Transportation Facilities Information System for Pavement Management

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ABSTRACT

Many transportation agencies are moving toward the implementation of pavement management systems (PMSs). Such systems are often computerized and employ algorithms to determine various pavement management strategies for consideration by the agency's engineers and management. Unfortunately, data required as input to such algorithms often come from a variety of sources developed over time, which makes the data difficult to integrate. In addition, awkward data maintenance practices often frustrate attempts to "clean up" the data required by the PMS algorithms. The accuracy of these input data obviously affects the usefulness of the strategies recommended by the PMS. The work reported in this paper represents the initial phase of an ongoing research project. The objective of this phase is to build the foundation for a transportation facilities information system (TFIS) that will address the issue of collecting and maintaining the data on the agency's highway and bridge network by customizing an available software package. Such research is important because it represents a fresh way of looking at issues that have been elusive for researchers and practitioners alike. The need for managing the highway network is well known, but the network has been difficult to define in such a manner that data collected throughout the agency are integrated and support both analytical and graphic applications. The approach used in this research project is to consider highways and bridges as assets that have the geographic properties of location and connectivity in addition to their descriptive data. These data are entered, updated, and retrieved through either a graphics workstation or an interface with external applications. The data base provides an integrated source of input data for the PMS and other applications.

There has been a great deal of work in recent years on pavement management systems (PMSs) for use by transportation agencies. Significant advances have been made in the development and implementation of analytical tools (software) used for the examination and evaluation of pavement strategies. One component of the PMS that has been elusive for researchers and practitioners alike is a system that defines the network in such a manner that data collected throughout the agency are integrated and support both analytical and graphic applications. This information includes not only the descriptive data (such as structural properties and maintenance history), but also the location and connectivity (logical relationship of one location to another) of the various facilities that make up the highway and bridge network.

Because these data represent the input to the algorithms of the PMS, any inaccuracies introduced by input data that are either invalid or out of date will bias the decision strategies recommended by the PMS. There is a need to provide a reliable method of capturing and maintaining this type of data. The data must continue to be presented to existing algorithms in the current format. It is possible to accomplish this while concurrently providing a number of additional capabilities.

The research project documented in this paper is building the foundation for a transportation facilities information system (TFIS). The TFIS addresses the problem of collecting and maintaining data on an agency's highway and bridge network in such a manner that they will support PMS and a number of other applications, both graphic and nongraphic. The project uses the Graphics Program Generator (1), a commercially available, table-driven software package developed during the past 12 years to help public utility companies manage their networks of pipelines and power distribution lines (2). Capturing, maintaining, and reporting data associated with a network of highways and bridges are conceptually similar to these processes for a utility company's network of pipelines. The data base support is provided by another commercially available package, Geo-Facilities Data Base Support (3).

This type of approach is important because it represents a fresh way of looking at a solution to the problems of managing the data that are the input to a PMS. This approach considers highways and bridges as assets that have the geographic properties of location and connectivity in addition to their descriptive data. These data are entered, updated, and retrieved either through a graphics workstation or through an interface with external applications. The location and connectivity data, placed in a specified data base structure, enable the TFIS to build a model of the actual highway and bridge network in the computer's memory. This approach, therefore, not only makes an agency's highway and bridge data available through a common data base, but it also permits the agency to "walk" a particular route or network with an application program and to process the descriptive data along the way.

At the writing of this paper, the project is just being initiated. This paper provides a historical perspective of the work already done in this area and highlights the specific objectives of this research. The data management and graphics concepts associated with the dispersed assets that are characteristic of a highway and bridge network will be presented. Considerations associated with applying this type of system to transportation are discussed.

PROJECT BACKGROUND

Historical Perspectives

The software packages that form the basis for this study, the Graphics Program Generator (GPG) and Geo-Facilities Data Base Support (GDBS), are the output of a joint effort by the system developer and a number of its public utilities customers (1,3). These packages were the result of continuing efforts to examine customer requirements and to evaluate them in light of available technology.

In the early 1970s one of these reviews pointed to the data problems that utility companies experience when they try to keep their asset data on manually maintained maps. Timeliness, accuracy, and "which map set is the current set?" considerations made the reliability of the maps questionable. Consequently, a study was undertaken to determine the feasibility of building data base systems for such distribution facilities as pipelines, electric lines, and highways.

Two software packages were developed to meet the joint requirements of providing rapid interactive response to system users and, simultaneously, of maintaining a massive data base. Because most users of a geographic information system work with only a small geographic area at any one time, the system architecture was developed to provide extract files (subsets of the overall facilities data base, called workspaces) to individual users. GPG is the software package used to support the interactive sessions in which users add, modify, or delete data within the workspace. When the data modifications are complete, the workspace is sent back to the GDBS package, using a predefined interface format to exchange the data. By using the power of the data base manager, GDBS actually posts the changes to the data base. The existence of two packages, although of interest from the system architecture standpoint, is invisible to the user.

