The Pontis Bridge Management System: State-of-the-Practice in Implementation and Development

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ABSTRACT

The Pontis® Bridge Management System (BMS), a product of the American Association of State Highway and Transportation Officials (AASHTO), is now in its fourth major version, Release 4. Pontis continues to support the complete bridge management cycle, including bridge inspection and inventory data collection and analysis, recommending an optimal preservation policy, predicting needs and performance measures for bridges, and developing projects to include in an agency's capital plan.

Transportation agencies licensing Pontis use the system in greatly varying ways, and frequently have taken advantage of the system's flexibility to customize their implementation of Pontis to meet agency needs. This paper details how U.S. transportation agencies are using the Pontis BMS, the approaches taken to implementing the system, and agency-specific developments or customizations that may be of relevance to other agencies. Details are provided including the level of use and degree of customization for agencies licensing Pontis with regard to supporting data collection and management, supporting the asset management process, and supporting other agency-specific needs.
INTRODUCTION

The Pontis® BMS, a product of the American Association of State Highway and Transportation Officials (AASHTO), is now in its fourth major version, Release 4. Pontis supports the complete bridge management cycle, including bridge inspection and inventory data collection and analysis, recommending an optimal preservation policy, predicting needs and performance measures for bridges, and developing projects to include in an agency's capital plan (1), (2), (3). Pontis is used extensively across the U.S., and has a significant presence internationally. As of October 2002 there were 46 agencies in the U.S. licensing Pontis, including 39 state or territorial transportation departments and 7 other agencies, as shown in Figure 1. In addition, 7 agencies outside the U.S. have licenses for the product.

Pontis is supported and maintained through AASHTO's joint software development technical service program. This program offers member agencies an opportunity to pool their resources and produce complex software solutions at a fraction of the cost of custom in-house development, while promoting a best practices approach to design. By allowing agencies across the country to combine their resources, the joint development program provides enormous economies of scale, particularly in comparison to developing and maintaining individual custom solutions. This results in significant cost savings—not only during initial software development, but also throughout the software product life cycle.

A critical factor in the success of Pontis has been its functionality for supporting a high level of agency customization. Agencies using the product may define their own bridge elements, deterioration models, and agency business process rules for use in the Pontis program simulation. They may develop their own screen layouts, reports, and data entry forms. Further, agencies may customize the Pontis database, take advantage of the open architecture of the product to add database tables, build their own applets or external applications for connecting to the database, and/or build interfaces between the Pontis database and other agency databases. Agencies are using all of these approaches to customizing Pontis to best meet their needs.

This paper summarizes the functionality available for customizing the Pontis BMS. Further, it details how U.S. transportation agencies are using the Pontis BMS, the approaches taken to implementing the system, and agency-specific developments or customizations that may be of relevance to other agencies. Details are provided including the level of use and degree of customization for agencies licensing Pontis with regard to supporting data collection and management, supporting the asset management process, and supporting other agency-specific needs.

FUNCTIONALITY FOR CUSTOMIZING PONTIS

Customizing Data and Product Behavior

Through the Pontis user interface, one may make a range of customizations to the data used by Pontis and to the product behavior. Customizations in this category include:

- Customizing data definitions and picklists. In the Configuration module an agency may customize the data definitions used by the product, such as definitions of operating environments, bridge treatment action categories and types, and element types. Also, an agency may redefine the contents of the picklists used in the application.

- Customizing element definitions. Central to Pontis is the representation of a structure as a set of structural elements. AASHTO has identified a set of commonly recognized (CoRe) elements (4). Agencies may supplement the AASHTO CoRe elements with their own element definitions, or may replace them with a different set of element definitions, though this option of redefining CoRe elements is not acceptable to FHWA and is strongly discouraged by AASHTO. Action cost, action effectiveness, and deterioration models are defined for each combination of element and operating environment.

- Customizing product behavior. Using the application security and configurable options one may enable or disable selected fields or screens for all or selected users.

- Customizing the program simulation. Pontis uses inspection results and element models to predict future network-level and bridge-level conditions, and to make specific project recommendations through a program simulation. All significant parameters used in the program simulation are exposed for agency customization. In
addition, beginning with Release 4 of Pontis, an agency may develop a comprehensive set of business process rules that allow Pontis to better simulate agency practices (3).

