Pontis Version 3: Reaching Out to the Bridge Management Community

Paul D. Thompson, *Cambridge Systematics, Inc.*

AASHTO, through its AASHTOWare software joint development and support program, has recently adopted the Pontis bridge management system and has completed development of Release 3, to be known as AASHTOWare Pontis. With the participation of 46 state-level departments of transportation (DOTs) and FHWA, the project represents a significant effort to advance the implementation of the system and broaden its audience to include large and small transportation agencies, including local governments working in cooperation with their state DOTs. The Release 3 software will be a major advance in the product: it will be highly graphical in its user interface, work with a wide variety of commercial data base managers, employ an innovative system for coordinating the work of multiple decision makers, and include a state-of-the-art project-level analysis to complement its already-advanced network-level capabilities. Cambridge Systematics, Inc., as a contractor to AASHTO, developed the product.

Pontis was conceived in 1989 by a unique team consisting of FHWA, six state departments of transportation (DOTs) (led by California, which administered the contract, and including Minnesota, North Carolina, Tennessee, Vermont, and Washington) TRB, and three consulting firms (Cambridge Systematics, Inc., and Optima, Inc. in a joint venture, and the Urban Institute). At the time, development of bridge management systems was just beginning to bloom, with many states beginning creative efforts. The Pontis project was initiated by FHWA through its Demonstration Project 71 as a way for states to cooperate on the development of a core system that would address difficult central issues in bridge management while leaving unlimited room for innovation by the states.

Initially the focus of the effort was a methodology for combining engineering and economic concerns in network-level policies, priority setting, and project scheduling. Pontis 1.0 was completed in February 1992 and beta-tested over the remainder of that year by 13 states and 1 local government. From the beta-testing results, it was clear that the project had defined and addressed an important need recognized by almost all the states. The beta-testers had accumulated a long list of enhancements to make the software easier to use and recommended the standardization of an improved procedure for assessing bridge condition and the eventual development of a more comprehensive bridge management system that would include full-scale data base management and project-level features.

With participation by 21 states, a standardized condition assessment system, called the commonly recognized (CoRe) elements, was developed in 1993. Combined with a slate of small and medium-size software enhancements, this work resulted in the completion of Pontis Release 2 in November 1993. FHWA distributed the software and manuals to the states in summer 1994,

when AASHTO assumed ownership and support responsibilities for the project participants.

Release 2 represented an incremental enhancement of Pontis, in that the fundamental modeling methods and network-level orientation of the system were unchanged from Release 1. Some of the beta-testing recommendations, however, were much more ambitious: many of the states foresaw that Pontis could be extended to cover a broader range of bridge management needs, including providing a software framework that ultimately could house new developments in the science of project-level bridge management models. Many Pontis users could also see the potential for the open-system philosophy of Pontis to be extended to work seamlessly with diverse external systems such as data base managers; doing so would greatly enhance the agency's ability to access Pontis and use its results.

Finally, the experience gained by the many states using Pontis 1.0 has led to a new vision of ways in which the perspectives of budgeting, levels of service, project programming, and project-level bridge management could be closely integrated. By taking advantage of newly available computing power and computer graphics, it is now possible to maintain multiple consistent models of an agency's bridge management health and its future plans, with an intuitive way of looking at bridge management problems from all sides. This could allow local bridge managers to maintain a comfortable project-level perspective without losing the link to network-level budgets and performance standards. Combining the need for support of Release 2 and the development of this new concept in Release 3, AASHTO secured the financial support of 46 states and FHWA to begin the effort, which was completed in summer 1995 under a contract with Cambridge Systematics, Inc.