The concepts and experience gained through the development of this system, referred to as the Distribution Facilities Information System, have been reported in a series of design guides (4-7). Because space limitations permit dealing with this topic only at an overview level, the reader is referred to these design guides for detailed information on the concepts discussed here. The experiences of a utility company in implementing this type of system have also been documented (2). The application brief also contains photographs of workstations and sample menus used to control system operation. Sample map documents are included to illustrate the utility company's process of updating its facilities data base. Additional work in this area is the Regional Mapping and Land Records (RMLR) project, a public-private consortium (centered in Philadelphia, Pennsylvania) whose members share data and resources to develop a geobased information system (8).

Study Objectives

This study involves customizing the GPG software package. The customization is being accomplished by developing the tables needed to cause the product to collect and maintain data associated with highway and bridge networks. This study will not produce a "turnkey" system because each transportation agency has its own operating policies. However, with the input from interviews conducted with transportation officials, an application that addresses the global requirements for a transportation facilities information system (TFIS) is being developed. Such an application will create fundamental capabilities and will develop a base of experience in the TFIS area, while still permitting any agency the flexibility of tailoring the system to its own unique requirements.

Specific objectives of this study are to

1. Review available literature and interview transportation officials to determine the requirements for modeling a transportation network using the concepts employed by the GPG software product;
2. Determine the types of facilities that should be included in the network;
3. Develop the menus and other features (rules) needed to implement the model, with emphasis on creating the appropriate connectivity in the data base to support anticipated transportation agency applications (such as the applications contained within a PMS); and
4. Demonstrate a selected number of sample applications.

GEOGRAPHIC INFORMATION SYSTEM OVERVIEW

User's Viewpoint

Before discussion of the components of the TFIS and their interaction, the system's appearance to the user will be briefly outlined. The most obvious part of the system to the user is the workstation. Typically, a workstation is composed of a terminal and a keyboard. The terminal is capable of displaying alphanumeric characters and, in some cases, business graphics. In contrast, the TFIS uses a multicomponent workstation that greatly increases the functions made available to the user, as shown in Figure 1. The interactive graphics workstation uses the dual display concept, so that the user has a terminal for alphanumeric functions, such as entering commands or displaying descriptive data, and an independent graphics display tube. The graphics display tube has its own attached hardcopy device for making rapid copies of the displayed image. The cursor control is a joystick used for positioning the crosshair cursor displayed on the graphics display tube. The workstation also contains the tablet used for digitizing information destined for the facilities data base and for making menu selections.

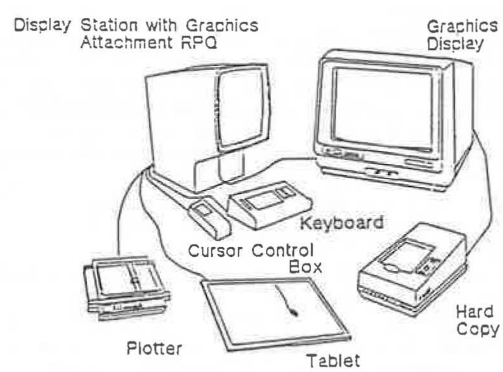

FIGURE 1 Transportation facilities information system workstation.

Plotters to produce hardcopy graphics output can also be attached to the workstation.

Use of the TFIS involves combinations of "pointings" to map documents or to selection menus, which are either taped to the digitizing tablet or displayed on the graphics storage tube, along with an occasional keyboard entry. The meaning, number, and sequence of these pointings is entirely controlled by the agency implementing the software packages.

The ability to simply point to items and cause data to be entered or computation processes to be invoked, or both, provides a new way of interacting with a computerized system. A key on the keyboard usually transmits a single character to the computer. But a key on one of the selection menus (taped to the digitizing tablet or displayed on the storage tube) can invoke any number of commands, displays, and computations. A single pointing to the menu can perform as much or as little work as the transportation agency desires. When editing data for a specific facility, the typical approach is to enter the identifier for the facility through the keyboard. With TFIS, a user can display a series of highway sections (such as a map of an area) and simply point to the highway section desired. The system will "correlate" on that facility, determine the identity of the highway section, and then display data on that section for editing.

A powerful concept of TFIS is that of "visibility." One common property of map documents is that they can easily become cluttered as more types of data are recorded. Typically, a single user is concerned with only a few types of data at any one time. By controlling the display visibility (by a variety of techniques), users can make all the facilities or labels invisible except those in which they are interested. This action dynamically creates an "exception map" tailored to the individual user's needs. A related technique is to vary the picture of a facility on the basis of user-specified criteria. For example, the user may decide to display overpasses with less than 14 ft of clearance with a different symbol. The actual value of the clearance is one of the data items stored in the data base, so the user could change the picture by simply updating the "clearance" data item.