- **Customizing data import/export.** Pontis Data Interchange (PDI) files are used to exchange data between different Pontis databases, such as between a field inspector’s laptop and a central database. Pontis users have an extensive set of options for customizing what database tables and fields are included in their agency’s PDI files. Third party development efforts can also exchange data with Pontis through the PDI file.

**Customizing the Database**

The Pontis application connects to a relational database. The database may be a Pontis database, or an integrated BRIDGEWare database with data for Pontis, as well as for the other AASHTO BRIDGEWare products Virtis® (bridge load rating program) and Opis® (bridge design program). Agencies may implement the Pontis database either in Sybase Adaptive Server Anywhere® (ASA) or Oracle®. Agencies have full access to their Pontis database, and may make customizations to the database. Additional tables and fields added to the database may be used in Pontis reports, and may be exchanged using PDI. Agencies may customize the security of the database outside of the Pontis application, and add stored procedures and triggers as needed to support other needs.

**Customizing Screens and Reports**

Using the Sybase Infomaker® application provided with Pontis, agencies licensing the software may develop their own custom screens and reports, and include these in the product. Specifically, the bridge and project lists (desktop layouts) used to navigate in most of the product’s modules may be customized using Infomaker. Also, agencies may define an arbitrary number of agency-specific reports; these are included in the Pontis Report Manager when the product is launched. Further, the basic screens provided with the product may be supplemented with agency-specific screens for collecting bridge, inspection, structure unit, roadway and/or project data. Figure 2 shows an example of a custom screen used by the Kansas Department of Transportation (KDOT) for collecting bridge data.

**Developing Custom Applets and Applications**

Given the open architecture of the Pontis application, it is possible to develop additional applications that interface with Pontis or that connect directly to the Pontis database to supplement the functionality offered by the system. Agencies with expertise in the Sybase Powerbuilder® development environment may build Powerbuilder applets integrated with Pontis. These applets operate in conjunction with Pontis. They use the same database connection as the product and exchange information concerning what bridges are selected on the Pontis Desktop. Agencies may use applets to provide additional data entry forms, reports or other functionality.

External applications may be developed that connect to the Pontis database outside of the Pontis application. These applications may use Application Programming Interface (API) calls to access the modeling and data import/export functionality of the product (developed in C++) (3). Such applications may be used to collect additional data or provide functionality not available in Pontis.

**ANALYSIS OF AGENCIES’ USE OF PONTIS**

**Analysis Overview**

Information on agencies’ use of Pontis was compiled in September and October of 2002. This information was compiled primarily through telephone interviews with Pontis users. The interviews were supplemented with information gathered by authors at the annual Pontis User Training Meeting (the 2002 meeting was held in September 2002 in Phoenix, Arizona) and through information compiled from the Pontis Support Center. Topics covered in the telephone interviews included the following:

- Current version of Pontis in use;
- Number of application and database users;
- Type of database in use (Sybase or Oracle, single-user or multi-user);
- Information on functionality of the product used by the agency (e.g., data collection, program simulation, project planning);
• Information on customizations made to Pontis (e.g., custom screens, reports, forms, data definitions);
• Information on other applications used to connect to the Pontis database; and
• Feedback on the product.

Through the interviews and additional information, profiles were created detailing how each licensing agency uses the product, with emphasis on the extent to which the agency has customized the Pontis application and/or database. Of the 46 agencies licensed to use Pontis, profiles were created for 34 agencies for which the authors could confirm that the agency has a production database. A total of 12 agencies were excluded in tabulating the statistics presented in this paper. Of the agencies excluded, one is a new licensee that had not yet received the product; two could not be contacted; and one (the Federal Highway Administration) uses the product for a mix of training, research and data collection that is not directly comparable to the use of the product by other agencies. The other 8 excluded agencies are state transportation departments that have not yet implemented a production database.