New Vision for Pontis

By providing an objective way of reconciling budget limitations with service expectations, Pontis filled an important need, proving the value of network-level bridge management systems. Even so, Pontis Releases 1 and 2 were in many ways embryonic. Although the software is fast and not difficult to learn, system users must devote considerable attention to maintaining the software itself, such as paying constant attention to the use of the correct models in the correct order and keeping track of exceptions and overrides to the many network-level generalizations about costs, deterioration, and service levels. When beta-testers encountered difficulties in using the system, it was often because of missteps in the modeling process or difficulty in determining what features should be used to accommodate project-level factors. As in the first generation of any completely new system, it has been necessary to observe people using the system the way that they envision that it should work, in order to discover how the system should best be presented.

What emerged from the first 2 years of active Pontis implementation is a much-improved understanding of how different people in a transportation agency can use Pontis to help them improve their understanding of bridge conditions and the implications of their decisions. Although Pontis already includes an extensive toolbox with all the tools necessary to build and operate valid network-level models, it became clear that a higher level of operation of the system is needed, one in which users do not have to be so strongly aware of the mechanics of the engineering and economic models in order to answer their questions related to bridge management. The network-level models can be made more intuitive by the use of graphics and a more flexible optimization method, and the relevance to the agency can be greatly enhanced by the full implementation of a true project-level perspective. Moreover, these features can be best implemented not by adding menu items to the existing software but by completely redesigning the way in which the system will be perceived and used. Thus even though the same network-level modeling methods and data are used, their organization and appearance have been changed greatly.

In the conceptual development of Release 3, a major challenge for the team was to conceive an organizing framework for the new system that is simple, familiar to all users, and exhaustive of the major features of the system. This framework should describe the system in a way that makes it obvious which parts any particular user will need at any particular time, and it must completely include all of the features that exist in the earlier versions.

This latter point has great short-term importance: since Release 3 was developed at the same time that Release 2 was being implemented, it was vital that users clearly perceive Release 2 as a partial implementation of Release 3, that adopting Release 2 is the best path toward the ultimate adoption of Release 3, and that no work done previously using Release 2 must be discarded once Release 3 is available.

Figure 1 is a conceptual framework that meets these requirements. The diagram shows a project-level dimension of bridge management intersecting with the network level. In the network-level box is the set of major modeling features that currently exist in Pontis; in the project-level box is a new set of features for analyzing a selected bridge. Where these two boxes intersect is the domain of project prioritization and scheduling, which must satisfy both the network and project-level perspectives. Every transportation agency has responsibilities in all of the domains of this diagram, but each

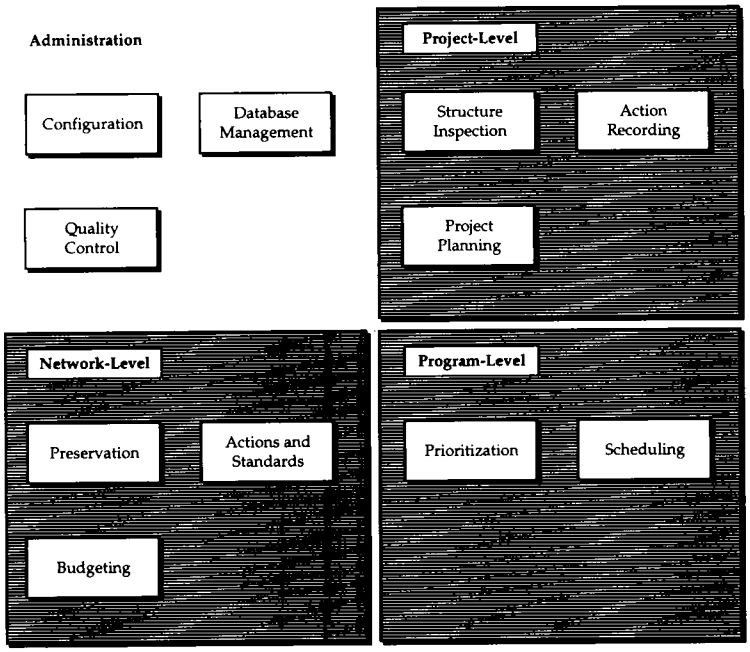

FIGURE 1 Conceptual framework for Pontis 3.0.

individual tends to concentrate on just one part. Through a common data base and an integrated set of models, Pontis can allow each individual to work in the domain for which he or she is responsible, while maintaining access to up-to-date information on how the other domains affect his or her own concerns.

