INVESTIGATION OF *PONTIS* - A BRIDGE MANAGEMENT SOFTWARE

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DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the

ABSTRACT

In 1991 federal transportation legislation, Congress mandated that state Departments of Transportation develop and implement comprehensive bridge management systems (BMS). Related to this, a rigorous BMS software package, PONTIS, was developed via federal contracting to industry. Since the national bridge inventory was to be based on PONTIS, many states elected to adopt it as their BMS. A major aspect was the need to introduce PONTIS to local and county bridge owners and prepare them for its implementation.

PONTIS is a complex, exhaustive software package with extensive documentation. It greatly expands the bridge inspection process; requiring more detailed data, providing statistical and probabilistic capabilities and ability to perform "what if?" repair/replace scenarios as part of management decisions concerning entire local, county or state bridge inventories. A need existed to provide new users — particularly at the local and county level — a much-abbreviated introductory user's guide for PONTIS. The purpose was to enable ready familiarization with PONTIS capabilities and example cases of its use at various management levels.

This research provided the needed introductory guide, titled “PONTIS Made S-I-M-P-L-E.” A graduate student experienced in bridge inspection, but unfamiliar with PONTIS was the active researcher under faculty and Colorado Department of Transportation guidance. Draft versions of the document were trial run by representative intended users in a “hands-on” workshop. The identified PONTIS based issues and needs, and the process leading to the user-friendly end result are described in this report.

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EXECUTIVE SUMMARY

The 1991 Intermodal Surface Transportation Act (ISTEA) mandated that each state develops a bridge management system (BMS). Many states began installation and implementation of PONTIS, a federally-funded and advocated computerized BMS. PONTIS was developed, via contract to industry, as an eventual replacement of the existing National Bridge Inventory System (NBIS).

The NBIS provided for conduct and documentation of bridge inspection according to a prescribed inventory appraisal sheet. An NBIS inspection produces a sufficiency rating (SR), which is a broad rating of the “goodness” of a bridge. The SR is largely based on subjective criteria and a quantitative load rating. Bridges are qualified and ranked for federal repair and replacement funds based on their SRs. It evolved that, by using the NBIS procedure, fund allocation was being done with insufficient information, data and tools. More detailed inspection data, statistical features and decision-making tools were needed.

PONTIS is comprehensive BMS software that provides the needed capabilities. However, its documentation and use is overwhelming to the new user. To a large degree, PONTIS is in a “black box” environment and masks the rigor and complexity of its workings and versatility. County and local bridge owners and managers are accustomed to inventorying by the NBIS approach and have evolved a “feel” for its outcomes. Indeed, some initial action was taken to develop a “translator” program to convert between the NBIS and PONTIS databases.

The research conducted in this project addressed the following needs:

(1) Examination of the PONTIS documentation with the incentive of developing a simplified user’s guide

(2) Investigation of the inner workings of PONTIS from a neophyte user’s perspective, so as to convey them succinctly and clearly

(3) Writing an abbreviated PONTIS documentation and commentary for new users

(4) Evolve a prototype version and conduct a “hands-on” workshop for representative users from local, county and state agencies

(5) Refine and finalize the manuscript into a user-friendly introductory user’s manual and tutorial

Working in conjunction with representatives of the bridge management section of the Staff Bridge Division of the Colorado Department of Transportation, researchers at Colorado State University (CSU) achieved the above needs. Via the workshop, interactive feedback from the direct user was obtained to refine and customize the document to their expressed preferences and needs. The complete process and outcomes are described here as is the availability of the document itself.

INTRODUCTION

The Colorado Department of Transportation (CDOT) is implementing the mandated use of PONTIS, a federally-advocated bridge inspection/management computer package. Many potential users are unfamiliar with the technical basis and workings of this software. This is due in part to the highly advanced nature and technical sophistication of the underlying probability based methods, which are the foundation of PONTIS. This project was aimed at facilitating the use of PONTIS for new users at various levels of bridge management, particularly local and county agencies.