Statistics on Pontis Use

In each of the 34 agencies, Pontis is used on a regular basis, with the frequency of use depending on what functionality of the product is used by the agency. The number of users at each agency varies from one to several hundred. Each agency uses one of several options available for deploying the Pontis database. The product is shipped with a single-user version of the Sybase ASA product. Agencies may use the version of ASA provided with Pontis as their database management system, or they may upgrade to a multi-user version of Sybase or Oracle. This allows multiple users to connect to the database simultaneously, and allows the agency to take advantage of other advanced functionality typically found in database management systems. As indicated in Figure 3, 50% of the agencies use Oracle as their primary database management system, often in conjunction with ASA used for field computers. Approximately 38% (13) use the single-user version of Sybase ASA shipped with Pontis, while the remaining 12% (4) use a multi-user version of Sybase.

Figure 4 summarizes what functionality is used by the different agencies. As shown in the figure, half of the agencies (17) use Pontis solely for inspection data collection and management through the Inspection module. These agencies do not, as of the time of this writing, use the advanced functionality of the system for performing program simulations or developing project plans. Approximately 12% (4) of the agencies use the advanced functionality of the system but do not use the Inspection module. Two of these agencies use systems integrated with the Pontis database for collecting inspection data, while two use external systems and have developed procedures for importing needed data into Pontis.

Also shown in Figure 4, approximately 41% (14) use the program simulation functionality in Pontis (included in the Programming module) to analyze bridge needs at the network level. These agencies use the Programming module in conjunction with the Inspection module, the Project Planning module, or both. Approximately 32% (11) use the project planning functionality (included in the Project Planning module) in conjunction with the Inspection module, Programming module, or both. The level of use of the Project Planning module appears to have increased significantly since the last examination of agency’s use of this functionality performed prior to the release of Pontis Release 4 (6).

Level of Agency Customization

Most of the 34 agencies interviewed have made extensive customizations to the product. Nearly all have customized their element definitions and/or data definitions used in the product. Approximately 59% (20) have customized their database in some fashion. Over 58% (20) have developed data import/export procedures for exchanging data between the Pontis database and other databases.

Figure 5 summarizes the extent to which agencies have customized Pontis. The figure shows that most agencies using Pontis have customized the product. Approximately 46% (16) have performed “moderate” customizations. These include customizations that can be made through the product or through Infomaker, including developing form, reports and desktop layouts, as well as customizing product behavior. Approximately 36% (12) have made “major” customizations, including development of applets or external applications to connect to the Pontis database. Over one-third of the agencies have used all of the basic approaches to customizing Pontis, including developing
STATE-OF-THE PRACTICE IN PONTIS IMPLEMENTATION AND DEVELOPMENT

This section presents the state-of-the-practice in current efforts to implement Pontis and develop additional functionality to complement the system by the agencies licensing the product. Several primary themes in Pontis implementation and development were observed through the interviews discussed in the previous section. These include an emphasis on customizing Pontis and developing additional applications for supporting agency business processes, interest in developing thin-client applications, and a focus on using Pontis to implement asset management concepts. The discussion in this section is organized around these prevailing themes, with relevant examples of Pontis-related software implementation and development efforts currently being undertaken related to each.

Supporting Agency Business Processes

The primary reason that most agencies licensing Pontis customize the system, or develop additional applications to work with the Pontis database, is that they need to tailor the system to better match their agency’s business processes. Given the diverse needs of the many agencies using Pontis, and the flexibility offered by the system for supporting customization, agencies have generally found that customizing Pontis provides an effective means to reconcile differences between the product’s default settings and behavior and the needs of the agency.

The following are representative examples of efforts agencies are taking to customize Pontis to support their processes. The experience of the South Dakota Department of Transportation provides an example of the customizations implemented in many agencies to support agency processes related to performing bridge inspections (7). South Dakota began supporting Pontis in 1993. The agency began customizing the system in 1996. Customizations performed by the agency include:

- Adding six custom tables to the Pontis database to collect agency-specific data not included in the National Bridge Inventory (NBI) or the Pontis product;
- Developing four custom forms for use in the Pontis Inspection module for editing the agency-specific data items;
- Customizing database security;
- Customizing the procedures and files for using PDI to import and export data between the central database and field units. The customized procedures and files restrict the data that is exchanged based on agency processes, and ensure that only the data from the latest inspection is sent from a field machine back to the central database;
- Developing custom desktop layouts; and
- Developing procedures for updating the Pontis database with data from mainframe systems.