Through this conceptual framework, budgets and service policies can constrain programming decisions and guide project-level decisions; at the same time, project-level decisions can provide detail to program plans, influence priorities, and supply refined alternatives to network-level decision making. Through this framework, the differing perspectives can work together to achieve an agency direction that meets both sets of needs. Given the availability of a graphic user interface, it has become possible to have a software package whose overall appearance follows the general outlines of this diagram.

Network-Level Domain

The network-level perspective of Pontis uses an engineering economic model of the agency's bridge inventory, its cost structure, and its aggregate life-cycle behavior to analyze questions of budget allocation and policy that affect large subsets of the inventory. Among the major management concerns at this level are

- Ensuring that funding is adequate to deliver expected levels of service,
- Determining the economic and opportunity costs of new policy commitments that the agency may need to make,
- Making satisfactory progress in reducing the accumulated backlog of deferred maintenance,
- Ensuring that new preservation needs are identified and met in a strategically timed manner,
- Forecasting and coping with new functional needs that may arise, and
- Communicating the agency's capabilities and needs in a consistent manner to elected officials and the public.

Although this domain, by definition, does not include bridge-level analysis, it is important that network-level planning values be consistent with the aggregated body of project-level concerns and that project-level activities be constrained by network-level policies. When such consistency exists, then the agency is most likely to be able to meet its commitments to the public with the limited budget available.

Figure 2 summarizes the key trade-offs in the network-level domain. In this diagram, maintenance, repair, and rehabilitation (MR&R) needs and functional/structural needs are brought side by side. The shaded bars for each need category indicate decreasing benefit/cost ratios, increasing annual funding requirements, and increasing accomplishments over several years. Each bar begins at the zero funding level and ends at the level at which all possible actions considered by the models are taken in the first year. Any horizontal line drawn across the

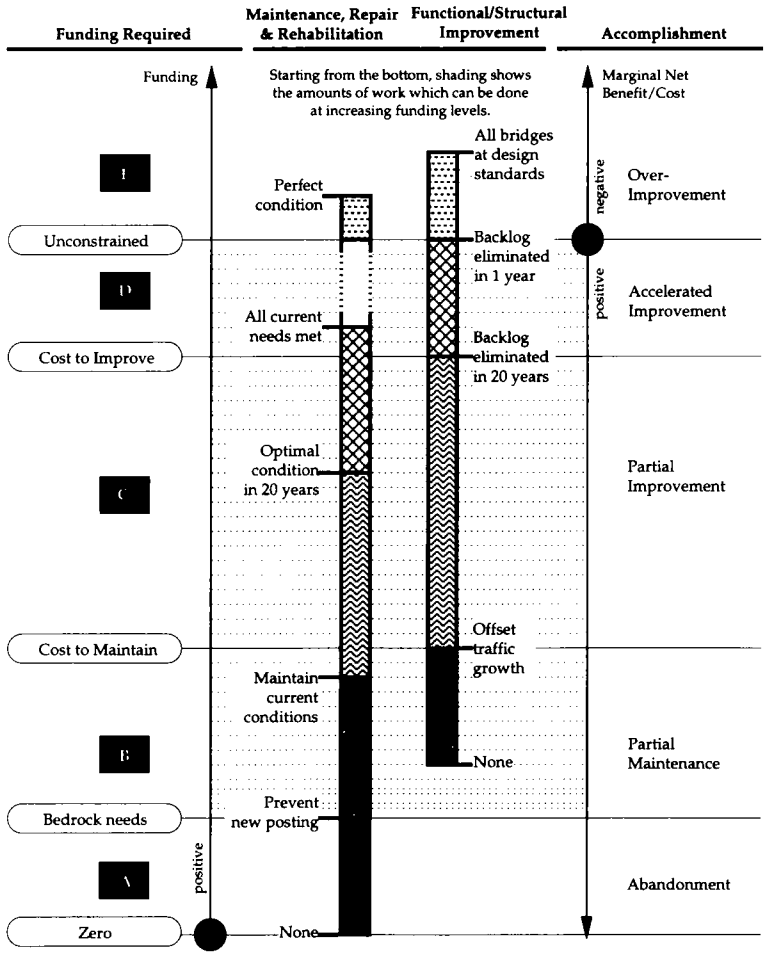

FIGURE 2 Network-level perspective: investment and accomplishment trade-offs.