Processes such as those just described solve a basic problem encountered in most cases in which a paper document is used as a central source of information. In addition to containing many types of information, often to the point of being confusing, paper documents cause readers to "wade" through all the data to find needed information. The goal should be to separate the record of the data from the report of that data. The introduction of the punched card in the 1880s accomplished this task for information processing in general. Controlling visibility of the various facilities (by varying such items as scale, pictures, line types, annotations, and displayed data) meets this requirement for the TFIS.

Another capability, which has great significance in the highway area, is that of centerline expansion. The user need only digitize the centerline of a highway. Then, by simply pointing to one of the keys on a menu, the software will read the highway's width from the descriptive data stored with the highway segment and draw the highway edges parallel to the centerline and offset by half the width on either side.

A discussion of the system architecture will follow this brief overview of the way the system will appear to the user. Although the architecture contains three major components, it appears as a single system to the user. That the various selections made on the menus accomplish processing tasks using different system components is invisible to the user.

System Architecture

There are three major components of the TFIS: (a) interactive graphics workstation, (b) GPG software package, and (c) GDBS software package. The relationship of these components is shown in Figure 2.

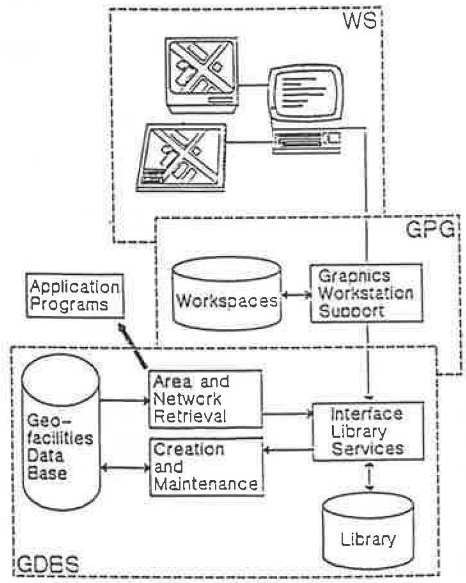

FIGURE 2 Transportation facilities information system architecture.

The interactive graphics workstation has been discussed and is shown in Figure 1. The primary means of using the TFIS is through a series of pointings to either the digitizing tablet or the graphics display tube. Control of the operation is provided by the functions coded into the keys on option menus. These option menus are either taped to the tablet or displayed on the storage tube. The processes invoked by these pointings result in commands being given to GPG or GDBS to perform required tasks. Figure 3 shows a sample menu and a map document taped to the digitizing tablet. It also shows the data base version of the map displayed on the graphics storage tube.

GPG provides the direct support for the interactive user sessions. It is a set of programs designed to create, maintain, and display information about facilities (e.g., highway sections and bridges), their locations, and their relationships to one another (connectivity) (1). It presents the graphics and interprets the pointings made by the user. As the workspace manager, it performs the tasks of model building and maintenance, workspace storage and retrieval, and tracking of the changes made in the workspace. (A workspace is a subset of the facilities data base and is discussed in the section on interactive users.) GPG also includes utility programs for defining the data items to be stored with each facility and the picture or pictures to be displayed for the facility. Other utilities are used to build the menus and to specify the graphics or mathematical processes to be invoked when the user points to the various menu keys and to create special symbols for use when displaying or plotting maps or other graphic reports.

GDBS provides support for the massive volume of data that represent the facilities data base, a model of the highways, bridges, and related facilities of interest to a transportation agency. (The