The Kansas Department of Transportation has made extensive customizations to its Oracle Pontis database to support the agency’s processes. KDOT collects over one hundred agency-specific data items, and has added these to the agency’s Pontis database through customizations to the database and development of additional reports and data entry forms. Most of the agency-specific items are essentially NBI items collected at a more detailed level (e.g., at the structure unit level rather than the bridge level, or additional Kansas codes that map back to a single NBI code). An extensive set of database triggers has been established to calculate NBI fields automatically as a bridge inspector enters data in the agency’s customized forms. In addition, the agency has developed custom reports, and has developed a Powerbuilder applet for performing batch entry of inspection data, consistent with past agency practice. Further, the agency has developed an interface between the Pontis database and the agency’s CANSYS-II system used to store information on bridges, pavements and other assets.

Agencies such as the Illinois Department of Transportation have customized the behavior of the product to better support their practices for bridge programming and project planning. Illinois has defined its own set of elements as an alternative to the CoRe elements to better match its processes for inspections and recording costs and quantities. Further, the agency has developed an extensive set of program simulation rules to ensure that Pontis project recommendations are consistent with agency practice. To support these efforts, Illinois has made customizations to the Pontis desktop layouts and database to include additional data items relevant to bridge programming.
Developing Thin-Client Applications

Pontis has been developed as a client/server application. As such, it is typically necessary to install a client application (also call a “thick” client) on each machine running the system. The client can then access a database stored on a server or locally.

A number of agencies using Pontis have expressed an interest in implementing Pontis as a thin-client application. In this architecture, application logic is stored on a server, and the footprint of the application on the client machine is minimal. This is an attractive approach to implementing management systems such as Pontis, as with this approach software deployment and maintenance costs are minimized. Also, training is typically simplified and security is enhanced, as there are fewer ways to access the Pontis database outside of the application. For the large number of agencies with geographically dispersed users, a thin-client approach is particularly advantageous.

Thus far, three agencies have developed approaches to using a thin-client architecture to implement Pontis or data collection applications tied to the Pontis database. The California Department of Transportation (Caltrans) and the Montana Department of Transportation have developed applications outside of Pontis that are used to update inspection and inventory data in the Pontis database. Both applications were developed in Oracle and allow users with access to a web browser to enter inspection data. At the same time, users in the central office have access to the Pontis application and can use Pontis to view the data being entered into the database. Both agencies use the Pontis database extensively, but rely on the Pontis application primarily for use in supporting programming and project planning.

In the case of Caltrans, the agency’s thin-client application contains additional screens for enter hydraulic and seismic data required for the agency. Caltrans distributes the Pontis application to local agencies with less stringent data requirements, and uses PDI files submitted by local agencies to update the central database.

The Florida Department of Transportation (FDOT) has implemented thin-client support for Pontis using Citrix MetaFrames. With this approach, several hundred bridge inspectors, including state personnel and consultants, enter data into the agency’s central Oracle database using Pontis and additional Powerbuilder applets for collecting agency-specific data. Citrix software installed on each user’s machine allows the user to run a copy of Pontis stored on a server without installing the application on the client side. FDOT is currently funding a series of enhancements to the Pontis product to improve bridge-level security and add multimedia support to the product. This functionality also will be supported using the MetaFrames approach, and will enhance the functionality of the product for meeting the agency’s needs.

At present, deploying Pontis using a thin-client approach requires an agency to invest significant additional time and effort. A number of other agencies have expressed an interest in making thin-client support a standard part of the Pontis product. AASHTO and its Pontis contractor Cambridge Systematics are currently engaged in developing the technical architecture for future versions of Pontis. As part of this effort they are exploring the potential for supporting a thin-client approach in Pontis, particularly a thin-client version of the Inspection module.