two bars must cross both bars at the same benefit/cost ratio, and thus it represents a particular funding level and allocation of funding between MR&R needs and functional/structural needs. This is equivalent to saying that the two lists of needs are combined and priority ranked together.

In Funding Interval A in Figure 2, the highest-priority needs may be the MR&R actions that would prevent bridges from becoming posted if they are not already. If funding is maintained continuously within this interval, then new postings and closings must occur, since there is not enough money to prevent it. This funding interval is therefore referred to as abandonment. As funding increases to the top of Interval A, called "bedrock needs," only enough money is spent to prevent any additions to the structural needs list. Funding Interval B represents additional funding between the level of preventing new postings and the level at which current conditions can be maintained in the MR&R model. At the end of this interval, there is at least enough funding to offset deterioration and enough to address the highest-priority functional and structural needs, up to the point at which the total backlog of needs does not increase.

Funding Interval C represents sufficient funding to improve the condition of the bridge inventory. MR&R policy in this interval is geared toward reducing the backlog of deferred maintenance, eventually achieving a condition level at which a long-term cost-minimizing maintenance policy can be put in place. Funding Interval D represents accelerated improvement, where the backlog of functional and structural needs is exhausted in fewer than 20 years. This interval extends to funding levels for which the backlog might be funded as quickly as the first year. Since the MR&R needs are based on a life-cycle cost optimization, they represent not the maximum possible expenditure, but only the maximum expenditure on projects having positive net benefits. Similarly, functional and structural needs represent only the possible expenditures on bridges that are below desired service standards. As Interval E indicates, it is possible

to spend beyond the total unconstrained needs, implementing projects that have a negative net benefit according to the assumptions of the models. As with the abandonment interval, this overimprovment interval is considered unrealistic and therefore is not included in the capabilities of the models.

As Figure 2 suggests, the Pontis models generate a continuous range of funding and policy alternatives and use benefit/cost models to recommend relative priorities. For policies that are not "optimal" according to the economic models (but that may be attractive for non-economic reasons), Pontis can offer feedback in terms of the economic performance of such policies and the amount of deviation from economic optimality.

To make the network-level analysis quick and convenient, Pontis Release 3 will feature graphic controls in the user interface that control bridge allocations, MR&R policies, and service objectives. The trade-offs among these factors will be managed by a set of optimization models nearly identical to the Release 2 models (based on Markovian deterioration probabilities and linear programming optimization), with considerable input from the project-level and programming domains of the system. Users can set funding and policy decisions of interest and receive responses by means of presentation graphics, showing the resulting adjustments to other planning factors. For example, a user can lower the functional standard for clear deck width for a particular functional class and see either the amount of money that it saves or the best alternative use of the saved money.

Project-Level Domain

For many (perhaps most) users of bridge management systems, it is most intuitive to view bridge management problems from the perspective of one or more specific bridges for which immediate analysis is needed. Such analysis can take into account the particular site-specific factors that often dominate decisions on cost estimation and project development. It is essential that project-level planning be conducted within the context of a consistent network-level model, because only then is it possible to be sure that a project is affordable, will not be displaced later by a project of higher priority, and meets the requirements of an affordable set of agency policies. When the marriage of network- and project-level concerns is inadequate, the symptoms can be obvious: scope creep (cost escalation due to work added relatively late in project development), deferred work (usually maintenance and repairs), expensive stop-gap actions, unenforceable policies, and loss of credibility with elected officials. One of the most important planned features of Pontis Release 3.0 will be the addition of a project-level domain and a set of models which link them to the network-level domain. Major project-level concerns to be addressed are:

