering District and one county. The system testing phase will last one month and will be used to iron out any problems. Following the testing phase, SIMOS will be implemented in the remaining counties in the Pilot District. It is estimated that a complete implementation of SIMOS on a statewide basis can be completed within 14 months, from notice-to-proceed.

Cost

It is estimated that it will cost $1,773,900 to develop a statewide SIMOS. Significant savings have been projected by utilizing the GIS workstations and Oracle databases proposed for each Engineering District. Currently, PennDOT is negotiating with Intergraph Corporation for a $300 cost per seat for GeoMedia. This would reduce the costs by $140,400.

We have identified $468,000 for pen-based computers for the counties and Engineering Districts field data units. This cost was arrived at using market rates for pen-based computers. Due to the purchasing power of PennDOT, it is likely that a much lower price could be negotiated. Additionally, laptops may be an acceptable substitute which would reduce the FDU costs by one-third.

The cost estimate also includes $475,000 to convert the available sign information and begin building an inventory in a database. PennDOT could reduce this cost by hiring student labor to assist in this effort. It should be noted that SIMOS is effective with or without an inventory in place. The use of SIMOS will automatically build an inventory over time.

Cost Benefit Analysis

The Sign Information Management and Ordering System (SIMOS) proposed to the Department meets all of the objectives established for this project and achieves the concepts and goals established in moving PennDOT forward. SIMOS is an effective solution that will provide PennDOT with the tools to improve its service to the general public. The general public will benefit greatly from safer roads through better signage, and more effective use of tax dollars. The direct benefits realized by PennDOT will include:

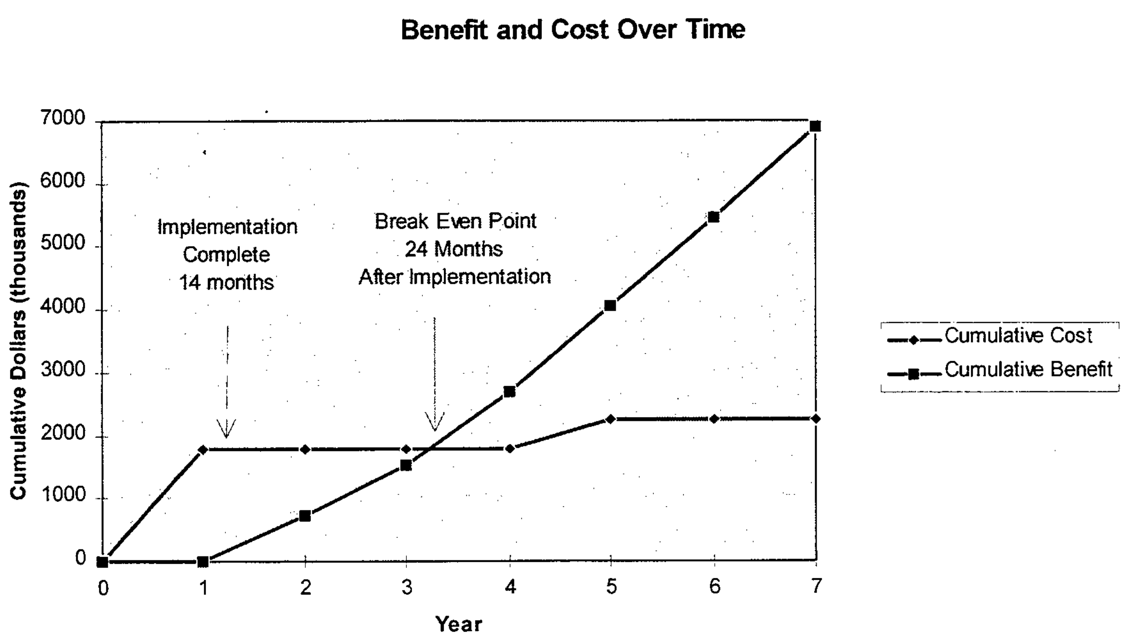
- Effective statewide sign management system for better decision making and maximizing effectiveness of available funding;
- Increased operational efficiency by reducing manhours required for sign management;
- Lower operation costs by eliminating duplication of work efforts;
- Improved quality by eliminating existing error-prone operations;
- Reduced tort liability for sign-related lawsuits; and
- Reduce current sign review cycle from seven years to two years. SIMOS is an effective tool to facilitate this initiative.

The proposed SIMOS is a sustainable information system that will provide great benefits to

PennDOT and the general public. It is difficult to determine the actual savings for many of the benefits of implementing SIMOS, for example, the cost savings due to safer roads, improved roadway information, safer methods for inventory/inspection, or happier motorists. We have conservatively estimated the cost savings to several of the key benefits of the proposed SIMOS solution, as identified below:

	Benefits				
(Years Following Notice-to-Proceed)	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**
1. Field Inventory/ Inspection Preparation	$101,246	$104,283	$ 107,411	$ 110,634	$ 113,953
2. Field Inventory/ Inspection Collection	216,008	222,488	229,163	236,038	243,119
3. Work Order and Sign Order Generation	378,000	389,340	401,020	413,051	425,442
4. Reduce Sign Order Errors	28,500	29,355	30,236	31,143	32,077
5. Tort Liability	-	-	350,200	525,300	541,059
6. Inventory Reduction	-	45,500	46,865	48,271	49,719
	$723,754	$790,966	$1,164,895	$1,364,437	$1,405,369

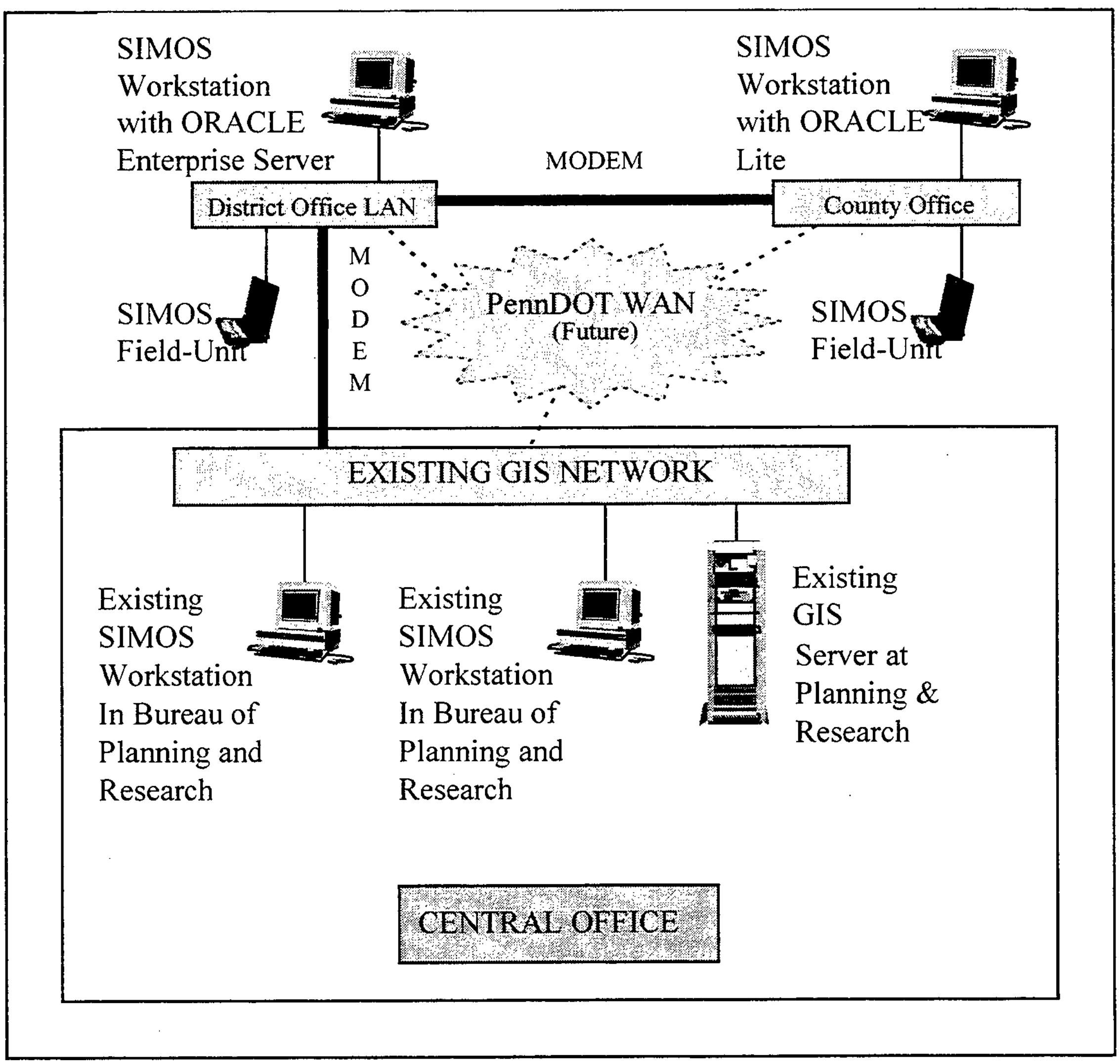
SIMOS will break even early during the second year after implementation. Implementing SIMOS on a statewide basis will save PennDOT and the taxpayers significant money during future years. The savings are depicted by the difference between the two lines in the following Cost Benefit Chart:



SIGN INFORMATION MANAGEMENT AND ORDERING SYSTEM
SELECTED OPTION

PennDOT was presented with three infrastructure alternatives for a statewide SIMOS solution. The option that was selected was distributed database server/workstations with a wide area network. In this design, it is assumed that both a district office LAN and PennDOT WAN will be in place, although the proposed SIMOS solution will still be viable if they are not. Each district office will have one SIMOS Server/Workstation running Oracle Enterprise Database software and one SIMOS field-unit. Each county office will have one SIMOS PC running personal Oracle Lite software and one SIMOS field-unit. Refer to **Figure 3**.

Figure 3. Distributed Database Server/Workstation with Wide Area Network



Using database servers at each district office has several advantages:

- Provide better service to the counties;
- Full application function will be available even if the WAN is down;
- Communications with Central Office existing GIS database server will occur during off-hours;
- If one server is down, the other locations will not be affected; and
- Database updating and replication can occur extremely efficiently with minimal input.

The current configuration in **Figure 3** shows communication lines between county, EDO and Central Office via high speed modem. The flow of information originates from the county and flows through the EDO to the Central Office. Each district office will be responsible to maintain the sign database for every county in their district. This configuration will minimize the number of counties accessing a sign database simultaneously on a statewide basis. This will provide the best service to the counties.

The future WAN connecting the counties, EDO and Central Office could provide an effective communication channel and change the proposed flow of information. Under this scenario, the counties could upload/download information directly with the Central Office database. The EDO could obtain sign information by downloading data from the Central Office. Under the latter scenario, the EDO would not have a role in maintaining the database and would download sign data for its own use.

The hardware and software cost for SIMOS will not be effected by either approach to the flow of information. The WAN solution could easily be implemented following the connection of all counties and EDOs.

Recently, PennDOT decided to purchase an Oracle Database server for each district office for GIS, CADD, MPMS, and APRAS. It is intended that this unit will also serve as the SIMOS Server/Workstation. This will reduce the cost for SIMOS considerably.

Because this server will also be used for other purposes, in addition to SIMOS, there is a concern that the performance of the server will be impacted in the future. Should this become a problem it is recommended that a separate computer be purchased to act as a SIMOS workstation. The SIMOS database would continue to be maintained on the Oracle server workstation. The cost for an additional workstation is not included in this estimate.

It will be necessary that Oracle Enterprise Database software be purchased for the server. This software's full automated replication capabilities will be used to maintain the database when uploading or downloading data between the Oracle server and the field data unit, between the EDO Oracle server and the county personal computers, and between the Central Office Oracle server and the Engineering District Offices' Oracle database.

The existing GIS Oracle server, located in the Planning and Research Department, will be used to maintain the statewide SIMOS data. The Planning and Research Department will also play an important role in SIMOS by recalibrating sign location information. This is necessary as the linear referencing system (LRS) is continually changing due to road realignments. The GIS Oracle server will maintain the current sign location information. The counties will have to download the latest sign location information on a regular basis.

Currently Planning and Research has 5 GIS workstations. There is sufficient access and capacity with these units for the staff in Traffic Engineering Operations Division (TEOD) to use these workstations for sign management. These units will provide access to all the information TEOD will need for statewide sign management. Utilizing the hardware and software in Planning and Research will help reduce costs in implementing the SIMOS.

HARDWARE/SOFTWARE

County/District Office Configuration

Each district office will consist of the following:

1. The District Server will be running Oracle.

   A. Function

   - Provide database service for GIS operations

   B. Hardware Specification

   - Intel Pentium Pro PII 233
   - 6 GB Hard Disk
   - 128 meg RAM

   C. Software Specification

   - Windows NT Server
   - Oracle Enterprise Server. This software comes with an 8-user license. SIMOS would use one of these.
   - RIS Oracle Data Server

No additional costs will be incurred since an existing Windows NT Oracle database server will be utilized for SIMOS.