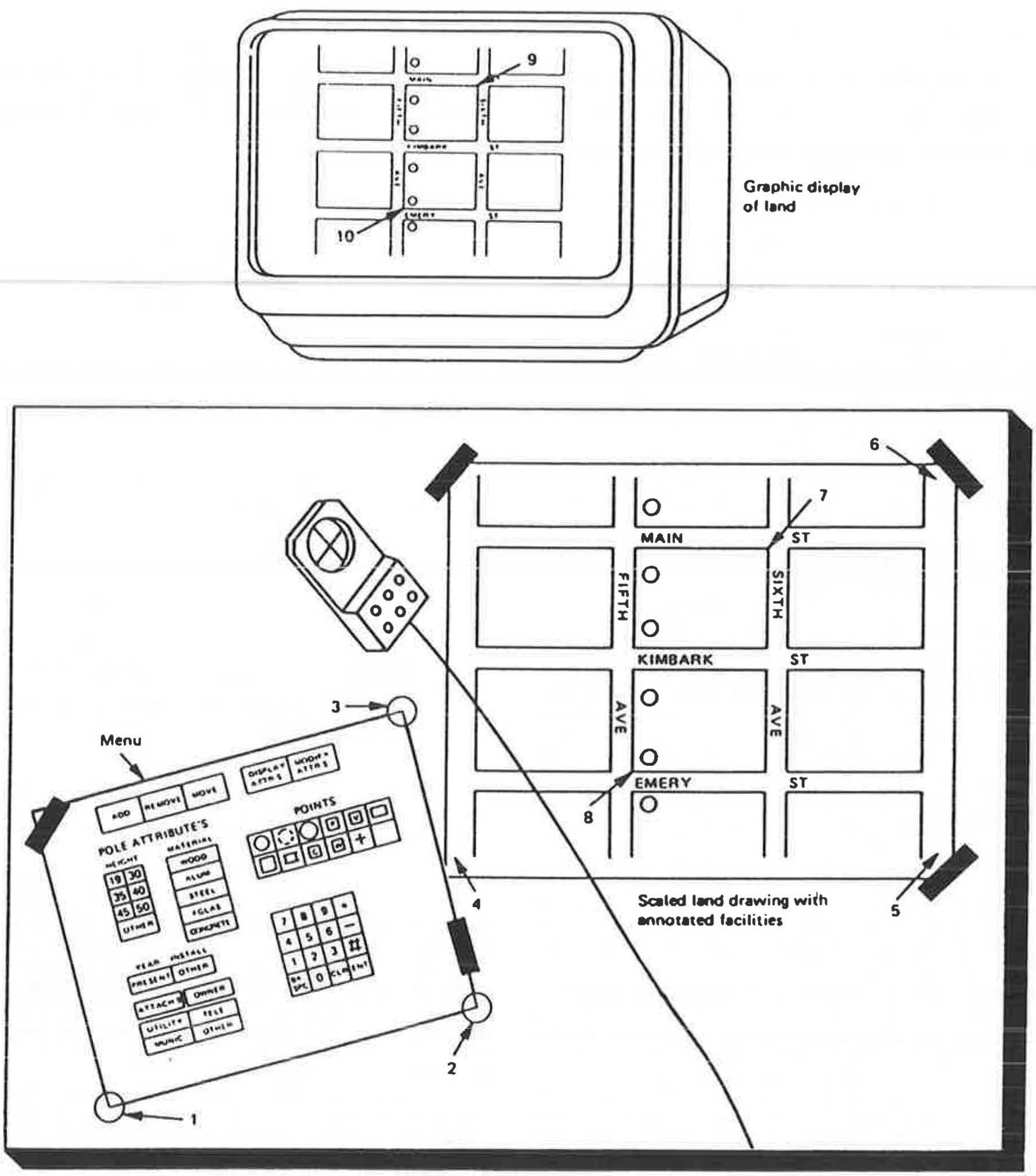

FIGURE 3 Sample menu, map document, and display.

facilities data base is actually a collection of separate physical data bases.) It provides two major types of support: interface library support and data base support. The interface library is itself a data base that serves as a staging area for exchange of information among the workspaces (interactive users), the data base, and external systems.

The data base support consists of the processes required to create and maintain the facilities data base, as well as to perform retrievals from the data base for specified areas or networks. The data base represents a model of the highway and bridge network, including the location of and connectivity among all facilities. Preserving these relationships and maintaining the integrity of the facilities data base are complex tasks.

It is the data base support's ability to do these tasks that makes the TFIS a powerful tool in support of a PMS. As shown in Figure 2, application programs can make direct use of the data retrieved from the data base. Many of these applications are the analysis programs (algorithms) contained in a PMS.

The TFIS architecture, therefore, employs software packages to build and maintain a model of the assets for which a transportation agency is responsible. The model actually represents the facilities as they appear in the field, because it includes location and connectivity data as well as descriptive data on all assets that compose the network of highways and bridges. An agency can employ the TFIS to consolidate its variety of data sources into an integrated facilities data base. This process provides a single central source of information for all users in the agency. In addition, procedures, schedules, and data verification requirements for updating the data base can be clearly defined and controlled to minimize problems with untimely and inaccurate data. The TFIS also serves as a source of input for applications such as a PMS. The format of the data extracted from the facilities data base is controlled by the user agency. This permits the TFIS to provide data in already specified formats to existing PMS algorithms and, as new algorithms or systems are developed, to meet their input data format needs. In addition to the PMS-type applications, the TFIS provides significant capabilities for creating graphic reports, such as maps, tailored to the user's needs.

Additional information on major aspects of the system will be provided in the following subsections. Detailed discussions of these topics are available elsewhere (4,5,9-11).

Interactive Users

The most visible part of the TFIS is the interactive dialogue employed by the user at the graphics workstation. This dialogue is supported by the GPG software product. In a general sense, it performs the task of a geographic editing subsystem (GES) that provides support for geographic data manipulation (9,p.456). The GES accepts input from user pointings to keys on menus or pictures on map documents. The menus and pictures may be either taped to the digitizing tablet or displayed on the graphics display tube. In addition, input may be entered through the data entry keyboard on the alphanumeric terminal. The GES uses workspaces that consist of data from a number of physical data bases (e.g., land data base, accident data base, road sign data base). It also maintains detailed attribute data on all facilities in the workspace.