CONDITION OF TODAY'S BRIDGES

It is known from existing bridge inventory data, that about half of the nearly 580,000 highway bridges in the United States were built before 1940. Most of the bridges were designed for less traffic, smaller vehicles, slower speeds, and lighter loads than are presently encountered on the nation's highways. Lack of maintenance also caused deterioration not only in the older bridges, but in newer ones as well. Nearly half the pre-1940 bridges initially were classified as "structurally deficient" or "functionally obsolete" by the Federal Highway Administration (FHWA). This assessment was based on inspection data and classifications contained in the National Bridge Inventory System (NBIS) at the time.

Based on the NBIS database, the cost of rehabilitation and replacement of the inadequate bridges initially was estimated at more than $50 billion. However, only 2-3 billion federal dollars annually have been available through the Highway Bridge Rehabilitation and Replacement Program. Thus, only a few thousand bridges are repaired or replaced annually; other satisfactory bridges age more and enter the pool as time passes. The available funds — even with augmentation funds available in some state bridge funding programs — will not permit rehabilitation or replacement of all deficient/obsolete bridges on a realizable time frame

BACKGROUND TO THE NBIS DATABASE

The NBIS was developed as a consequence of several events. In particular, a series of catastrophic bridge failures occurred in the 1960s (1,2). Some newsworthy collapses of long span bridges involving loss of human lives highlighted the gravity of situation to the public. Congressional action led to the passage of the "Federal Highway Act of 1968," which mandated basic regulations relating to bridge safety and bridge management and resulted in two important developments — updating of bridge inspection methodology leading to a comprehensive bridge inspection manual and the computerized NBIS. For collection of the needed current data, inspection of all highway bridges over 20 feet in length was mandated as well as thereafter on a biennial basis.

The NBIS-based bridge inspection process implemented a "sufficiency rating" (SR) for each bridge to reflect its physical state, functional condition, and load rating. SR values were used as the basis for determining a bridge's eligibility for competitive federal and state bridge funds. However, the NBIS process proved to be less detailed than needed. The SR values rely on qualitative visual assessments reflecting the experience and judgement of the bridge inspector. The bridge inspector uses single integer number measures to assign a state of condition to a bridge superstructure, substructure, channel etc. They are incorporated into the SR to numerically characterize or rank the overall condition of a bridge.

The NBIS provides no capability to detail the relative extent of deterioration in members, project usable remaining life or assess the functional and fiscal impact in maintenance management of the inventory. A need to document bridge inspection with more detailed and rigor inspections became evident. With limited funds it was vital to have more reliable assessment of the reality of the repair needs and benefits than the sufficiency rating provides. "Reliable" implies more detailed inspection data as well as probabilistic considerations in the condition assessment. It also was necessary to provide means of comparing the needs and merits of bridge repair and replacement decisions within the scope of a state's entire inventory of roads, bridges and other systems.

THE PONTIS BMS

The 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) mandated that each state DOT develop a bridge management system (BMS) on a defined time schedule. The CDOT, and many other state DOTs, began implementing the use of PONTIS, a federally-advocated, computer-based BMS model. PONTIS eventually will replace current inspection and inventorying procedures based on the NBIS. PONTIS allows more detail about individual bridge components. It also can be used to assess the state of deterioration and likely consequences, allowing "what if?" scenarios to be examined. However, PONTIS presently is a "black box" environment to users. Also, county and local bridge owners are accustomed to inventorying bridges by the NBI approach and have a "feel" for the resulting, albeit simplified, report data that results. Indeed, initially a translator program was developed to approximately convert NBIS data base information to the PONTIS data base format and vice-versa.

PROJECT OBJECTIVES

In simple terms, the documentation provided with PONTIS can be overwhelming to the new user, even if experienced with other BMS software. Researchers at CSU, working with the CDOT bridge management personnel, undertook the writing of a user-friendly documentation and commentary. The outcome was much abbreviated material that explains PONTIS and its use to a bridge inspector or manager in a targeted and usable way. This is done for a range of management levels.

Unlike the NBIS, PONTIS has statistical models to operate on groups of bridges or whole inventories. At the state DOT level, the complete state bridge inventory is involved and must be managed at the global level and, to a lesser degree, at the detailed level. At county or local levels, the need may be quite detailed or not depending on the approach at any given jurisdiction. Bridge inspection may be done in-house or by sub-contracting. In the former case, detailed knowledge of PONTIS usage is imperative. In the latter case, a manager may operate at the level of interpreting results, observing overall activity and developments, and conveying or receiving PONTIS information to and from the state DOT as related to the particular local or county inventory.