2. County/District Workstation

   The SIMOS workstations will not be used for significant amounts of time on a daily basis. Their primary function will be to maintain the database, generate work orders and sign orders, and order signs. These processes will take very little time, freeing up the workstation for other activities. It is anticipated that the districts will be able to take advantage of existing desktop computers. Some of the counties also have computers that will be able to be utilized. These county workstations may require an upgrade in operating systems, hard disk space, and memory. Where it is not economical to upgrade existing workstations or existing workstations are not available for SIMOS, new computers will have to be purchased.

   A. Function. Windows NT workstation will be required for the County/District Office SIMOS. In the Engineering Districts the workstation will be on a network connected to an existing Oracle database server. In the counties, all of the SIMOS applications including Oracle Lite would reside on the SIMOS workstation. The workstation would perform the following functions:

- Work Order Processing. Work order processing will occur through a Visual Basic (or Power Builder) application which can run standalone or could be accessed through GeoMedia.
- Sign Order Generation. Completed work orders will be processed with a Visual Basic application to generate sign orders.
- Standard Sign Ordering. Standard sign ordering will occur through a Visual Basic application which can run standalone or could be accessed through GeoMedia.
- Special Sign Ordering. Special sign ordering will occur through a Visual Basic application which can run standalone or could be accessed through GeoMedia. (The integration of existing sign design programs are not included in this report.)

B. Hardware Specification

- 166 MHz Pentium
- 2-4 GB Harddisk
- Network card
- 32 meg RAM

C. Software Specification

- Windows NT
- Microsoft Office Suite
- Personal Oracle Lite.
- GeoMedia. GeoMedia will provide the capability to query SIMOS data, generate reports, and print maps showing sign locations.

Each GIS workstation will require the following data for performing GIS queries. These data sets would be obtained from the GIS unit in Planning and Research. The GIS unit is responsible for maintaining these files.

- Coordinate Files. These contain information associated with the roadway graphics.
- Parameter File. Contains GIS database table-graphics file relationship information.
- Seed File. Contains coordinate projection parameters.
- Basemaps. Provide additional data (local roads, townships, municipal boundaries) for map production.

3. Backup. The County/District workstation database should be backed up daily. All field data should be uploaded to the County/District SIMOS workstation daily. Since the workstation will be backed up daily, regular backup of the FDU will not be required.

4. Training. It is anticipated that County/District personnel will require four days of training in the use of the SIMOS FDU and GeoMedia for query and editing. This includes three days of intensive training plus one day of follow-up.

5. Maintenance and Support. It is anticipated that District EDP Coordinators can provide the required hardware support to maintain SIMOS hardware. District GIS personnel and Central Office GIS personnel in Planning and Research can provide GIS support. The county will be trained how to maintain SIMOS on the county workstation and FDU.

It is anticipated that district personnel can utilize one of the new Windows NT workstations which are currently being installed in the district offices as the SIMOS server/workstation. It is assumed that existing MGE software in some districts will be available for SIMOS. If these resources cannot be used, refer to the Task 3 report for workstation and software costs. Additionally, existing computers in some county offices may serve as the SIMOS workstation.

3. Field Data Units Specifications and Software

The recommended Field Data Units (FDUs) will meet the requirements listed above. Pen computers will use a pen stylus as a software navigation tool and as an input device. One of the data collection requirements was that the driver would be the preferred field data collector in an operating environment. Because the relative simplicity of the pen interface, the pen computer solution most appropriately meets this requirement. In order to make the field system more compatible with mobile operations, it is recommended that vehicle mounting systems be integrated into the work vehicles so that the FDUs could be mounted next to the driver for ease of use, while allowing them to be removed at night or during other down periods. The in-vehicle mounting system provides a stable location for the computer when the vehicle is in motion, as well as when the operator is working with it. This is much more efficient than trying to store the computer while the vehicle is moving and then balancing it between the driver and the steering wheel for use. The mounting system must provide easy docking and undocking of the computer so that it can be used outside of the vehicle where safety constraints or convenience do not allow the vehicle to be parked in the proximity of the sign location. A vehicle mounting system will also allow the vehicle's 12V power system to be used to power the FDU as well as recharging the internal battery during the course of a work day

Since the majority of work within the SIMOS data collection context is done outside, screens that are usable outside must be selected. Monochrome backlit transflective displays have superior operating characteristics in an outdoor environment. The display renders a 640 x 480 VGA display, with a minimum of 64 shades of gray. This resolution and color depth is appropriate for applications that include a mapping environment. Since the screen on a pen computer also acts as a digitizer and input device, consideration must be given to this functionality if selecting a pen platform. The pen computer must utilize a passive pen stylus with an electromagnetic proximity sensing digitizer. This will insure reliability by eliminating the need to provide sufficient power for the stylus.

With the GIS platform such as GeoMedia, the computer should be supplied with sufficient processor power, RAM, and hard drive storage for that application. Because of the relative compute intensive nature of this data collection system, the computer should be based on a 586 processor operating at 75 MHz or greater with 32 MB of RAM. Hard drive storage is necessary to store software programs, data and any temporary program data files. Most mobile computers feature hard drives that can be removed and swapped between machines. A recent trend, especially in pen computers, is the use of PC Card Type III hard drives. These hard drives allow for the easy removal and replacement of drives when necessary. The largest Type III card is 340MB, but 520MB cards should be available in the beginning of 1997. Because of the potential for large mapping datasets within the GeoMedia environment, as well as the databases being managed, a PC card solution is not practical at this time. The system being considered for this project must have a minimum of 1.0 GB hard drive storage capability.

There is a movement towards Microsoft Windows as the de-facto standard among computer operating systems. Currently only Windows 3.1 and Windows 95 are supported on the pen platform. It is recommended that Windows 95 be selected for the mobile environment; Windows 95 is a 32 bit operating system, which means that virtually any Windows software will run on it. Windows 95 has an additional strength in that it is well suited to the mobile environment; remote connectivity and power conservation modes are just two of its advantages.

Central Office Configuration

The Central Office SIMOS configuration will consist of the following:

1. Hardware Specification. The Central Office SIMOS will utilize the existing Windows NT GIS database server located in Planning and Research. The existing workstation in Planning and Research can be used for SIMOS GIS query and to access the Oracle database.

2. Software Specification

   - GeoMedia. GeoMedia will provide the capability to query SIMOS data, generate reports, and print maps showing sign locations. As mentioned above, since it is fully Windows OLE compliant, all GeoMedia data (maps and data tables) can be cut-and-pasted into commonly used office automation software such as MS Word, PowerPoint, Harvard Graphics, Excel, etc.

- MGE. For advanced queries and analysis which cannot be handled using GeoMedia, TEOD should have access to MGE. In addition, MGE provides high quality map production. It is anticipated that TEOD can utilize one of the MGE GIS workstations located in Planning and Research. The TEOD will be a node on the GIS network in Planning and Research.

3. Training. It is anticipated that TEOD staff will require four days of training in the use of GeoMedia and MGE for SIMOS query and analysis. This includes 3 days of intensive training plus 1 day of follow-up.

4. Printing/Plotting. TEOD staff will use one of the large format (36") plotters located in the Cartographic Unit. A local laser printer can be used for smaller plots and reports.

5. Maintenance and Support. It is anticipated that existing EDP Coordinators will provide hardware support. The GIS unit in Planning and Research will provide GIS support.

EVALUATION OF ALTERNATIVE SOFTWARE

SIGN*view*™ is a software for sign assets management developed by CartéGraph Systems. The evaluation is based on five categories: functionality, database design, graphic user interface (GUI), system performance, and cost as summarized in the SIGN*view*™ Software Evaluation Results table. Each category is evaluated with five grades: excellent, good, fair, poor and do not exist.

Functionality

The evaluation of functionality focuses on what functions the software provides for sign management. The evaluation is based on the following functions:

Data Entry/Editing:	Provides easy data entry and data editing for sign assets; the users can enter/edit data for a single table or for multiple tables at the same time;
Data Viewing:	Provides a variety of functions for data viewing such as customized forms, tables, reports and photos;
Data Access:	Has limited data import/export formats; the software doesn't support ODBC connection to access other DBMS such as Oracle;
Data Query:	Provides a variety of functions for database query, but the query is too complicated;
Reporting:	Has very sophisticated reporting functions, and provides a number of reporting formats;
Mapping/GIS:	The mapping functions are very limited, can only read DXF file; for basic GIS functions, ArcView is needed which requires purchase of ArcView and SIGNview for ArcView extension.
Data Charting:	Does not have data charting functions (e.g., bar chart for annual report);
Work Order Generation:	Cannot automatically generate work order.

Database Design

The SIGN*view*™ database design was evaluated to determine its ability to meet PennDOT's requirements for sign management. The evaluation is based on the following database design issues:

Linear Referencing Model:	Uses link node model for linear referencing which is not a good model because the link node definitions cannot be efficiently handled and editing of link node is very time consuming;
Sign Information:	Has very rich sign inventory and management information such as sign location, sign design attributes, sign maintenance and sign libraries;
Relational Design:	Uses relational data model to design tables but relations between tables are not clearly defined, some redundant fields have been found among tables; in addition, table names are very confusing;
Database Management:	Uses Access as database management system and provides tools for database manipulation such as change table definitions

Graphic User Interface (GUI)

The following component evaluation is based on the user's viewpoint on the GUI's ease of use:

Intuitivity:	The software has customized GUI but it is not intuitive, in particular, the start-up GUI doesn't give enough hints on where to start;
Easy-to-start:	Not easy to start with, the start-up GUI is not user-friendly;
Easy-to-use:	In general, it is easy-to-use, most of GUIs use point-and-click, but the menus are not straight, and not many command buttons are available;
Help Tips:	Provides help tips;
Flexibility/ Customization:	Not flexible, cannot be customized;

System Performance

The system performance evaluation is looking at the system performance such as response speed, file size, data security, etc. In general, the SIGN*view*™ software's response time is fast, and it has reasonable file size, but doesn't have security functions for data protection.

Cost

Single license:

SIGN*view*™:	$1,500	
ArcView extension:	$500	optional
ArcView:	$1,100	optional

Network license: Not available.

SIGN*view* SOFTWARE EVALUATION RESULTS

	Excellent	Good	Fair	Poor	Do Not Exist	Note
Functionality						
Data Entry/Editing	x					
Data Viewing	x					
Data Access			x			Such as access data in other DBMS, data import/export
Query		x				
Reporting	x					Generate report
Mapping/GIS				x		View GIS data, run basic GIS search
Charting					x	Bar chart, or line chart for reporting
Work Order Generation					x	Automatically generate work order
Database Design						MS Access
Linear Referencing Model				x		Link node model, but it is not a good model
Sign Information			x			Very rich sign information, but not very clear in terms of data flow
Relations between Tables			x			Relational design between tables is OK, but table names are confusing
Database Management		x				Such as modify database structure
GUI						
Intuitivity				x		GUI is too complex, not straight for the users
Easy-to-Start				x		When open the system, is not clear where to begin with
Easy-to-Use			x			Such as point-and-click
Help Tips		x				
Flexibility/Customization					x	There is no flexibility to customize the GUI
System Performance						
Speed		x				
File Size		x				
Security					x	Such as security on records or fields or tables
Cost						
Single License						
SIGN*view*™	$1,500					
ArcView Extension	$500					Interface between ArcView and SIGN*view*™
ArcView	$1,100					To view GIS data
Sum	$3,100					
Distribution Cost	$1,500 per license					
Network License	N/A					For SIGN*view*™ only

DATABASE DESIGN

The SIMOS database will use a relational data model and Oracle will be the database management system. This is consistent with PennDOT's GIS system in the Planning and Research Department. The SIMOS database design will be implemented at two levels: the County/District level and the Central Office level. Database design at the County/District level focuses on sign inventory and maintenance activities, while database design at Central Office emphasizes statewide management and planning. The Central Office database will consist primarily of data uploaded from district offices, as well as statewide database management. A detailed look at the database structures for both the Central Office and County/District Offices has been preliminarily investigated to determine the structure and size of the final SIMOS databases, as well as to ensure that database query and updating can occur efficiently. The following sections summarize the preliminary SIMOS database design.