Because the GES must receive data extracted from the facilities data base, modify the data, and then return the data to the facilities data base for updating, it supports a structure similar to that of the facilities data base. The hierarchical data structure is employed for the GES workspaces. A detailed discussion of the workspace structure is beyond the scope of this paper and is documented elsewhere (5,p.53). The primary concept that permits the workspaces (and, subsequently, the facilities data base) to accurately model the connectivity in the network is the ability to logically separate multiple facilities all located at the same physical X-Y coordinate.

For the purpose of definition, the TFIS employs five types of facilities to model the highway and bridge network. Although a detailed discussion of the types is beyond the scope of this paper, a brief description is provided (1,p.23):

- Type 1: The Type 1 facility is a point facility, such as a road sign, that exists at a specific geographic X-Y coordinate.
- Type 2: The Type 2 facility is a span facility, such as a highway section, that exists between two X-Y coordinates.
- Type 3: The Type 3 facility is a control facility. It also has two end points, except that the two end points both exist at the same X-Y coordinate. An example of this would be an intersection. To change from one of the intersecting highway routes to the other, the user must travel "through" the intersection, even though he enters and leaves this facility at the same X-Y coordinate. A model of a Type 3 facility would be used if the user required the ability to retrieve a specific highway route. In this case, the network retrieval program would be instructed not to cross any Type 3 facilities. This instruction would prevent the retrieval from straying to other routes at intersections.
- Type 4: The Type 4 facility is a subfacility. It is similar to other facilities except that it is always a "child" of a Type 1, 2, or 3 facility. For example, a down guy (anchor) might be modeled as a Type 4 facility as a child of a telephone pole (Type 1 facility). If the telephone pole were removed from the data base, all its children would automatically be deleted. This would eliminate the need to individually delete all the child facilities.
- Type 5: The Type 5 facility is a repeating data group. It is used to add historical data that do not require a picture. For example, a repeating data group could be added to a highway segment facility each time some maintenance activity was performed.

As these descriptions may indicate, there are many ways to model the facilities that make up the highway and bridge network. The approach chosen by any specific transportation agency will depend on the intended use of the model.

Facilities Data Base

The facilities data base consists of any number of physical data bases, each representing a large, continuous map covering the entire area of interest to the transportation agency (nation, state, county, city, etc.) (5,p.16; 9,p.454). Each physical data base contains information on facilities that are "connected." For example, all highways and bridges would be stored in a single physical data base because there is connectivity among the various highway sections, routes, and networks that compose the highway and bridge system. However, there is no connectivity (flow of traffic) between this network and, say, road signs. If data on road signs were to be included in the TFIS, they would be stored in a different physical data base than the data for the highways and bridges. This separation of physical data bases within the facilities data base is of interest from the system architecture standpoint but is invisible to the user because the GPG tracks which data items belong in which physical data bases. The user simply retrieves data, makes updates, and sends the updates back to the facilities data base. GPG keeps track of which data items come from which data base and ensures that the updates are properly posted. GDBS uses a data base manager to actually process the facilities data base (as well as the interface library).

The data base structure permits rapid retrieval of data when they are requested in the most probable fashion. In geographic information systems, the vast majority of data retrievals is by area. Therefore rapid retrieval is provided by physically locating, in the data base, data associated with facilities that are actually physically close to each other on the ground. A hierarchical data base structure is employed. More accurately, a linked hierarchy is employed to define span-type segments (i.e., those with two end points such as a highway segment). A detailed discussion of the data base structure is beyond the scope of this paper and is provided elsewhere (7,p.5).

The data base stores information on the location and connectivity of the facilities. Even though two facilities appear graphically to "cross" each other, the data base structure must determine if the two crossing facilities are connected or if they simply pass over each other. It also provides the capability to perform area (polygon, county, district, etc.) or network (Interstate, primary, Route 345, etc.) retrieval.

Interface Library

The interface library manager is the "traffic cop" handling the flow of data between the various environments within the geographic information system (3,p.6). It defines the interface format to be used as the common medium of data exchange. This permits data flow not only between the facilities data base and the interactive users but also with external data files or between different interactive workstations.

The interface library provides an area to back up user files and workspaces. It also accommodates multiple access to the records in the interface library by the data base retrieval and maintenance programs, by the library job scheduler, and by the users.

Interface with Other Agency Data Bases and Applications

Any organization considering a TFIS probably has a number of data bases it already uses for various purposes. A design philosophy coming out of the work with the utilities industry is that the TFIS should provide an interface with these systems. A detailed discussion of these capabilities is provided elsewhere (3,p.33).