An equally vital aspect is that the mandated BMS must be capable of assessing deterioration, projecting its consequences on repair needs, planning resource allocation by priorities and relating the impact of bridge repair needs in other systems management needs, e.g. pavement management. PONTIS provides these capabilities and is a completely new element of capability available to the learner who is only accustomed to the NBIS.

THE STUDY

PONTIS is an extremely powerful BMS tool, which surpasses the capacity of NBIS in helping officials to manage their bridge networks. However, since PONTIS is so powerful, it also is complex. This is reflected by the extensive documentation associated with the software.

As is often the case with such powerful software, few users actually need to tap into all of its abilities and features. People are not inclined to embrace a radically different BMS when confronted with several hundred pages of manuals, therefore the main objective of the CSU researchers was to develop user-friendly documentation for the PONTIS software.

KICK-OFF MEETING WITH THE COLORADO DEPARTMENT OF TRANSPORTATION

The research process with regard to new PONTIS documentation essential began with a kick-off meeting Nov. 23, 1994. The meeting involved the co-author Nicholas Arenella,CSU graduate research assistant, and Walter Mystkowski, CDOT bridge management engineer.

The general time line for the project was discussed at this meeting. More importantly, the general make up of the study, as set forth in the scope of work, was more rigorously defined. In general, the study was to consist of several meetings with local bridge management officials to get a sampling of their questions and concerns regarding PONTIS in general. Next, a comprehensive questionnaire was to be developed based on the interviews and then sent to local bridge management officials throughout Colorado. Based on research results, new PONTIS documentation would be developed.

MEETINGS WITH LOCAL BRIDGE MANAGEMENT OFFICIALS

After the kick-off meeting, a meeting was set with several local bridge management officials. On Jan. 9, 1995, CSU researchers mailed letters (see Appendix A) to individuals in nearby locations introducing the PONTIS project and requesting an interview to discuss questions, concerns and desired results for such a project.

This letter was proceeded by interviews of three people selected from the responding individuals: 1) Mike Whalen of the Weld County Engineering Department, Greeley, Colo. on March 31, 1995; 2) Ron Winne, et. al. of the Larimer County Engineering Department, Fort Collins, Colo., on Jan. 26, 1995; and 3) Greg Muhonen of the City of Loveland Street Division-Maintenance in Loveland, Colo., on Jan. 24, 1995. The meetings were each approximately two hours long with an open format keeping a constant focus on how to make it easier for local and county users to take advantage of PONTIS.

The meetings gave the CSU interviewer insight into the specific needs of actual potential users. The interviews were beneficial in this sense, because the individuals being interviewed were typical of the personnel that would be inspecting and rating the structures, preparing the input and responsible to varying degrees for the allocation of funds in their respective jurisdictions. Subsequently, a questionnaire was written by the CSU researchers and reviewed by CDOT for input from other bridge management officials on topics generated from the original interviews.

PONTIS QUESTIONNAIRE TO LOCAL BRIDGE MANAGEMENT OFFICIALS

The resulting questionnaire addressed many topics (see Appendix B). The questions ranged from the practical, such as “Do you have an IBM or compatible computer?” to the more probing such as, “Whether or not you know about PONTIS specifically.” “ If a bridge management software package could do anything you wish, what would like to get as its principal output?” Approximately 20 surveys were mailed out and seven were returned.

RESULTS AND CONCLUSIONS FROM THE QUESTIONNAIRE

The returned surveys indicated definite consistencies. As anticipated, local and county bridge management officials did want more user-friendly PONTIS documentation. However, it also was learned that such documentation should not only be user-friendlier, but drastically abbreviated. There was a consensus that these officials did not require an understanding of the complex theory behind PONTIS' statistical models or several mathematically elegant ways of obtaining the same information. It also became apparent, that such documentation should not only serve as a reference, but as a teaching tool. The resulting documentation, therefore, is an abbreviated user's manual as well as a tutorial. Before discussing the resulting documentation developed at CSU, it is helpful to discuss the PONTIS software in more detail.