1. County and Engineering District Database Design

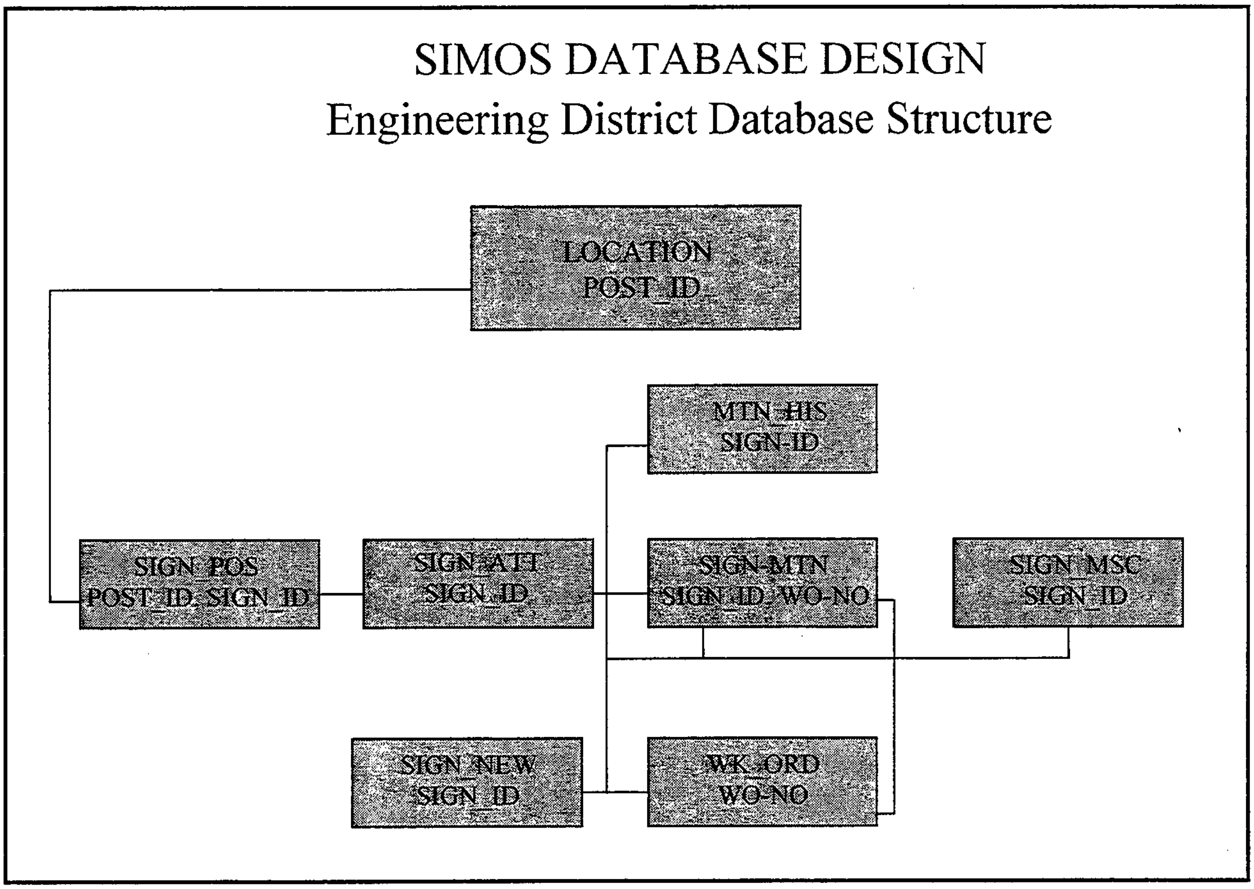
A. Database Structure

The County/District Office database design is based on information required for sign inventory and maintenance. The database structure is shown in **Figure 4**. This preliminary structure will be further defined during project implementation. Naming conventions will also be modified as needed for the final database structure.

Field definitions for each table are listed in **Table 1**. The shaded fields are information required in SIMOS database. These shaded fields are also basic data requirements for the data conversion process. It must be pointed out that the field names and widths are preliminarily defined in this report, further modifications may be made during the database design phase.

The **Location Table** contains information used to locate signs spatially. The four attributes, 'State Route Number', 'Segment', 'Offset', and 'County Code', will be obtained from district office databases. 'Nlf_id' and 'nlf_cntl_bgn' will be generated using programs used by the Planning and Research GIS unit. A unique 'Post ID' will be generated in consultation with County/District and Central Office SIMOS personnel. The 'Post ID' will be unique across the state (the same 'Post ID' will not be used in more than one district). A 'Post ID' was chosen for spatial location since a single location (post) may contain multiple signs. Signs become an attribute of the post. This greatly increases database performance and has the added benefit of reducing database table space. Post_ID is the primary field used to link to the sign table.

Figure 4. Engineering District Database Design



The **Sign_Pos** Table provides information on sign positions and directions. Sign_id is the unique identifier used to link to all other sign attribute tables. The **Sign_Att** table contains sign attribute information, such as sign type, size, sheeting and installation. The **Sign_Mtn** table provides maintenance information on conditions, maintain actions and work order numbers (Wo_No). Wo_No is the primary field to link to the work order table (**Wk_Ord**). The **Sign_Msc** table provides miscellaneous information about signs such as inventory date and inspection date. The **Wk_Ord** table stores work order information including the date the work order was generated, the date the work order was completed, and the work order number. The **Sign_New** table holds all new signs which are added at county offices, this table will be periodically updated.

Table 1. Preliminary SIMS Database Field Definitions

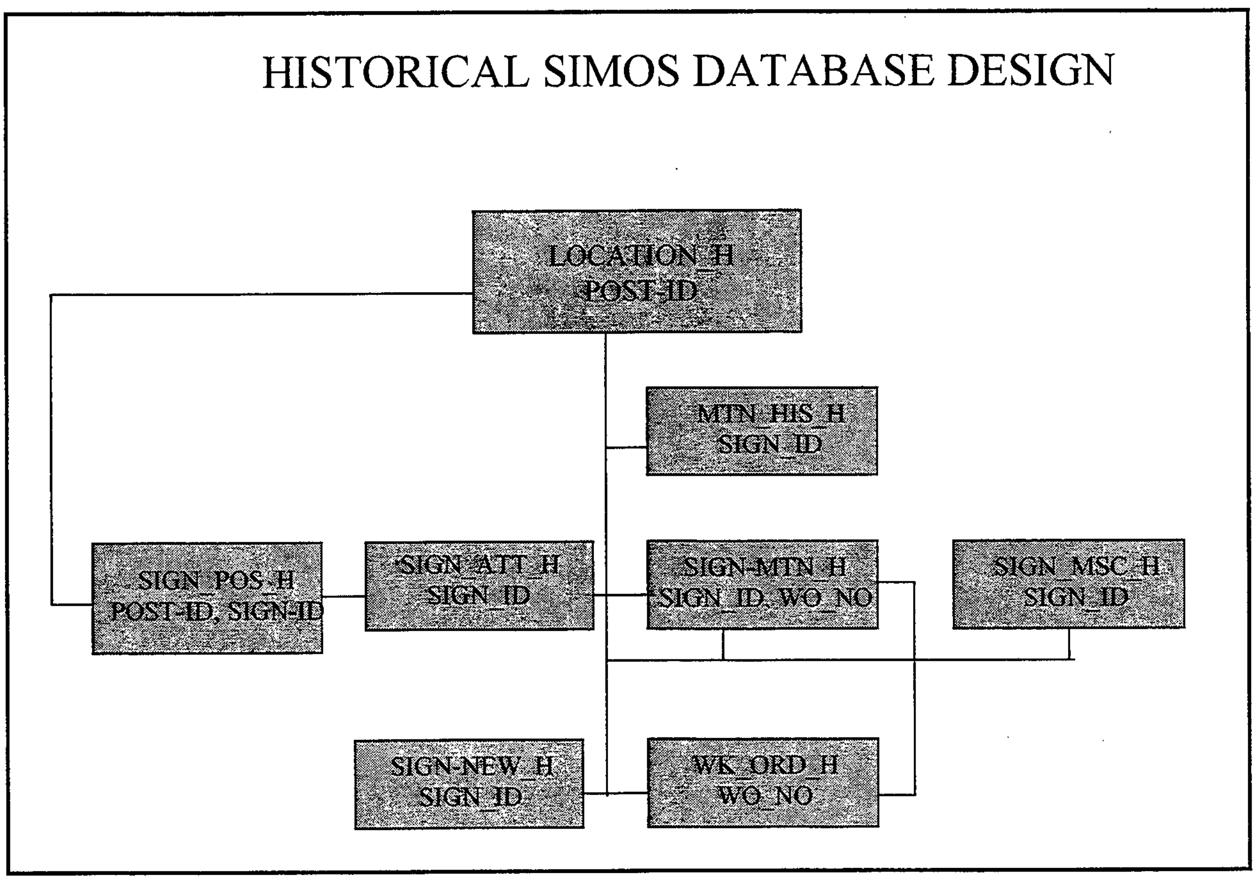
Table Name	Field Name	Width	Description
Location Table	POST-ID	2	Sign Post Location ID
	CTY_CODE	4	County Code
	DIST_ID	2	District Code
	SR	4	State Route Number
	SEG	4	Segment Code
	OFFSET	4	Offset
	NLF_ID	4	
	NLF_CNTL	4	
Sign-Pos Table	POST-ID	2	Sign Post Location ID
	SIGN-ID	6	Sign ID
	DIR	1	Direction Travel
	POS	1	Position of Sign
	FACING	1	Sign Face Direction
	IMGFILE	12	Sign image file name
Sign-Att Table	SIGN-ID	6	Sign ID
	POST	2	Type of Post Code
	SIGNTYP	12	Nomenclature
	WIDTH	3	Width of Sign
	HEIGHT	3	Height of Sign
	COMMOD	14	Commodity Code
	MESSAGE	30	Sign Message
	SHEET	2	Type of Sheeting Code
	INSTALL	8	Date Sign Install
	REMARK	30	Remarks/Comments
Sign-Mtn Table	SIGN-ID	6	Sign ID
	COND	1	Condition of SignCode
	ACTION	4	Maintenance Action Code
	WO-NO	6	Work Order Number
Sign-Msc Table	SIGN-ID	6	Sign ID
	INV_DATE	8	Inventory Date
	INV_INI	3	Inventory Initials
	INSP_DATE	8	Inspection Date
	INSP_INI	3	Inspection Initials
Wk-Ord Table	WO-NO	6	Work Order Number
	WO_GEN	8	Date Work Order Generated
	WO_COMP	8	Date Work Order Completed
Sign-New Table	POST-ID	2	Sign Post Location ID
	CTY_CODE	4	County Code
	DIST_ID	2	District Code
	SR	4	State Route Number
	SEG	4	Segment Code
	OFFSET	4	Offset
	SIGN-ID	4	Sign ID
	DATE_ADD	8	Date Sign Added
	NLF_ID	4	
	NLF_CNTL	4	
Mtn-His Table	POST-ID	2	Sign Post Location ID
	SR	4	State Route Number
	SEG	4	Segment ID
	OFFSET	4	Offset
	NLF_ID	4	
	NLF_CNTL	4	
	SIGN-ID	6	Sign ID
	COND	1	Condition of SignCode
	ACTION	4	Maintenance Action Code
	WO-NO	6	Work Order Number
	WO-GEN	8	Date Work Order Generated
	WO-COMP	8	Date Work Order Completed
	STATUS	1	Existing or Removed
	DATE	8	Date Changed

* The shaded areas represent the required data which must be obtained from each Engineering District Office.

The Maintenance History (**Mtn_His**) table, which is a historical database for maintenance records, contains columns for sign_id, sequence_number, action_taken, and date. As a new action is performed, a new record will be added to this table. Because old maintenance data will be maintained in the database, this will permit easy access to the historical maintenance data for any sign. It will be important to standardize action codes between county offices so that a consistent set of codes will be used.

In addition to the database tables described above, a set of historical database tables, which are the repository for all removed/unused signs, will be generated during data updating. These tables have the same table and field definitions as the main database. (See **Figure 5**).

Figure 5. Historical Database Design



The basic database (required information) size is estimated at 216 bytes per sign, the statewide database will be about 900 MB including sign inventory information from all districts, historical databases, and 200 to 300 MB sign imagery inventory. The estimated database size for each district is listed in **Table 2**.

It was found in the Task 1 Report that the current coding system for some fields, such as Sheeting Code, Condition Code, Action Code are not standardized across districts. In order to keep data integrity, these fields should be standardized. The following is a list of fields that currently are not standardized, and new standards will be developed during the database design:

SR: state route number
DIR: direction travel
POS: position of sign
FACING: sign facing direction
POST: type of post code
SHEET: type of sheeting code
COND: condition of sign code
ACTION: maintenance action code

In addition to these fields, there are two fields, Post-ID and Sign-ID, that will be automatically generated during database development. These two fields also need to be standardized (i.e., unique codes for all signs).

2. Central Office Database Design

The Central Office database serves two primary roles: as a repository of databases from all districts; and as a system for statewide management and planning. Therefore, the central database includes several tables in addition to all tables in the district office database. (See **Figure 6**). The **MetaData** table provides descriptive information concerning all database tables; **Dist_Sum** Table is a summary/analysis table for all districts.