In some cases the interface may be required to convert the data from an existing data base into the facilities data base. In this case the data would first be converted into interface format and then be placed in the interface library. From that point, GDBS would place the data in the facilities data base. The data would then be maintained (entered, updated, deleted) from the facilities data base.

There are other cases in which the agency does not want to alter the existing data base or the applications that run against it. For these cases GDBS provides an "exit" in its area and network retrieval routines. This capability permits the user agency to have GDBS retrieve the data from the facilities data base and then to exit to one of the agency's own programs (along with the retrieved data) so that the agency's program can update or retrieve from its existing data base.

Of course, because the facilities data base employs a standard data base manager, there is nothing to prevent the transportation agency from writing application programs that process directly against the data base.

As shown in Figure 2, TFIS also supports nongraphic applications. The primary example cited throughout this paper has been the analysis routines associated with a PMS that permits agencies to continue using existing applications without modification. The only difference is that the source of the data would be the facilities data base.

Another group of applications exists at the network and system level. TFIS has the ability to readily and interactively retrieve data to answer a number of important questions about roadway conditions by functional classification (e.g., Interstates, arterials), traffic volumes, comparisons of roadways in different districts, location and inventory of traffic regulatory devices, and traffic accident data. Such information is of considerable value to network management and the distribution of available highway funds.

Operation Environments

The TFIS is implemented on a mainframe computer. Specific hardware and software requirements are discussed elsewhere (5,p.8). The interactive graphics component (GPG) will operate in either the MVS/TSO or the VM/CMS interactive environment. The data base component (GDBS) will run in the OS/VS1 or the OS/MVS environment and, with some modifications, in the DOS/VSE environment.

Support of the graphics workstations can be local, remote, or distributed. However, response time on remote graphics workstations tends to be degraded (compared to local) by the inherent slowness of the communications lines. The most rapid response time will be provided when a workstation is directly connected to a processor. For users not at the central office location, a distributed processor will offer the fastest response time. The distributed processor would drive the graphics workstation and, when requested by the user, handle the communications with the central processor to retrieve workspaces from or send workspaces to the interface library. This computer-to-computer exchange of workspaces is invisible to the user; he or she can continue to process other workspaces while that operation is taking place.

TRANSPORTATION FACILITIES INFORMATION SYSTEM CONSIDERATIONS

Need for TFIS

The discussion to this point has dealt with the concepts underlying the TFIS, with transportation examples cited where appropriate. In essence, TFIS views the elements of the highway and bridge network as the assets of the transportation agency. These assets are modeled in a data base with their location and connectivity data in addition to their descriptive data. This permits retrievals by area, network, or individual routes. In this section the considerations that establish the applicability of TFIS to the information processing needs of an agency will be discussed.

In a general sense, a PMS employs various algorithms to examine a network (or portions of a network) and formulates alternative maintenance and rehabilitation strategies to assist managers in choosing the best course of action. The algorithms are used assuming that the input data are accurate and timely. Experience has shown, however, that the assumption of timely and accurate data is not valid in many cases. Transportation agencies define and maintain data on their highway and bridge networks in a variety of ways (e.g., some computerized and some manual, some with timely data update schedules and some with "when we can get to it" schedules, some with standards to verify accuracy and some the accuracy of which depends on the individual posting the updates).

This research project addresses the problem of collecting and maintaining data on an agency's highway and bridge network, while minimizing problems caused by untimely or inaccurate data.

The software package being used to accomplish the work combines the best points of the tools that some agencies are already using in separate and nonintegrated modes: data bases and graphics. Although the actions of the operator may look very similar to those required for other graphics packages, there is one significant difference. In addition to creating a graphic representation of the facility (highway section, bridge, ramp, etc.), the operator is also defining the facility's descriptive properties, location, and connectivity into a data base manager. Capturing the data in this manner essentially builds a model of the network in the data base.

In addition to simplifying maintenance of the network's data, this model can serve as the input to the algorithms used by the PMS. The architecture of the software package is open (i.e., it can accept data from and provide data to external software packages such as the PMS algorithms). The PMS is only one of the many applications that can use this network model.

Modeling the Network

An earlier discussion outlined the five types of facilities used to build the network model. There are many ways to represent the same facility in the data base; the method selected depends on the application for which the model will be used. Which facilities should be included, how they should be modeled, and what picture or pictures should be used for their graphic representation are questions the research team faces. Input on required applications, obtained through interviews with transportation agency officials, will help provide the answer.