- Describing correctly the elemental configuration of the bridge and maintaining an up-to-date picture of the elements' conditions;
- Developing a programmatic strategy for the bridge that ensures its continued health;
- Recognizing past trends that may indicate changing conditions and possible unexpected needs;
- Identifying and resolving functional deficiencies;
- Recognizing project interrelationships that may affect the bridge's programmatic strategy;
- Estimating cost accurately, accounting for unique characteristics of the bridge;
- Selecting actions that consider unique characteristics of the bridge; and
- Performing efficient routine inspections.

Cost estimation will receive special emphasis, because it is widely considered to be the weakest component of bridge management analysis. In particular, the software has the ability to incorporate traffic control, mobilization, and work zone user costs, can supply these estimates at the project level, and uses the same information to ensure that these costs are included in network-level analysis. The Pontis database stores all historical actions which have been recorded in it, and this information is used in a cost updating procedure similar to the deterioration model updating procedure which was already available.

Programming Domain

The programming domain includes information and models which integrate the network-level and project-level perspectives. This includes an analysis of project priorities, including the possibility of multiple project alternatives on the same bridge, and a scheduling capability which can recognize the constraints of multiple funding sources. Changes to network-level budgets and service levels can be reflected in the priority lists and schedules. Changes in project-level information, including new inspections, can have an immediate impact on the project's standing in the program. Unlike the step-by-step "batch-oriented" analysis of earlier versions of Pontis, Release 3 automatically finds the models it needs to update the program.

To enhance the convenience and relevance of programming information, users can organize it into goal-oriented program categories, such as bridge replacement, deck overlay, painting, etc. This will make it easy to see the costs and priorities within these programs,

and to see how the programs overlap on specific bridges. Programs based on vulnerability factors such as seismic, fatigue, and scour can also be developed.

Although the primary emphasis of Pontis is on economic analysis of bridge programs, the system has features to provide alternative ways of prioritizing projects, in order to take into account important issues such as vulnerability, equity, mobility, and air quality.

Software Features

Pontis Release 3 was developed for Microsoft Windows and is compatible with Windows NT. Taking advantage of the Windows user interface, the software is highly graphical, including statistical graphics as well as specialized graphic controls and icons. Special emphasis is given to making it easy to navigate around the system. Software features are organized into user-focused perspectives: thus, for example, bridge inspectors will be provided with a full-featured inspection module that appears separate from other system features which the inspector would not normally need. It is possible to have multiple windows, possibly from multiple perspectives, open at the same time. All windows have the same set of features for printing and exporting, and a very flexible reporting facility is provided.

Recent developments in the standardization of software interfaces has made it possible to adopt an open-systems approach to Pontis. Instead of limiting the system to just one data base manager, Pontis uses the open data base connectivity (ODBC) standard to provide access to multiple data base managers such as Access and Oracle. Pontis is delivered with just one data base manager, but agencies have the option of replacing it with one meeting their own standards. Pontis is a true multi-user system with appropriate security and access controls.

An important feature of the new software is the total elimination of the "black box" feel of the models. It is often possible to work backward from results to inputs, which should be tremendously helpful in grasping the underlying analytical process. Users can attach textual notes to any data record, which can help to call out unresolved issues or to document model assumptions. Complete context-sensitive help features at several levels of detail are provided, including an on-screen tutorial and automatic look-ups of glossary items and element/state/action definitions.

Conclusions

Release 3 of Pontis is intended as a total bridge management system package, which can replace and upgrade the older systems now in existence in many state DOTs. Release 3 represents a comprehensive effort to reach out to the entire bridge management community, providing a balanced approach to meeting the needs of a diverse user group which includes local agencies and decentralized state DOTs. The new version is intended to be easier to use than Release 2, and more flexible in its ability to adapt to multiple data bases and customized models.