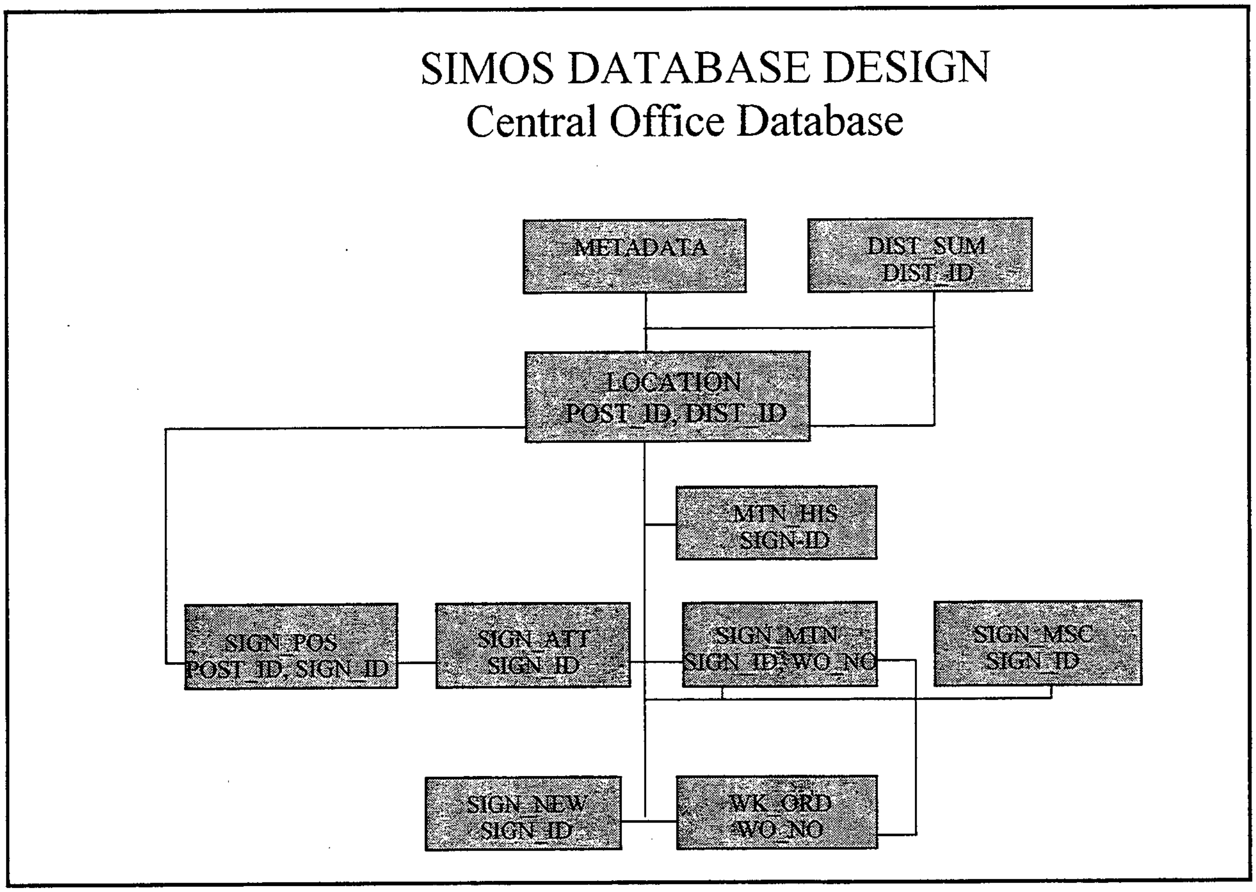
Table 2. Estimated SIMS Database Size

Engineering District	Required Info (Bytes/sign)	Entire Database (Bytes/sign)	No. of Signs**	Estimated Database Size	Total Data Volume (including Historical Database)*
District 1-0	216	320	90,000	28800000	48240000
District 2-0	216	320	80,000	25600000	42880000
District 3-0	216	320	100,000	32000000	53600000
District 4-0	216	320	80,000	25600000	42880000
District 5-0	216	320	90,000	28800000	48240000
District 6-0	216	320	90,000	28800000	48240000
District 8-0	216	320	200,000	64000000	107200000
District 9-0	216	320	100,000	32000000	53600000
District 10-0	216	320	110,000	35200000	58960000
District 11-0	216	320	90,000	28800000	48240000
District 12-0	216	320	90,000	28800000	48240000
TOTALS			**1,120,000**	**358400000**	**600320000**

* It is anticipated that the total data volume will increase by 200-300 mb when the state-wide sign imagery inventory is included

** The total number of signs per District were estimated when this information was unavailable from the District.

Figure 6. Central Office Database Design



3. Database Security

Oracle provides multiple level privilege control to ensure data security. Through the use of "views", privileges (access) can be defined for specific fields, tables and databases for individual users. Only authorized persons can update the database at specific levels. This privilege setting will protect data integrity, as well as provide easy updating. The privilege level should be set up during database design for the county, district and Central Offices.

4. Design Procedure

The following items summarize the detailed database design components. These components form basic step-by-step procedures for the Oracle database design.

1. Conceptual Design: is a conceptual design using Entity-Relation Model;

2. Schema Design: is database schema design for tables and their relations;
3. Table Structures: is table field definitions and key set up;
4. Design: using Oracle design tools to physically design SIMOS database;
5. Data Standard: standardizing codes for some fields;
6. Testing: using pilot dataset to test database design;
7. Finalizing: finalize database design.

Estimated Man Hours for Oracle Database Design Procedures

Conceptual Design/Schema Design	*160 mh*
Table Structure/Design	*80 mh*
Data Standard	*120 mh*
System Testing	*120 mh*
Finalizing	*80 mh*
Total	*560 mh*

DATA CONVERSION PROCEDURES

General Approach

Each Engineering District Office maintains sign inventory data in a unique format. Due to the format of existing sign data at each of the Engineering District Offices, five types of conversion procedures will be required for the complete conversion of existing sign inventory data to the SIMOS Oracle GIS database. These five methods include the conversion of electronic spreadsheet data, conversion of electronic database data, electronic conversion of paper files using a scanning process, conversion of electronic drawing files, and the conversion of non-scannable paper files. Although these conversion processes are available to convert all existing data, it must be considered that not all of the required sign attribute data exists in electronic and/or paper files to completely populate the minimum required SIMOS Oracle GIS database structure. The county offices could participate in the data conversion process.

The five methods for converting existing sign data to the SIMOS Oracle GIS database are further defined below:

1. Conversion of spreadsheet data to SIMOS Oracle GIS database. Sign inventory data currently exists in a Lotus spreadsheet format in four district offices. Each district office using Lotus has developed a unique format for storing their sign data. Because of the differences in structure and content, each Lotus format will require separate programming for data conversion.

   This procedure will require three steps:

   A. Individual programs will need to be written for the conversion of each type of spreadsheet into a .dbf format.

   B. Processing will be required to manipulate the data into the .dbf format and to allow for quality control of data conversion.

   C. The data in the .dbf files will then be converted into the SIMOS Oracle database.

2. Conversion of database data to SIMOS Oracle GIS database. Sign inventory data exists in two types of database formats, R-base and Alpha Four. The data in these two formats will require separate programming for data conversion due to the differences in structure and content.

   This procedure will require three steps:

   A. Individual programs will need to be written for the conversion of the two types of database files into a standard .dbf format.

B. Processing will be required to manipulate the data into the .dbf format and to allow for quality control of data conversion.

C. The data in the .dbf files will then be converted into the SIMOS Oracle database.

3. Scanning of typed paper files for conversion to SIMOS Oracle GIS database. A scanner will be used to convert text on typed paper files into an electronic format. This process requires that the paper files be clearly legible and clean. Each type of ASCII file created from the paper files will require unique processing in order to structure and convert the data correctly. Paper files which are structured in a column-type format will require less manipulation, while those in a non-structured format will require significant manipulation. The paper files for each district office will be evaluated to determine if this will be an efficient process for data conversion. If it is determined that this process will not be efficient, manual data entry will be performed for those districts to populate the SIMOS database.

   This procedure will require five steps:

   A. The scanning of all clean, legible, paper files will be performed with a scanner. Specialized scanning software will be used to read only the text information from the paper files into a standard ASCII format.

   B. Once the electronic, ASCII files are created, clean-up work must be performed to correct errors which may have occurred during the scanning process and to allow for quality control.

   C. Individual programs will be written for the conversion of each type of ASCII file into a standard .dbf format.

   D. Processing will be required to manipulate the data into the .dbf format and to allow for quality control of data conversion.

   E. The data in the .dbf files will then be converted into the SIMOS Oracle database.

4. Conversion of electronic drawing files to SIMOS Oracle GIS database. Sign inventory data exists in two types of electronic drawing files, AutoCAD and MicroStation. Each of these types of files will require individual programs to be developed in order to extract the sign attribute data existing as text on the drawing files. If, during the implementation of this task, this approach is found to be cost prohibitive, other methods will be used to convert data.

   This procedure will require three steps:

   A. Individual programs (LISP in AutoCAD, MDL in MicroStation) will need to be written for the conversion of the sign data on the two types of electronic drawing files into a standard .dbf format.

B. Processing will be required to manipulate the data into the .dbf format and to allow for quality control of data conversion.

C. The data in the .dbf files will then be converted into the SIMOS Oracle database.

5. Data entry of all other relevant sign data existing on non-scannable paper files to SIMOS Oracle GIS database. This may be a significant part of the data conversion process for many of the district offices due to the type and format of sign inventory data that is currently available. This conversion process will be made more efficient by developing user-friendly programs and screens for data entry. Look-up tables, buttons, and domains will be used to assist the data entry operator in entering data quickly and ensuring that accurate data is entered.

   This procedure will require three steps:

   A. Programs will be developed to assist in the manual data entry of sign inventory information into standard .dbf files. These programs will consist of look up tables and quality control checks to help ensure that accurate data is entered.

   B. Additional processing will be required to allow for quality control of the data conversion.

   C. The data in the .dbf files will then be converted into the SIMOS Oracle database.

Engineering District Data Conversion Procedures

Earlier in this report, the preliminary detailed database structure was defined. This structure may now be used to help evaluate each district's data in terms of the presence or absence of required data and to develop a cost for the complete data conversion process. The shaded areas of **Table 1** represent required fields of information.

District 1-0

As reported in the Task 1 Report, District 1-0 maintains 100 percent of its sign inventory data in an industry standard database, R-base. Procedure 2 will be used to convert this electronic data. However, only 48 percent of the fields required for the SIMOS database are in this format. The remaining 52 percent of data will need to be obtained from paper files using a combination of procedures 3 and 5. We estimate the data conversion process for existing data will take approximately 601 hours. If the paper files do not contain the required additional data, procedures will need to be defined to collect this data. The additional data may be collected as future sign surveys are completed.

District 2-0

District 2-0 maintains 100 percent of the sign inventory data in typewritten forms. These forms will be converted using a combination of procedures 3 and 5. However, only 45 percent of the required fields exist on the two types of handwritten sign survey sheets we reviewed. The total hours required for existing data conversion will be approximately 774 hours. Additional information to complete the database will require additional data collection, which may be performed as future sign surveys are completed.

District 3-0

District 3-0 maintains 100 percent of sign inventory data as text in MicroStation CADD files. The conversion procedure required for these files is listed as procedure 4. However, only 56 percent of the required data exists in these electronic files, therefore conversion of paper files may also be required to complete the remaining amount of required data to populate the database. The conversion of paper files will require the use of procedures 3 and 5. Due to the programming and manipulation of data, an estimated 1505 hours will be required for the conversion of existing information. Additional information to complete the database will require additional data collection, which may be performed as future sign surveys are completed.

District 4-0

District 4-0 maintains some sign upgrade information in an electronic database format which will be converted using procedure 2. This electronic format only contains 9 percent of the required data for the SIMOS database. Additionally, typed forms contain 27 percent of the required sign information. These files will be converted using a combination of procedures 3 and 5. Because only 36 percent of the required sign data exists in either paper or electronic format, a great deal of the required sign inventory data will require collection of additional data. The total hours required for existing data conversion will be approximately 817 hours. The remaining required data may either be obtained from additional forms which may not have been reviewed, or during future sign surveys.

District 5-0

District 5-0 maintains approximately 30 percent of its sign attribute data as text in AutoCAD Design files. However, this electronic data only contains 24 percent of the required sign data for the SIMOS database. The conversion procedure required for these files is listed as procedure 4. Additionally, a Lotus program has been used to manage all sign upgrade activities. Approximately 28 percent of the required sign attribute data is maintained in this standard Lotus program which exists for all signs in the District, however some of the information is redundant with AutoCAD files. The remaining required sign data will need to be converted from any additional forms which may not have been reviewed through a combination of procedures 3 and

5. The total hours for existing data conversion will be approximately 1354 hours. If the data does not exist on paper forms, additional data collection will be required.