PONTIS AND THE ABBREVIATED PONTIS MANUAL

Background Information on the PONTIS Software

To develop statistical models and software that accomplishes goals for a BMS as set forth by the ISTEA, the bridge management problem must be seen in a fundamentally different way from what has been suggested and practiced earlier. According to the PONTIS developers, it was necessary to look at the problem **not** from the point of view of doing what was possible with the data on bridges collected over the years according to the FHWA rating method. An approach was taken which assumed there are better ways to present the information gathered from inspections rather than lumping all of the information in one rating number.

As will be described, the current rating method, despite its advantages for descriptive purposes, has severe limitations, which would make models based on it questionable. Although rating numbers are good descriptive measures and easy to communicate — after all, they assume that one number can describe a deck, substructure or superstructure — another option has been selected, which allows presentations of information to the model in much greater detail (page 10 of Tech. Manual).

STATISTICAL THEORY

At its roots, PONTIS is a decision support system that uses a probabilistic Markovian model for optimizations (Thompson, 1993). The Markovian model has two particular characteristics that make it well suited for use in PONTIS. One is the assumption made about the source of information. The other is the way in which the model operates on that information.

The Markovian model is based on different assumptions than those of typical random variable statistics. In the simpler, more commonly understood field of random variable statistics, one assumes that the information to be transmitted consists of the outcome of an experiment involving a random variable X.

For such an experiment, if successive values of X are to be transmitted, the values are assumed to be independently chosen. However, in a Markovian model, any given transmitted value off is *dependent* on *all* preceding values of X (Ash p 169). In the case of PONTIS and bridge inspection and management this can be illustrated as follows.

Assume that in a previous inspection report a structural element was given a low value corresponding to a deteriorated state. Now, unlike the rolling of die, the chance of the element having a particular rating in the future is not evenly distributed among all possible ratings. This would be impossible in the case of a high rating, which indicates the element was in good condition, because it is not possible for an element to spontaneously become less deteriorated. In this case, the probability of future states is not random, but based on the past history of the variable.

The other characteristic of interest of the Markovian model is that it operates on the functions of variables — actually chains of variables — rather than on the chains directly (Rosenblatt p. 87). This has the direct advantage taking into account other factors that affect a variable other than only its previous history. Again, using the same example above, assume that an element has been rated low in a previous inspection. It already has been shown that in a Markovian model the increased likelihood of some future outcomes over others can be modeled. However, in addition to this, one also can take into account other factors using this model.

For example, in PONTIS a deterioration formula is generated by using consecutive inspection reports. That is, the model can take into account, not only that some outcomes of the elements' condition are impossible, but that some may be more likely than others due to the rate of deterioration from the local environment. Further, a Markovian model could include other functions of the chain simultaneously in its decision making process, such as using a formula based on maintenance habits of a particular jurisdiction, which are based on answers to an online survey given by PONTIS to potential users.

Also, because the Markovian model can recognize certain outcomes as impossible, it has an indirect advantage. This helps the model to pack more information into a smaller space as far as computer programming is concerned (Rosenblatt p. 87). Although computer technology continues to grow rapidly, the incredible volume of information associated with a bridge inventory, coupled with the limited resources of rural and local users for high end computer hardware, still makes this an advantage when considering the available RAM, ROM and clock speed of an older, non-networked PC.

THE PONTIS BRIDGE INSPECTION PROCESS

The actual inspection procedures carried out by bridge inspectors in the field are not drastically different for a PONTIS inspection than for a NBI inspection. Actually they are quite similar. However, the ways in which their results are reported, cataloged, and most importantly, used vary.

A bridge inspector examines all the elements of a bridge and makes note of their conditions. However, this detailed work is lost in the results of a NBI inspection because the only information that is readily available to decision makers are the single condition ratings for “deck,” “superstructure,” “substructure,” and “waterway adequacy.” In comparison to that, PONTIS results are element based. Actually, due to mathematical and programming considerations, a PONTIS database is a collection of bridge elements not bridges. Consequently, PONTIS results give an indication of the condition of elements such as bearings or stringers. There are many “standard” elements built into the PONTIS database for the analyst’s use. PONTIS also allows the user to input additional elements that may be unique, or of interest to, a particular agency or individual.