Implementing Asset Management Concepts

As recognized by the Governmental Accounting Standards Board (GASB) Statement 34, asset management is an area of significant interest for U.S. state transportation departments, as well as for AASHTO and the FHWA. Asset management has been defined as “a strategic approach to managing transportation infrastructure (8).” Pontis provides exemplary support for implementing asset management concepts for bridges and other structures, and includes functionality vital for implementing asset management at an agency, such as:

- Determining the optimal maintenance policy for preservation a network of bridges;
- Allowing an agency to establish its funding needs and evaluate the impact of making tradeoffs between different investments;
- Enabling detailed tracking of the inventory and condition of bridge assets, as well as the actions taken to preserve a bridge; and
- Supporting integration of bridge data with data for other assets.
In agencies such as the Michigan Department of Transportation and the Vermont Agency of Transportation, legislation has been passed requiring the agency to implement asset management concepts, highlighting the importance of implementing management systems. The Utah Department of Transportation has recently completed reconstruction of the Interstate 15 Corridor in Salt Lake City, and has committed to using asset management concepts to maintain the corridor in the future. The agency is evaluating what changes are needed to its systems and business processes, including Pontis, to support this initiative.

Although Pontis provides excellent support for implementing asset management concepts even without extensive customization, agencies have nonetheless found it valuable to make customizations to the systems to support their asset management efforts. For example, agencies such as the Illinois Department of Transportation (described previously) and the Virginia Department of Transportation are pursuing implementation of the advanced programming functionality in Pontis incorporating asset management concepts. These agencies have carefully reviewed and customized the program simulation rules in the product to produce recommendations that best match agency practices.

At FDOT, Pontis has been customized with a number of additional element definitions. These new elements are used to describe other assets managed by structures personnel, including structure types such as tunnels and sign structures. By defining Pontis elements for these assets, FDOT can apply Pontis modeling functionality to assets besides bridges, and manage these assets in an integrated fashion.

Data integration is an important component of asset management, as asset management emphasizes collecting quality data on all of an agency’s key assets, and bringing relevant data on those assets together to support integrated decision-making and evaluation of tradeoffs. Through its open database architecture Pontis helps enable data integration efforts between Pontis and other applications, such as those recently performed in Michigan, Mississippi, and Kansas.

Recently AASHTO completed an integration of the databases of its BRIDGEWare products Pontis, Virtis and Opis into one integrated database. Additional work is being performed to explore adding support for Extensible Markup Language (XML) to facilitate data exchange between BRIDGEWare databases and other agency databases. Additional opportunities for integrating data for additional assets and from other agency databases are being explored as part of the technical architecture work described previously.

CONCLUSIONS

The Pontis BMS provides a broad range of functionality for supporting bridge management. Of the agencies using the system, approximately half rely on the system primarily for supporting the bridge inspection process. The other half use some combination of the system’s functionality for inspection, bridge programming and project planning.

Supporting agency customization is a critical component of the success of the Pontis BMS. Agencies licensing the software have access to extensive functionality for customizing the behavior of the Pontis product, as well as the Pontis database. The product supports development of applets and external applications that can utilize the Pontis database. Agencies using the product have taken advantage of the customization options, and rely on the functionality for customizing Pontis to allow them to tailor the product to meet agency needs. Over 80% of the agencies using the product have made customizations to the system, and over one-third have made extensive customizations. Key themes in implementing and developing Pontis include customizing the system based on agency business processes, developing thin-client applications and implementing asset management concepts.

Recognizing the diverse needs of the agencies licensing the product is an important step in considering how the product should evolve in the future, and what functionality should be added. The study suggests that certain types of functionality would be valuable to many agencies, such as support for a thin-client architecture, and additional data integration and exchange functionality. However, future enhancements to the product should be made in a manner that preserves agencies’ options for customizing the system to meet their unique needs.
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FIGURE 1. U.S. Agencies Licensing Pontis
FIGURE 2. Example of a Custom Screen in Pontis

Screen shot courtesy of the Kansas Department of Transportation
FIGURE 3. Approaches to Database Deployment Used for Pontis

Oracle, Multi-User 50.0%

Sybase, Multi-User 11.8%

Sybase, Single-User 38.2%
FIGURE 4. Pontis Functionality Used by Licensing Agencies

- Inspection Only: 50.0%
- Inspection, Programming and Project Planning: 11.8%
- Programming and Project Planning: 11.8%
- Inspection and Project Planning: 8.8%
- Inspection and Programming: 17.6%
FIGURE 5. Extent of Pontis Customization

- Extensive Customization: 36%
- Moderate Customization: 46%
- None or Minor Customization: 18%