District 6-0

District 6-0 maintains approximately 30 percent of its sign inventory data in an industry standard spreadsheet, Lotus. However, only 15 percent will be used in the SIMOS database. For the 85 percent of sign data that has not been entered into the Lotus program, procedures 3 and 5 will be used to convert paper files. Approximately 1108 hours will be required for complete data conversion of existing data. If data does not exist on these paper files, additional data will need to be collected during future sign surveys.

District 8-0

District 8-0 maintains an estimated 60 to 65 percent of its sign inventory data in an industry standard database, Alpha 4. Unfortunately, the database contains only 40 percent of the required data for the SIMOS Oracle database. The remaining data will be converted through the conversion of paper files. The paper files will be converted using procedures 3 and 5. The total hours for existing data conversion will be approximately 2147 hours. If data does not exist on these paper files, additional data will need to be collected during future sign surveys.

District 9-0

District 9-0 maintains 100 percent of its sign inventory data in typewritten and handwritten forms. These forms will be converted using a combination of procedures 3 and 5. However, only 52 percent of the required fields exists between the two forms. The total hours required for existing data conversion will be approximately 1118 hours. The remaining required 48 percent of the required sign data may be obtained from any additional forms that may not have been reviewed or during future sign surveys.

District 10-0

District 10-0 maintains approximately 6 percent of its sign inventory data in an electronic database format that will be useful for the SIMOS database. Procedure 2 will be used to convert this electronic data. For the remaining information, a combination of procedures 3 and 5 will need to be used to convert this information from paper files. We estimate the data conversion of existing data will take approximately 1716 hours. If data does not exist on these paper files, additional data will need to be collected during future sign surveys.

District 11-0

District 11-0 maintains 100 percent of its sign inventory data in an industry standard spreadsheet, Lotus. The Lotus files contain 32 percent of the total required data for the SIMOS Oracle database. This electronic data will be converted using procedure 1. However, the missing 68 percent of sign information will have to be converted from paper files if they exist using procedures 3 and 5. Approximately 876 hours will be required for existing data conversion. If data does not exist on these paper files, additional data will need to be collected during future sign surveys.

District 12-0

District 12-0 stores approximately 25 to 30 percent of its sign inventory information in Lotus spreadsheets. Procedure 2 will be used to convert this electronic data, however only 25 percent of this will be useful for the SIMOS database. The remaining missing data will require conversion of paper files if they exist using procedures 3 and 5. Approximately 1264 hours will be required for complete data conversion of existing data. For all required information that is not on paper files, further data collection will be required.

Data Conversion Cost

The data conversion costs, shown in **Table 3**, have been estimated based on the following considerations:

- The required information for the SIMOS database that is not available in either electronic or paper format will have to be collected. This estimate does not include the time or cost of future data collection.

- The total estimated signs per district was taken from the estimates provided in the Task 1 Report. Where estimates were not available, it was assumed that approximately 90,000 signs are present in each district.

- The estimated time for data conversion of electronic files is based on the evaluation of sample data which was supplied to us by each district office. Where both electronic and paper sign data is available in a district office, and where the files contain some duplicate information, we have assumed that all required data will be converted from the electronic files. Only the additional, required information available in the paper files will be converted.

- The estimated time for data conversion of paper files is based on the total information available on the paper forms which were supplied to us during this project. For the district offices for which we do not have paper files to evaluate, the assumption has been made that approximately 70 percent of the required data for the SIMOS database will be available in some paper format. If it is determined that a significantly smaller amount of information is available from the paper files, the required hours for manual entry will be significantly less.

Table 3. Data Conversion Cost

Engineering District	Estimated Number of Signs	Electronic Required Data	Paper File Required Data	Required Data Not Available	Electronic Conversion Hours	Manual Entry Hours	Approximate Total Hours for Data Conversion	Cost of Data Conversion *
District 1-0	90,000	48%	22%	30%	176	425	601	$25,030
District 2-0	80,000	0	45%	55%	0	774	774	$30,220
District 3-0	100,000	56%	14%	30%	1204	301	1505	$52,150
District 4-0	80,000	9%	27%	64%	353	464	817	$31,510
District 5-0	90,000	30%	40%	30%	580	774	1354	$47,620
District 6-0	90,000	15%	55%	30%	44	1064	1108	$40,240
District 8-0	200,000	26%	44%	30%	255	1892	2147	$71,410
District 9-0	100,000	0	52%	48%	0	1118	1118	$40,540
District 10-0	110,000	6%	64%	30%	32	1684	1716	$58,480
District 11-0	90,000	32%	38%	30%	141	735	876	$33,280
District 12-0	90,000	6%	64%	30%	26	1238	1264	$44,920
TOTALS	1,120,000				2,811	10,469	13,280	**$475,400**

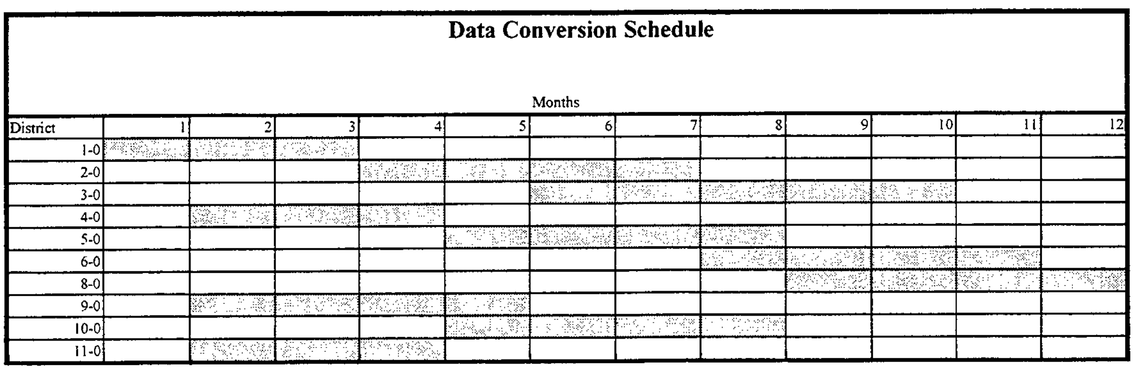
*** $7,000 has been added to the Cost of Data Conversion Column for each District to account for direct costs and application development.**

- Total hours for the conversion of all paper files have been estimated based on manual entry for all data. If the scanning process is applicable and efficient, the total hours required for data conversion will be less.

Data Conversion Schedule

In order to provide for the complete conversion of each Engineering District's existing sign inventory data and to coincide with SIMOS project implementation, an approximate schedule has been developed for data conversion. (See **Figure 7**). The schedule is based on the four project firms working simultaneously on data conversion, one district at a time. The schedule provides for one district to be completed within the first three months for use in the pilot project. Additionally, two other districts will be completed within the first four months. Having three districts at least partially, if not completely, converted when system testing occurs will provide a great advantage to working out problems which may occur at each district office.

Figure 7. Data Conversion Schedule



A significant cost savings in the data conversion process could be achieved through assistance with PennDOT staff in each district office. Assigning a PennDOT employee to assist in conversion, and locating and coordinating missing data would also improve the implementation schedule.

We are recommending that District 1-0 or 11-0 be the Pilot District for this project. They have a significant amount of data available in electronic format. This will permit us to develop a database quickly for the testing phase of the SIMOS implementation. The tentative schedule figure attached is not to show any favoritism to any district but to demonstrate that 4 tiers could complete this task within a one year time frame.

COMMUNICATIONS

There are five modes of communication required for a successful statewide SIMOS:

1. Engineering Districts to Central Office to update Oracle database;

2. County database to Engineering Districts database;

3. Counties to MORIS for sign ordering;

4. Field data unit to County/District workstations;

5. Sign Shop to MORIS to retrieve sign orders.

Efficient communication links allowing easy access and quick processing of data will be necessary for an effective SIMOS solution. How often data will have to be transferred and the site of the data to be moved are key concepts that must be addressed when determining the impacts to existing systems. Fortunately, the SIMOS data is very manageable in size and the scheduling requirements for updating or moving data are very flexible.

Refer to **Table 2** for the estimated database size. The entire SIMOS database, including the historical information, is under 1 gigabyte, which can be easily handled by the Oracle server in the Planning and Research Department. The average database for each district will be approximately 75 MB, which can easily be accommodated on the Engineering Districts' Oracle server. Additionally, the average database for each county will be less than 20 MB.

Engineering District to Central Office

Communications between the district office and Central Office consist primarily of communication between Oracle servers. This can be accomplished through the following mechanisms, whichever is available:

- Modem. Communication via a modem can be used until the WAN is available.

- Internet through PennDOT WAN system. This is highly desirable since much of the updating process can be automated requiring minimal operator input.

- Electronic media (8mm tape, tape cartridge). Transferring database updates can be performed at anytime using 8mm tape. These tape drives are commonly used in each of the districts and in the Central Office.

The Central Office must receive sign data from each of the districts to maintain a statewide database. Fortunately, this data does not change that often. This will allow the eleven districts to schedule uploads to the Central Office at different scheduled times. These uploads could occur on a monthly schedule. Uploads will occur during non-peak times to minimize impacts to the WAN or server.

The districts must also download the most current sign location data from the Central Office. The sign location information is only a fraction of the total database. Therefore, moving this data will have little effect on the server or WAN. Each district will be responsible for downloading the latest sign location information. This also could be scheduled on a monthly basis.

County Database to Engineering District Database

Following the installation of signs, the counties will upload work order information to the EDO. The EDO will process this information and update the database. The primary mode of communication between the county and the EDO initially will be high speed modem. Due to the limited size of information to be transferred, this will be an effective solution.

County to MORIS

It is estimated that 8,400 signs and/or sign components are ordered each month. These orders will be placed by the 67 counties throughout the day. The sign orders will be small in size and will have very little effect on the performance of the WAN or mainframe.

Approach 1: Before a WAN is Available

Approach 1 requires that SIMOS workstations have software and hardware to emulate a 3270 Terminal Session in TSO. The SIMOS Client Server Application will provide "Post Sign Orders to MORIS" menu selection, ICON, button, etc. that will initiate a dialog that interfaces with the 3270 Emulation Session.

The user must open the 3270 Terminal Window and logon to TSO (to the Ready prompt) before beginning the posting process. The posting process will transmit all new sign orders, and sign orders identified to repost, into a temporary sequential file on the mainframe. Once completed, the posting process executes a TSO CLIST to run the program to process the transmitted file. The posting process will be completed by receiving a results file that identifies which sign orders were updated successfully and which sign orders updates failed (with a specific reason). Sign orders failing update will be identified to "re-post".

Estimated time for Communication Application Development process:

Design upload/download files	*2 weeks*
Design MORIS update program	*3 weeks*

Program and test MORIS update	*4 weeks*
Assist with Transfer Dialog testing	*2 weeks*

Approach 2: PennDOT's WAN and Software A.G.'s Entire Broker are Available

Approach 2 requires that SIMOS workstations have software and hardware available to connect them to PennDOT's WAN and access Software A.G.'s Entire Broker middleware product. With this access in place, the SIMOS Client Server Application can create, read, update and delete data directly to MORIS IMS Sign Order Database. The SIMOS Client Server Application will then simultaneously update the Oracle sign order data and MORIS sign order data.

Estimated time for Communication Application Development Procedure

Define MORIS attributes to Entire Broker	*3 weeks*
Program and test Client Server update routine	*3 weeks*

Field Data Unit to County/District Workstations

The field data unit will download one days worth of inventory or data collection. This download will occur directly to the server or through the districts' LAN. The amount of data downloaded will be small and will have little effect on the performance of the server or LAN.

Approach 1: Use a 10BaseT Network Connection to Connect to the District Network

Data can be easily transferred from the FDU to the district SIMOS workstation. This is the ideal communication method because automated client/server application programs can be used to perform the upload with minimal operator intervention.

Approach 2: Use of "Lap-Link" Type Software to Connect to County/District Oracle Server and Transfer Data File

Field changes are manually copied to the County/District workstation and a load program is initiated. This approach will be considered only when Approach 1 is difficult to implement.

Sign Shop to MORIS

The Sign Shop will continue to receive sign orders through MORIS. The proposed SIMOS will have no effect on this line of communication.

FIELD DATA UNIT

The development of a SIMOS for PennDOT has a variety of components as described in this report. This section outlines the requirements and implementation strategies necessary to provide the mobile field data collection and management tools recommended in our report in undertaking the SIMOS project.

An important consideration in undertaking the SIMOS project will be its integration into PennDOT's existing and proposed MIS environment. The field system being considered will require development of a system based on Intergraph's GeoMedia GIS platform and be compatible with the Oracle database engine, since Oracle database servers are being installed at each District Engineering Office and personal Oracle Lite is being installed at the counties.

There are various "mapping" environments being used in the districts, such as AutoCAD and MicroStation SLD's, RMS files, and PennDOT ROAD files, among others. SIMOS will utilize the PennDOT ROAD files as the graphical mapping base through which the signs will be placed by a route segment-offset referencing system.