THE UTILIZATION AND ANALYSIS PROCESS

PONTIS is a network level BMS, which incorporates a set of probabilistic models and a detailed bridge database to predict maintenance and improvement needs, recommend optimal policies, and schedule projects within budget and policy constraints. PONTIS makes use of many modules. Some of the modules are not directly accessible by the user. The modules work “behind the scenes” only when called upon by other modules that do have a user interface. Of the modules with a user interface, there are four that are of the most concern. Following is a brief description of them.

First there is the Database. The database includes all inventory and condition data, and all maintenance improvement and user cost data. It contains answers to an online expert elicitation questionnaire, which are used to set deterioration rates in the model based on several experts’ answers to questions concerning deterioration rates.

Second, there is the Maintenance, Repair, and Rehabilitation (MR&R) model.The MR&R model uses deterioration models and maintenance costs to choose minimum cost maintenance strategies for up to 160 different kinds of bridge elements. The MR&R model does not directly take funding constraints into account. It assumes there is unconstrained funding for typically less expensive MR&R actions. If a user’s jurisdiction does not have enough money in its MR&R budget, one can overcome this aspect of the software by using a standard PONTIS report that will rank MR&R actions in decreasing order of benefit to cost ratio.

Next, there is the Improvement model. The improvement model in PONTIS is a module used to identify potential improvement action and prioritizes them along with MR&R action. PONTIS has three “improvement” options available to the user. The first two are widening and raising. These improvements are based on existing roadway width and vertical clearance, respectively. The third improvement built into PONTIS is the act of replacement with a functionally-superior structure based on a combination of widening, raising, load carrying capacity and MR&R consideration. The decisions are based on the unit cost for such improvements and MR&R, as compared to the cost for replacement.

Finally, there is the Integration model. The integration model combines the bridge element maintenance results and the improvement projects into a single recommended bridge level program. This capability uses a benefit/cost ranking to set priorities, and respects funding program eligibility requirements and budgets. It should be noted that this is done by assuming all MR&R can be paid for and then scheduling the most beneficial improvements as possible with respect to the budget.

As was earlier noted, PONTIS provides the capability to generate "reports." Actually, for staff who are responsible for making decisions about the bridge inventory, this is probably the most important and impressive feature of the PONTIS software. PONTIS has many types of reports that it can readily produce via the user selecting from its pull down menu system. An option to customize reports also exists for the advanced user. Possible reports generally fall into two primary categories. The first includes types of reports that simply display vital information in the database in a convenient arrangement, such as "all bridges falling below a certain sufficiency rating." The second category is defined by those that recommend MR&R and improvement actions in some manner. The second type of report is derived from the results of the probabilistic models and the software's forecasting capabilities. An example of such a report would be a listing of PONTIS recommended MR&R and improvement actions based on a given budget that most effectively targets an agency's budget.

The latter example of a typical PONTIS report is tied to another advantage of using PONTIS. By using the PONTIS software, one can readily run "what-if?" analyses. For example, one could raise or lower a given budget to determine its effect not only on the future physical condition of the bridge network, but the possible financial repercussions. Such information could be used to the advantage of an agency trying to substantiate that by cutting funding now, a larger outlay of money will be needed later.

SCOPE AND ATTRIBUTES OF THE ABBREVIATED MANUAL

The major result of this project is documentation that the Colorado State University researchers produced. The document's preliminary title was *"PONTIS Bridge Management Software, An Introductory User's Manual and Tutorial for Release 2.0."* The document is an abbreviated adaptation of the original PONTIS manuals and tutorial (Release 2.0) and, as indicated earlier, was written with the needs of the local and county bridge management community in mind. At the conclusion of the project it was retitled as *"PONTIS Made S-I-M-P-L-E, An Introductory User's Manual and Tutorial for Release 2.0."* It was retitled based on the reactions received from attendees at a demonstration workshop held near the project's conclusion. The full document is available from CSU where it is being maintained (Arenella, et al. 1997). The cover page and table of contents are in Appendix C.