To provide an example, Figure 4 shows a portion of a map document created for the utilities industry. A sample of a screen menu is also shown in the lower portion of the figure. Although the facilities represented are clearly not all related to highways and bridges, the analogy to a transportation application is readily apparent. Various symbols are used to represent facility types. The electric lines are pictured running down the center of the streets, even though they are actually attached to the poles. Thus displaying the picture of a facility at a different location than its physical location can enhance the readability of the display. (The conventions for doing this are determined by the using agency.) The content, size, and location of the annotations are controlled by the user. The displayed annotations are actually attribute data extracted from the data base. So, for example, if the user changes some of the descriptive data for a highway section and that data element is included as an annotation on a display similar to that in Figure 4, the new value of the data item will be shown the next time the user requests a display.

In addition to the analysis-type PMS applications, because each facility in the data base also has its picture stored with it, producing any number of graphic reports or maps is possible. Storing the network in a continuous data base (no map edges or discontinuities) is a significant accomplishment because it finally separates the record of the data from the report of the data. Historically, many of the data associated with the highway network have been manually recorded on a map or map-type document. Anyone needing this information has had to refer to the map and sort through all the information on the document to find the specific data items of interest. In this case the map is both the record of the data and the report of the data. Data maintenance is also a problem because typically there are multiple copies of maps throughout the agency, all being updated on different schedules. Determining which version is the correct one is almost impossible.

Because this software package builds a model of the highway and bridge network in the data base, producing a graphic report (map) is simply a matter of requesting a display. In this case the data base is the record of the data, and the ad hoc requests for maps represent the report of the data. Because the entire agency uses the same data base, the problem of "which map is the most current" is eliminated. Any map produced will contain only those facilities and annotations requested, which also eliminates the problem of having to "work around" extraneous information on the map document.

Centerline expansion is an example of a function that will see heavy use in the transportation area. This also helps demonstrate the concept of controlling the method by which the information in the data base is displayed. As shown in the upper portion of Figure 5, the user has only to digitize the highway centerlines. Then, by selecting an option from a menu, GPG creates the pictures of the highway edges by reading the highway width from the data stored with the highway section and drawing lines parallel to the centerline offset by one-half the width.

The user can control when the various pictures

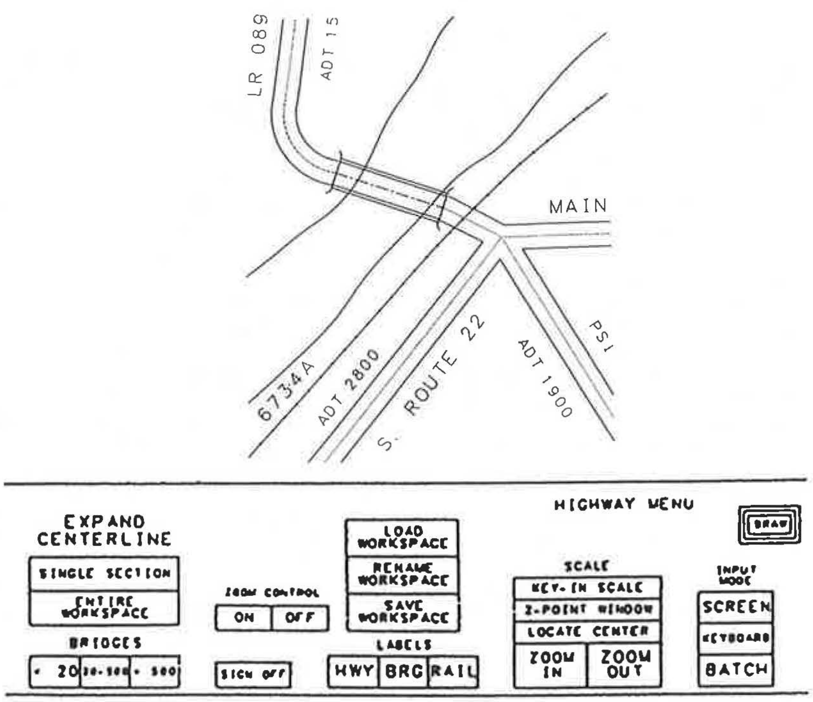

FIGURE 4 Sample map document.

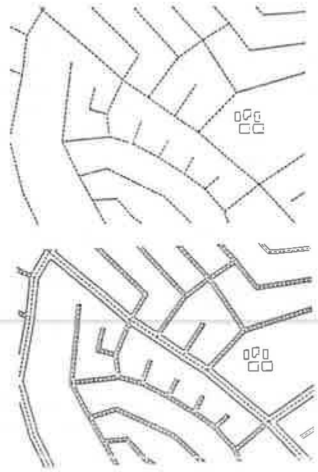

FIGURE 5 Centerline expansion example.

are actually visible. For example, the centerline could be visible (but not the highway edges) at smaller scales (e.g., 1 in. = 200 ft or smaller). At scales larger than 1 in. = 200 ft, the visibility of the centerlines would be turned off, the visibility of the edges would be turned on, and the display would show the highways with scaled widths. These changes to the pictures are controlled as the user zooms in or out, and they do not require operator actions.