Field Data Collection and Management

A significant component of the SIMOS implementation is the process by which data is collected in the field, communicated to county and district offices and the Central Office, utilized by maintenance and operation staff, distributed to district offices, area headquarters and utilized in the field. The dynamics of how the information is utilized indicates that the field component is an area where automation will produce higher levels of data accuracy and completeness while sustaining higher productivity rates.

Several requirements have been detailed in previous reports related to data collection, and are repeated below:

- Data collection must be performed from a vehicle;
- Data must be entered directly into a portable, laptop or pen-based computer through a user friendly graphic interface;
- Field data must be collected by one person, the driver of the vehicle;
- The computer must be powerful enough to allow for efficient editing and querying of large amounts of data. Prior to beginning the data collection, a portion of the SIMOS database will need to be downloaded;
- A data collection program must be developed to eliminate any manual efforts during the collection process. At a minimum, the program must be able to:
    * Query downloaded database information from the SIMOS database;

* Allow for easy editing of database information;
* Standardize sign condition codes and action codes; and
* Provide a graphic interface including point and click features where possible.

Field System Configuration

The recommended field data units (FDUs) will meet the requirements listed above. Pen computers will use a pen stylus as a software navigation tool and as an input device. One of the data collection requirements was that the driver would be the preferred field data collector in an operating environment. Because the relative simplicity of the pen interface, the pen computer solution most appropriately meets this requirement. In order to make the field system more compatible with mobile operations, it is recommended that vehicle mounting systems be integrated into the work vehicles so that the FDUs could be mounted next to the driver for ease of use, while allowing them to be removed at night or during other down periods. Field personnel may also find the need to, at times, remove the unit for out of vehicle field investigations. A vehicle mounting system will also allow the vehicle's 12V power system to be used to power the FDU during the course of a work day.

Since the majority of work within the SIMOS data collection context is done outside, screens that are usable outside must be selected. Monochrome transflective displays have superior operating characteristics in an outdoor environment. The display renders a 640 x 480 VGA display, with a minimum of 64 shades of gray. This resolution and color depth is appropriate for applications that include a mapping environment. Since the screen on a pen computer also acts as a digitizer and input device, consideration must be given to this functionality if selecting a pen platform. Electromagnetic digitizers require stylus pens to have batteries in them to enable communication between the pen and the digitizing screen.

The processors for the pen-based mobile computers are 486 class processors. While Pentium class computers are widely available in notebooks and laptops, they have limited availability in pen-based computers. The reason for this, besides price, is the power drain and heat dissipation from Pentium processors. Since pen computers are geared primarily as field units, battery drain is a major operating consideration. As this project progresses, faster platforms may become available. This will be monitored during the prototype development.

With a GIS platform such as GeoMedia, the computer should be supplied with sufficient RAM for that application. Generally speaking, 24 MB should be a minimum. Hard drive storage is necessary to store software programs, data and any temporary program data files. Most mobile computers feature hard drives that can be removed and swapped between machines. A recent trend, especially in pen computers, is the use of PC Card Type III hard drives. These hard drives, which are usually 2.5 inch IDE hard drives, allow for the easy removal and replacement of drives when necessary. The largest Type III card is 340MB, but 520MB cards should be available in the beginning of 1997. Because of the potential for large mapping datasets within the GeoMedia environment, as well as the databases being managed, it may be necessary to have access to more disk space. The system being considered for this project will have the capability of carrying two disk drives.

There is a movement towards Microsoft Windows as the de-facto standard among computer operating systems. Currently only Windows 3.1 and Windows 95 are supported on the pen platform. It is recommended that Windows 95 be selected for the mobile environment; Windows 95 is a 32 bit operating system, which means that virtually any Windows software will run on it. Windows 95 has an additional strength in that it is well suited to the mobile environment; remote connectivity and power conservation modes are just two of its advantages.

Software Development

The GeoMedia GIS environment creates the potential for the development of many robust data collection and management tools, all being readily accessible throughout the Department. As computer models have become more sophisticated, the use of GIS as a data integration and querying tool has become more and more widespread.

In the hierarchy of Intergraph's GIS data model, GeoMedia creates opportunities for developing specific user interfaces to allow the user community to easily access and maintain data. It does this by providing the necessary tools to access and integrate geographic data from numerous sources, including MGE and MGE Segment Manager and MicroStation data. Data requests can be as easy as specifying dataset names, the various themes required (i.e. interstate routes, traffic control signs) and even the geographic region being investigated (i.e. district area or county name).

Because of its open architecture, GeoMedia is easily customizable using industry standard development languages, such as Microsoft Visual Basic and Visual C++. Most of these development languages support "pen-centric" functionality, which means features that are specific to pen computers, such as sketching. The use of these "industry standard" development languages will allow tremendous flexibility in software development.

Although handwriting recognition can be an effective method for entering data, the use of graphic user interface design tools can speed up the input process. The following, while not an exhaustive list, is a discussion of some of these design elements that should be considered in the design of the forms for the field data collection software.

The tools mentioned above, used judiciously, can be utilized to develop very robust and comprehensive data collection forms and input screens. The design of the graphical user interface (GUI) will be a collaborative effort between the software development team and PennDOT staff. The forms will be used for data collection and maintenance, but will also be used as a data review tool. PennDOT personnel will be using the SIMOS in the field as a data query and review tool to verify information as it is observed in the field.

The GUI created for the GeoMedia field application will allow the user to view, geographically or visually, a record, which has a geographic positional value. This approach, which is recommended for the implementation of the SIMOS, will enable PennDOT staff to utilize database forms in conjunction with mapping information.

Data Verification and Management

In developing the data collection forms, the data entry interface could be designed or modeled after the existing paper forms, especially since seven of eleven districts currently use some sort of sign survey input form. This way the field personnel are familiar with what data needs to be collected or reported on. The only difference being that instead of entering the information on a paper form, the data is entered onto the computer screen. Additionally, new forms may be needed and can be designed accordingly.

The GIS map interface approach would allow review of the database using standard query tools. In addition, the user is able to select individual or groups of signs using graphical interface tools, such as a select tool. By using a select tool, the user could select a particular sign element or icon, which would cause a database form to come up on the screen. Within the form, information regarding the sign can be reviewed and, if necessary, added or modified.

As an example, the user selects a sign located on the base mapping by picking a select tool and clicking on a sign on the map. This causes a database form to come up on the screen, with the form being populated with information from the database record associated with the selected sign. After the information is reviewed or changed, the action of closing the database form saves the change to the database record, the form closes and control is returned to the map interface.

The mapping being used will be the PennDOT Road type files which rely on true geographic positional coordinate for the location of the signs. Use of a spatially correct mapping source, such as the Road files, allows management of the sign database to take place within the context of a geographic information system environment, as a separate data layer. The trend in the industry, and certainly within PennDOT, is towards using GIS as a spatial database manager. This would dictate that the Road files be used as the mapping source.

The development of a spatially correct map interface field collection system will allow PennDOT to make maximum use of the Road files. These files, which are fairly positionally accurate, represent a widely available mapping source, with the possible exception of detailed vector mapping such as project specific stereodigitized aerial mapping. The Road files represent a proper balance between content and accuracy. Using more detailed mapping may require mapping files that are rather large in size, while enhanced TIGER files may not produce base mapping files of sufficient accuracy.

Data Maintenance

While a significant portion of the data being verified and managed in the field will be processed throughout the rest of the SIMOS, it may be necessary to add new sign locations or sign panels to the SIMOS database in the field. This operation will be performed using many of the same GUI components as discussed in the previous section, however new sign assets will not be updated concurrently within the map display. This is due to the way that the signs are being located in the field using the segment-offset technique. Real time update of mapping typically requires that new coordinates be generated immediately when assets are added. Because segment-offset computations are performed within the existing PennDOT environment, this capability would not be duplicated in the field.

Instead, new signs and their related attribute information will be captured into a database table and flagged as new sign records. These records will be transferred into the office environment, and geo-processed in accordance with established procedures for computing the segment-offset values.

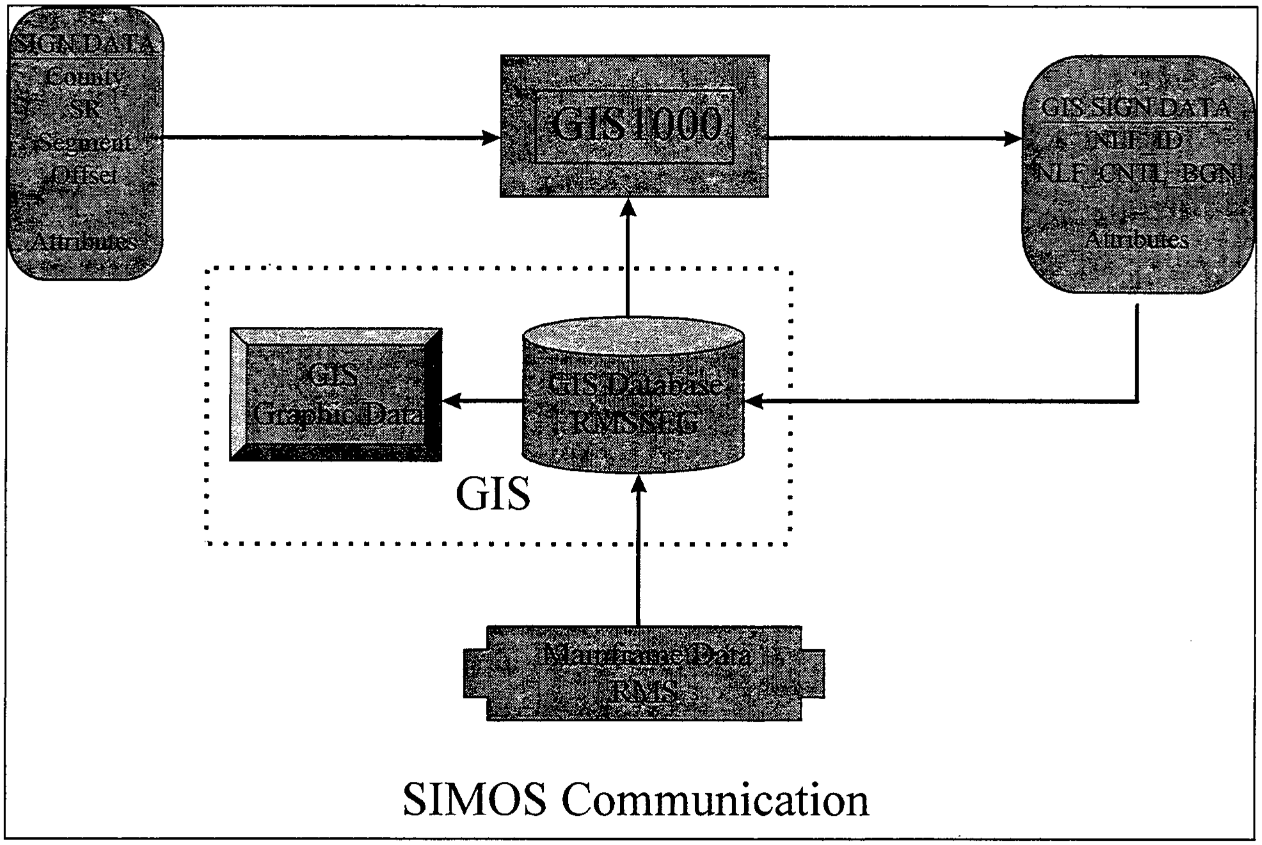
Data Transfer

For sign data collection in the field, as describe above, at a minimum, each sign in the database will contain data listing State Route (SR), Segment, Offset and attribute(s). The County, SR, Segment and Offset location data needs to be processed for use in PennDOT's GIS. This is due to the fact that the GIS does not use County, SR, Segment and Offsets *directly*. Rather, these location features are re-mapped to a GIS "Network Linear Feature" id (termed NLF-ID in PennDOT GIS parlance) and cumulative offset(s) (termed, NLF_CTRL_BGN, in GIS parlance). A PC-based Visual Basic application has been written to perform the re-mapping. This program, termed "GIS1000", creates a new database table which geo-codes sign locations based on the GIS NLF-ID and offset (NLF_CTRL_BGN). County, SR, and Segment cease to be used for location information and become GIS attributes of the roadway. GIS1000 uses a re-map table created from programs that currently reside on the mainframe. These programs utilize a GIS table, entitled, 'rmsseg'. Field-based location information (SR, Segment, and Offset) can be preserved in the new output table. See **Figure 8**.

GIS1000 currently requires user interaction to run (it uses a Graphical User Interface). The program would need to be modified slightly to run from the command line using command line arguments (i.e. automated with no user interaction).

Relying on the PC-based application will result in a delay in incorporating RMS changes. The GIS1000 application requires data that is refreshed every two weeks. This results in a maximum of a two week delay between the time RMS changes are made and when they are available to GIS users. Major changes to roadway alignments require updates to GIS graphic data. These updates occur on a more infrequent basis, approximately every two or three months.

Figure 8. SIMOS Communication.



Implementation

PennDOT staff should participate in several components of the initial implementation and pilot project:

- System and database designs;
- Field data unit criteria development and selection;
- Collection form development;
- Field data collection activities; and
- Field data management activities.

It has been our experience that the integration of technology into the daily workflow of the staff of any enterprise is often met with some trepidation, since this type of technology directly impacts their lives and careers. Bringing people in on the ground floor tends to create "champions" of the technology, which can be a great asset in a system-wide integration effort.

The field GeoMedia application, including the database design and data collection form development, will be developed and tested over the course of a six month period. This six month period will be the same period of time that office applications are being developed, as well as data transfer mechanisms.

During this six month period of time, evaluations will be made as to the final field hardware configurations. This can only be done when substantial software development has been accomplished, since software functionality often dictates hardware requirements.

The field application and transfer modules should be tested throughout all levels of its implementation to "weed out" any difficulties in its use on a Department-wide basis. This is best done through the undertaking of the pilot project, where a full depth system, including workflow processes and software, is implemented over a smaller geographic area, such as a single county office. Field activities, work processes, software testing, database development and other project components can be effectively tested in-depth over a geographic area of this size. Issues raised and resolved in the pilot project will eliminate any re-engineering of the system when implemented Department-wide. It is assumed that this testing will take place over a three week period, using the complete datasets for the county.

Upon successful completion of the Single District Pilot Project, it will be necessary to undertake training of PennDOT staff in field operations and office procedures for data transfer. This will be accomplished with in-depth hands on training, using project specific training guides. Consistency in training between field and office software will increase training effectiveness. It is anticipated that the training for County/District field personnel will take place over the course of a week, with follow up support as necessary. This will be in addition to the training for any office systems.

APPLICATION DEVELOPMENT

Oracle's open architecture and client/server structure offer great flexibility for application development. Applications can be developed using popular Windows Development Languages such as Visual Basic and PowerBuilder for data entry, data conversion, data update and report generation, and at the same time maintain data integrity on the server. We anticipate using Visual Basic for all application development. Most SIMOS applications will be integrated into Intergraph's new GIS query/viewing package, GeoMedia for database query and graphic representation.

Database Updating Application Development

Oracle Server delivers comprehensive synchronous and asynchronous replication capabilities. The SIMOS will take full advantages of Oracle's replication capabilities to automatically update sign inventory databases. The key issue in database updating is the data integrity and data security. Counties will have the privilege to update and maintain all information on the database at their own county including updates of location information. The following procedures will be taken to achieve the maximum level of automation of updating and to protect data integrity. The GIS unit in the Planning and Research Department will be responsible for maintaining and updating the roadway graphics files used for locating signs in the GIS. They will also be responsible for maintaining the latest recalibrated sign location data.

General Approach

Database updates will be implemented at four different levels: the Field Data Unit, the county office, the district office, and Central Office based on privilege level definitions.

- **Field Data Unit to County/District** updating occurs when the field data unit (FDU) uploads data collected and/or edited in the field to the district server to update the County/District's Oracle database. The application programs can be developed in two ways, whichever is available:

  Approach 1: Client/Server Application Development
  This development assumes that FDU uses a Laptop connecting to the County/District network to update the Oracle database. The program will be developed as client application and database tables will be automatically updated on the server. The advantage of a client/server application is the resource sharing and data sharing; that means multiple clients can share the same resource (Oracle) and the same database.

  Approach 2: SIMOS Workstation Application Development
  This development assumes that FDU uses Laplink to upload field data to the server and the server launches applications to update the Oracle database.

This development simplifies programming efforts by discarding client/server requirements, but limiting the updating process only on the server (i.e., FDU cannot use Laptop to update the Oracle database).

- **District to Central Office** updating will be the responsibility of the District Office EDP Coordinator. Application programs will focus on data validating, data integrity checks and data maintenance (e.g., historical database updates, new sign record generation and location table updates). The programs will handle two-way data updates: attribute data updates for the Central Office; and location table updates for the district office database. Updating of the Central Office database with district office information can be scheduled to occur in off-peak hours.

- **County to District Office** updating will be accomplished via a modem connection until a WAN is in place. The programs will handle two-way data updates.

- **Central Database** updating will be performed by the Central Office Database Administrator (DBA). This will include primarily the updating of sign location information which are calibrated to changes in RMS.

Development Procedures

The following items are the detailed development procedures for database updating. Although application programs for Counties/Districts and Central Office will be slightly different, developments will follow the same procedures.

- Component Design: to determine what functions will be included in the programs;
- GUI Design: to determine GUI layout and menu system;
- Pilot Development: to develop prototype programs based on initial design;
- Pilot Testing: to test programs using pilot datasets;
- System Development: revise and calibrate the programs based on pilot; testing results to develop complete application programs;
- User Testing: test application programs using selected test sites;
- System Completion: finalize application programs based on feedback from testing sites; and
- System Implementation: install and implement application programs at all Counties/Districts.

Estimated Man Hours for Application Development Procedures

Database Update:	
Component Design/GUI Design:	*160 mh*
Pilot Development:	*480 mh*
Pilot Testing	*80 mh*
Program Development	*360 mh*
User Testing	*160 mh*
Program Completion	*280 mh*
Sub-Total Cost	*1520 mh*

Work Order Generation

Currently, work orders are generated at each district, by various methods, most of which are manual. This task will now take place at the county offices. The application program will automate a work order generation and facilitate work order tracking. The work order generation program will be operated on the SIMOS workstation. The application program will provide the following capabilities:

1. Automatic loading of work order template;
2. Allow database query to get required information;
3. Allow manual editing of order information; and
4. User-friendly GUI design and easy operation.

In order to run the application program, the following information should be available in the database:

1. Work order information (e.g., condition code, action code, work order number, etc.);
2. Look up tables for the codes and detailed actions; and
3. Work order template.

The application development procedures include:

1. Work order template design will consider existing work order format and develop an electronic work order template;
2. GUI design will work with districts to determine GUI components and layouts;
3. Program development using Visual Basic; and
4. User testing and program completion. The program will be tested at the counties, and feedback will be collected to finalize the program.

The estimated development cost for work order generation program is 560 man hours.

Sign Order Generation

Sign orders will be generated from work orders when there is a need for sign replacement or new signs. The sign order generation program can be developed as a sub-program within the work order generation program. The sign order generation program will have its own GUI design and include a graphic presentation of sign imagery. The sign order generation program requires sign attribute information available in Oracle database and a link to specific sign image so that when clicking a sign image, attributes about this sign (e.g., size, sheeting type, sign message, etc.) will automatically be retrieved. A sub-program for special sign order generation will also be included in sign order application program. The program development will involve the same procedures in work order generation application development.

The estimated development cost for sign order generation program is 420 man hours.

Recalibrate Sign Location

Location recalibration updates Route's Segments and Offsets with changes that have occurred within RMS. ARS also has a recalibration program that will be reviewed to determine:

a. If the program's output can be used to update SIMOS sign locations?

b. If the program can be modified to update SIMOS sign locations or produce a transaction file to drive a SIMOS update program?

c. If the program should be copied and modified to meet only SIMOS' requirements?

The recalibration results will update the sign location DB2 Table, and will be downloaded to update the statewide Oracle database with the new location information (which will then be distributed out to each district office). This process will be run periodically during off-peak hours (bi-weekly or weekly would probably be sufficient).

Estimated Time for Recalibration Program Development Procedures

Review ARS' Recalibration process	*2 weeks*
Program & Test required programs	*4 weeks*
Program & Test Data download routines	*2 weeks*

DATA MAINTENANCE

Sign Attributes

The counties will be responsible for all sign attribute data. The Oracle database will be managed using user-friendly forms which will be developed for data entry/updating. Sign attribute data will periodically be uploaded to the district database and then to the Central Office Oracle database for use by the TEOD. If the WAN is in place, data transfer can occur through automated Oracle procedures with minimal human intervention. If the network is not in place, data can be transferred using automated Oracle data exports with manual transfers via modem or 8mm tape. It is assumed that District Office EDP Coordinator and CADD support will maintain Oracle table space.

Sign Location Data

For the following reasons, sign location data must be managed at Central Office:

- GIS does not use RMS referencing information *directly* for locating features. GIS assigns a unique ID to State Routes (the "nlf_id"). Roadway segments are treated as an attribute of a route. Efficient programs which run on the mainframe are used to correlate/calibrate RMS route designations with GIS route designations. The GIS route designations are also written to the GIS graphics files.
- RMS is frequently updated with changes in segments and alignments. While RMS is committed to less frequently updating linear referencing information, these updates can result in incorrectly placed features. Currently, each 'customer' of RMS referenced data (e.g., Safety), has their own methods for ensuring that roadway features are correctly calibrated to changes in RMS. For example, in ARS, accidents are recalibrated using a sophisticated program which adjusts accident location information to accommodate RMS changes. Sign data would require similar recalibration. Three options exist for recalibration of sign data. The first would be to modify the program used for accident data to accommodate sign data. The second option would be to write a new mainframe application to perform this task. The third option would be to use the GIS to calculate the new segments and offsets.

  The third option involves using the GIS to calculate an XY location for each sign. With the sign locations fixed in space, the adjusted roadway network is overlaid. The GIS can then calculate the new segments and offsets from the overlaid network.

  The first two options have the advantage of ensuring sign location data is completely calibrated to RMS and would allow this information to be easily accessed by other, non-SIMOS mainframe programs. In addition, the first option has the potential advantage of being a very low cost solution. The third option, using the GIS, has the advantage of being simple to implement. However, it may result in minor shifts from

RMS due, in part, to imperfections in the GIS graphics. The efficacy of each of these options will be explored more fully in the SIMOS pilot project.

GIS Roadway Graphics

MGE MicroStation graphics, which depict the roadway, are currently managed by the GIS group in Planning and Research. They have efficient procedures in place to ensure that the graphics are adjusted to accommodate modifications made to RMS. The optimal graphics file update schedule will be determined in consultation with district SIMOS personnel. We anticipate that a monthly update schedule would be adequate.

The Central Office updating of sign attribute data from the district offices should occur at regular intervals, for example, every two weeks (this is the current schedule used by Central Office to update its database with RMS changes and to update district GIS databases). Since the TEOD will not be modifying attribute data, it is not critical to synchronize attribute updates with TEOD activities. However, it is critical to synchronize district office activities with sign location updating with data from Central Office. This is due to the probability that district personnel will desire to update sign location information or place new signs while the location information is being updated at Central Office. If this occurs, interim sign edits may be lost when the district receives the update from Central Office. To accommodate this, all *new* signs and all sign location edits will be temporarily stored in a separate table. Only after a district receives an update from Central Office will the separate add/edit table be loaded to the main sign location table used by the GIS. An added advantage of this workflow is that new adds/edits will able to be reviewed prior to being loaded to the main database table.

As mentioned above, GIS does not *directly* use RMS Route and Segment information to map features. GIS uses its own route identifier (the "nlf_id"). A program exists which converts the RMS location information for use in the GIS. The mainframe program has been converted to Visual Basic on Windows NT. This program, referred to as "GIS1000", could be used to spatially locate new signs during the sign location updating period.