Not a Turnkey Solution

The user's dialogue at the graphics workstation is supported by the GPG software product. The ease of use and the productivity exhibited by the system users are directly controlled by the effectiveness of the menus provided at the workstation.

The control of productivity is a fundamental point. GPG is a collection of many processing routines that can be called on to perform literally hundreds of tasks, such as loading a workspace, changing the visibility properties of a picture, deciding which facility was pointed to (when a number of facilities are in the immediate area), balancing a transverse, expanding the highway centerline to display the edges of the highway, and calculating the distance between two points. But it is the user agency that has to decide how to combine these powerful routines into composite processes to maintain the model of the highway and bridge network in a manner that supports the applications for which it will be used. This effort is accomplished by coding tables that define the menus and instruct GPG to utilize specific processes in specific sequences, for instance, to add a new highway segment.

This process is the major focal point of this research project. Although it is understood that each agency has its own way of doing business, a number of common requirements span most agencies. Through interviews with officials at a number of transportation agencies, the research team is identifying these requirements. The team will then write the tables that define the facilities, menus, and pointing rules appropriate for highway agencies, using GPG to define their network of highways and bridges for use as input to PMS-type applications. (Pointing rules specify how GPG should interpret the physical pointings the user makes to either the tablet or the screen and which of the GPG processes should be invoked as a result.)

This will not be a turnkey system. It is unrealistic to expect that a single set of processes will conform to the operating procedures of each highway agency. The work performed by the research team will provide the general functions identified as requirements through the interview process. The TFIS architecture is flexible so that each transportation agency can then make any modifications required (to menus, pointing rules, picture definitions, etc.) to make the TFIS meet its needs.

In addition, the research team is gaining experience in using the TFIS concepts with highway and bridge networks. This experience will be documented in appropriate reports. The recommendations made as a result of this experience will prevent each agency from having to rediscover these techniques.

SUMMARY

The objective of this research project is to develop the foundation for a transportation facilities information system. It is a data base system that permits a transportation agency to define and to maintain data on its assets (highway and bridge network) through the use of an interactive graphics system or interfacing with existing data bases, or both. TFIS also makes those data available to the analysis algorithms employed by a pavement management system, while avoiding problems introduced by data that are not timely or accurate. It also provides the means of developing additional graphic and nongraphic applications.

The research involves writing tables to control the operation of a software package that builds a model of the highway and bridge network. Input for this work is being obtained from interviews conducted with transportation officials.

The project will not produce a turnkey solution. Instead, it will produce a system capable of performing the fundamental processes needed to model the network. The system has the flexibility to permit each agency to make the modifications needed to tailor the TFIS to meet its own unique requirements.

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Computerized Pavement Performance Evaluation Data Base Development for Structural Adequacy, Present Serviceability, and Distress Analysis

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ABSTRACT

Idaho Transportation Department's (ITD) Pavement Performance Management Information System (PPMIS) program requires input data (deflection, roughness, cracking, skid) collected in the field to be integrated with data from various agency data bases. The collection of the field data has been automated: Hewlett-Packard HP-85 microcomputers are used aboard the test vehicles to simplify data gathering and ensure uniformity. Field data are transferred from microcomputer tape cartridges to mainframe disk files without need of manual data entry with its attendant labor costs and errors. IBM 4381 mainframe programs format and augment the data for entry into the final data set for input to the PPMIS program. This entails queries to ITD data bases for traffic volumes, temperatures, section descriptions, and so forth.

In 1978 the Idaho Transportation Department (ITD), with the assistance of the Utah Department of Transportation, began adaptation of the Pavement Performance Management Information System (PPMIS) to Idaho conditions. This paper will begin with a brief description of the PPMIS system.

In July 1981, with the support of Boise State University (BSU), ITD began development of a computerized system for the capture of field data and for the inclusion of the field data with information from ITD data bases in an input data set for the PPMIS program. The building of this input data set is described here.

This computerized system has several advantages. It can be made to prompt field personnel for data (in some cases the system actually carries out the sequence of tasks necessary to deploy the measuring instruments). It has eliminated much need for human interpretation and recording of instrument readings. Data are consequently more accurate and uniform, and less effort is required of testing personnel. The mainframe reformatting and query programs have eliminated the need for human data search and translation--except to correct errors and handle rare special cases. The process also enables considerable personnel cost savings.

PAVEMENT PERFORMANCE MANAGEMENT INFORMATION SYSTEM OVERVIEW

Detailed information on the Idaho PPMIS is contained elsewhere (1,2). Offered here is a brief and oversimplified summary.

The Idaho PPMIS consists of three main components:

- The SYSTDY program, which makes up section-by-section reports based on the data;
- The SUMMARY program, which receives SYSTDY's section reports and sorts them into ranked lists according to various criteria; and
- The input data set, which includes section-