Historical Data

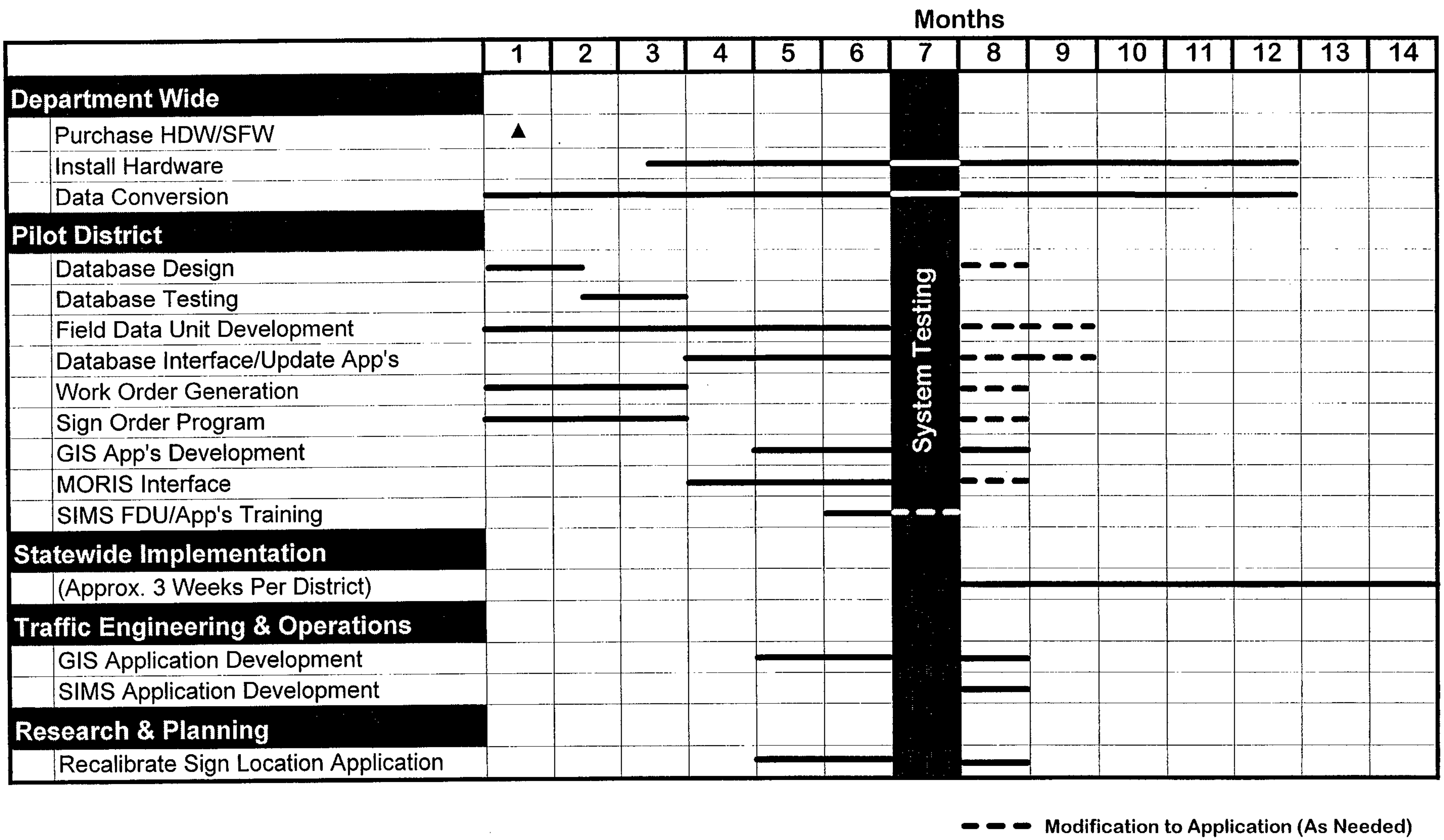
An issue that needs to be addressed regarding historical data concerns signs which are no longer in use and whose data is required for legal purposes. An example of this is a route replacement. In this case the old graphics would be archived in a separate graphics file with a unique route designation identifier assigned to the old route graphics (e.g., "Route 22" can be assigned "Route 22**H**"). The unique identifier for the posts and/or signs will also be changed in each of the attribute tables. All attribute data will be stored in separate "historical" tables. (Refer to **Figure 5**). This data must be kept separate since RMS may no longer maintain information for these routes and they may create inefficiencies for the location updating process.

These historical tables would reside in the SIMOS Oracle database at the district office. If desired, they can easily be loaded to the Central Office database. These tables should be small in size and since they are separate tables, they will not impact SIMOS performance.

Maintenance History Data

All sign maintenance information will be stored in a relational database table which includes fields for action taken and date of action. These data can be archived at regular intervals (e.g., every 5 years).

Sign Inventory Management and Ordering System
Project Schedule



SIGN INFORMATION MANAGEMENT AND ORDERING SYSTEM
COST ESTIMATE

County Offices	Quantity	Estimated Unit Cost	Estimated Statewide Cost
Hardware			
SIMOS Field Unit (Pen-based) (Laptop Computer) **	67	$6,000	$402,000
Software			
Personal Oracle Lite for FDU w/ Support	67	175	11,700
Personal Oracle Lite for County Office PC	67	175	11,700
GeoMedia GIS Software (FDU)	67	1,200*	80,400
GeoMedia County Office PC	67	1,200*	80,400
Application Development			
Database Interface/Update			94,000
Work Order Generation			34,400
Sign Order Generation			25,800
Database Editing, Queuing, Reports			22,000
MORIS Interface			21,000
Database Design			34,400
FDU GeoMedia Development			130,000
Training and Installation	67	1,400	93,800
Engineering District Offices			
Hardware			
SIMOS Field Unit (Pen-based)	11	6,000	66,000
Software			
Personal Oracle Lite for FDU	11	175	1,900
GeoMedia for FDU	11	1,200*	13,200
GeoMedia for Workstation	11	1,200*	13,200
Training and Installation (3 days)	11	4,000	44,000
Traffic Engineering and Operations			
Application Development			7,000
Bureau of Planning and Research			
Recalibrate Sign Location Application			12,000
Project Management, Project Coordination, QA/QC			100,000
SUBTOTAL			$1,298,900
Data Conversion (Building Inventory)			475,000
TOTAL			$1,773,900

Note: Possible purchase of additional SIMOS workstations for County Offices $249,000

*PennDOT is negotiating with Intergraph Corporation for a $300 cost per seat for GeoMedia.

** Laptop Computers may be suitable substitutes for pen-based systems.

COST BENEFIT ANALYSIS

The Sign Information Management and Ordering System (SIMOS) proposed to the Department meets all of the objectives established for this project and achieves the concepts and goals established in moving PennDOT forward. SIMOS is an effective solution that will provide PennDOT with the tools to improve its service to the general public. The general public will benefit greatly from safer roads through better signage, and more effective use of tax dollars. The direct benefits realized by PennDOT will include:

- Effective statewide sign management system for better decision making and maximizing effectiveness of available funding;
- Increased operational efficiency by reducing manhours required for sign management;
- Lower operation costs by eliminating duplication of work efforts;
- Improved quality by eliminating existing error-prone operations;
- Reduced tort liability for sign-related lawsuits.
- Reduce current sign review cycle from seven years to two years. SIMOS is an effective tool to facilitate this initiative.

It is difficult to assign cost savings to many of the benefits of SIMOS; for example, the cost savings due to safer roads, improved roadway information, safer methods for inventory/inspection, or happier motorists. We have conservatively estimated the cost savings to several of the key benefits of the proposed SIMOS solution. The discussion on cost savings and benefits follows.

1. Field Inventory/Inspection Preparation

Existing

- Significant effort is expended collecting and organizing information prior to going out in the field. The necessary information includes mapping, computer printouts, and paper files. Currently, this work is being done by the districts. The counties will assume this responsibility and the existing preparation time without SIMOS.

SIMOS

- All information required for inventory/inspection will be maintained on the field data units and SIMOS workstation. This will eliminate most of the preparation time required to assemble information.

***Benefit**: It is estimated that using the winter and early spring, the county will spend* *approximately ¼ of its time involved in inventory inspection activities. This translates to 65 days. At an estimated savings of ¾ manhour per day for each of 67 counties, 3,266 manhours per year should be saved on a statewide basis for this activity. Using an effective salary of $31.00 per hour (including payroll additives), this translates into a savings of $101,246 per year.*

2. Field Inventory/Inspection Collection

Existing

- Field information is collected by writing information onto paper maps and reports.

SIMOS

- Field data unit provides easy-to-use graphic interface for providing and collecting information. Standardized pick lists will allow the operator to identify maintenance activities (action items) at the click of a mouse button. Manual input into the computer will be minimal.

Benefit: *It is estimated that SIMOS will improve the efficiency of data collection by 20 percent. Using 65 days (established above) for 67 counties, this translates to 6,968 manhours savings per year. At a $31.00 salary rate, this will result in a savings of $216,008 per year.*

3. Work Order and Sign Order Generation

Existing

- Information collected in the field is manually summarized on paper and then manually duplicated on a work order form. A sign order form is then filled out manually from information on the work order. This process involves the same information to be manually entered three times. The sign order is then manually entered through a mainframe terminal connection to MORIS. This process involves keying in 40 digit codes for signs and is prone to errors. This process typically involves at least two people.

SIMOS

- Under the SIMOS solution, all action items identified in the field are stored in a queue on the SIMOS workstation in the county office. Work orders will automatically be generated by selection and processing items in the queue. The action items, for a work order, can be selected by a variety of options, such as geographic location, date, type of sign, etc. The work orders are then processed to automatically produce a sign order. The sign order will automatically be electronically transferred to MORIS by the operator clicking on the "send sign order" button on the SIMOS interface screen. The complete process for work orders and sign orders is performed in an automated fashion on the SIMOS workstation. The entire operation will be performed by one operator.

***Benefit**: It is estimated that three to four work orders will be processed per week in each county. Because of the large reduction of manual effort and paperwork, approximately one hour will be saved on the average for each work order/sign order. A savings of one hour per work order with 3 ½ work orders per week per county translates to 12,200 manhours per year. At a salary rate of $31.00, this will result in a savings of $378,000 per year.*

4. Reduce Sign Order Errors

Existing

- Current manual methods in work order creation and ordering signs frequently result in the manufacturing and delivery of incorrect signs.

SIMOS

- Because SIMOS automates the process from work order generation through the ordering of signs, errors that occur through the manual process of summarizing and entering data for work orders and sign orders will be greatly reduced. It is estimated that SIMOS would reduce the sign order errors by a minimum of 1 percent.

***Benefit**: Approximately 100,500 signs are ordered annually at an estimated cost of $45.00 per sign. At a one percent reduction in errors, this translates to a savings of $28,500 per year.*

5. Tort Liability

Existing

- There is a lack of an effective tool for managing and tracking maintenance activities for signing on a statewide basis. This makes it difficult to defend against lawsuits resulting from alleged signing deficiencies on Pennsylvania roads.

SIMOS

- PennDOT will be able to demonstrate that it has put in place a state-of-the-art Sign Inventory Management and Ordering System to better serve the Commonwealth. This system will be effective in reducing signing-related accidents, minimize tort liability, and provide a solid defense against future lawsuits. Through SIMOS PennDOT will be able to:
  - Demonstrate a reasonable/defendable sign maintenance system and procedures.
  - Maintain a historical record of all signing activities.

- Proactively address signing deficiencies. SIMOS will integrate a wide variety of data such as maintenance and accident data. This will provide PennDOT with the tools for analysis of data not possible with existing systems.
- Respond more quickly to signing problems as a result of instant access to information.

***Benefit**: PennDOT currently pays out $17 million in lawsuits on an annual basis. It is estimated that 10.3 percent of these are allegedly due to deficient signing. Traffic signs account for the highest percentage of these pay outs. This translates into $1,751,000 annually. The benefit of SIMOS to defend against litigation will increase over time as the historical signing information is being collected and maintained. The third year after implementation, it is estimated that the tort liability could be reduced by 20 percent or $350,200. By the end of the fourth year after implementation it is anticipated that tort liability could be reduced by 30 percent. (At the end of the fourth year following implementation, all signs will have been reviewed. Actual savings in tort liability should actually be significantly more.) At a 30 percent reduction, the savings will be approximately $525,300 per year.*

6. Inventory Reduction

Existing

- Signs sit in inventory at county shop approximately 3 months before installation.

SIMOS

- County crews automatically order signs for just in time delivery.

Benefit: *-100,500 signs are ordered annually.*
-25 percent are in inventory at any one time.
-Cost of Sign $45.00.
-Interest rate 6 percent.

SIMOS will reduce inventory from 3 months to 1 month. This will result in $45,500 of annual savings.

7. Traffic Engineering and Operations

It is difficult to assign costs to one of the major benefits SIMOS will provide. SIMOS is an information management system that will assist the Traffic and Engineering and Operations Division in making more informed and effective decisions. This will result in better use of available funding and overall improvement to signage statewide.

Benefit: *- Better signage for general public.*
- Better use of tax dollars.

Summary

The proposed SIMOS is a sustainable information system that will provide great benefits to PennDOT and the general public. SIMOS will provide a method for improved and effective sign management and better overall signage statewide. It is difficult to determine costs for many of the benefits that will be realized by implementing the proposed SIMOS. However, it is reasonable to assume a minimum savings of $700,000 the first two years following implementation with savings in excess of $1 million for subsequent years.

	Benefits				
(Years Following Notice-to-Proceed)	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**
1. Field Inventory/ Inspection Preparation	$101,246	$104,283	$ 107,411	$ 110,634	$ 113,953
2. Field Inventory/ Inspection Collection	216,008	222,488	229,163	236,038	243,119
3. Work Order and Sign Order Generation	378,000	389,340	401,020	413,051	425,442
4. Reduce Sign Order Errors	28,500	29,355	30,236	31,143	32,077
5. Tort Liability	-	-	350,200	525,300	541,059
6. Inventory Reduction	-	45,500	46,865	48,271	49,719
	$723,754	$790,966	$1,164,895	$1,364,437	$1,405,369

SIMOS will break even two years after implementation. Implementing SIMOS on a statewide basis will save PennDOT and the taxpayers significant money during future years. The savings are depicted by the difference between the two lines in **Figure 9**.

Figure 9. Cost Benefit