The user's initial impression of the manual should be favorable. It is 68 pages, making it about one-tenth the length of all the combined PONTIS manuals that come with the software. The manual has five chapters entitled:

1) Introduction

2) Getting Started

3) Bridge Element Information & the Database

4) The MR&R Optimization Model

5) The Annual Updating Cycle

The chapters address basic information needed for the potential user to quickly begin the process of implementing PONTIS and realizing its potential benefits. The chapters are organized in a logical manner for use by practicing engineers. They also are presented in an order relative to each other, which is most beneficial to the user who wishes to quickly "get up to speed" in implementing PONTIS. For example, in Section 3.1.1 of the CSU documentation it states, "Building the database is a relatively straight forward, although initially a somewhat time-consuming step. However, fortunately, the other modules of PONTIS do not have to be understood, or even accessed, for a user to effectively begin the process of building the database and thus, begin to realize the advantages of PONTIS." This passage is indicative of how, throughout *PONTIS Made S-I-M-P-L-E*, information is presented not only in a clear, concise, and useful manner for the user, but that the sensibilities and needs of the intended user — local and county bridge engineers and managers — are always kept in mind.

As was previously mentioned, the manual was developed to serve not only as a reference, but also as a teaching tool. As with many manuals, examples are used to illustrate different features of PONTIS. In this manual, examples throughout the manual have been tied together through a common example. People reading the manual can quickly assimilate how to implement PONTIS on their bridge inventories. To accomplish this most effectively, a miniature database of 16 actual bridges from Virginia is used throughout the manual. By using real bridges, users immediately get a feel for how to implement PONTIS for their bridges.

RESULTS OF TESTING THE ABBREVIATED MANUAL

The document produced at CSU was reviewed and revised in house several times to produce a clear, concise, and useful document. Then it was sent to select persons for content review. Once it was revised, the researchers went through every example to make sure that every PONTIS command entered and every response to the commands was consistent to examples in the developed manual.

To test the manual's effectiveness, a hands-on workshop was conducted May 3, 1998, for a small group — due to physical constraints — of selected participants. Some were sent an announcement and invitation (see Appendix D). Some were identified via an announcement (see Appendix D) in the newsletter of the Colorado Transportation Information Program, which is the Local Transportation Assistance Program (LTAP) center at CSU. The newsletter also had previously published articles about the federal BMS mandate and the PONTIS program (see Appendix D). Attendees consisted of individuals from the original interviewees, from other municipalities and counties, representatives of the CDOT and Colorado's FHWA Division office, a trainer from the LTAP center at CSU, and a structural engineering graduate student.

The workshop's program and some of the distributed items are shown in Appendix E. Background to the MPC project and its prior activities and developments were described. The basic principles of BMS and the features of the PONTIS software were summarized. Walt Mystkowski provided an update on the status of the implementation of PONTIS at the CDOT and its plans for access by local and county entities. A content overview of the developed manual was followed by a demonstration of several detailed examples, which illustrated the use of some of the basic features of PONTIS.

The second half of the workshop was comprised of an extensive hands-on example executed by the participants. The example led them through many sections of the developed user’s manual. The example used a miniature database of 16 bridges, which was supplied to the developers of PONTIS by the state of Virginia. By using the actual bridges and their actual inspection data, participants were confronted with a realistic experience from which to learn. Some experiences involved missing or incomplete data, as can all too often occur in actual situations. The small sample size enabled the workshop to be completed in a practical time constraint. The workshop leader took a hands-off approach for this segment of the workshop. Participants were required to rely on the prototype *PONTIS Made S-I-M-P-L-E*, which had been distributed to each participant.

At the end of the workshop, participants completed an extensive questionnaire to determine whether the manual had achieved its goal. The questionnaire and tabulated results are provided in Appendix E. A dialogue also took place to gather introspective reaction and input. It was clear from the results that the manual and the workshop were effective tools to introduce new users to the workings of PONTIS at the particular version level employed. The version used (Version 2.0) was chosen because CDOT indicated it was the most practical level, in storage requirements and capability, for targeted first-time users at local and county levels. Advanced versions were much more in use by the state DOT itself.

Two distinct observations were drawn from the results of this workshop. One was the evident success in achieving the project objective of getting potential PONTIS users past intimidation of the comprehensive documentation provided with the software. The other was that although a process for surmounting this initial hurdle was developed, another awaits — actual implementation of PONTIS at local and county levels.

Responses to the quality and “user-friendliness” of the workshop and *PONTIS Made S-I-M-P-L-E* manual were overwhelmingly positive. Question 5 asked if the workshop was effective. Twelve attendees rated it at a 4 or 5 level (5 being highest). Question 13 posed, “After the workshop do you feel (a) more competent about PONTIS, (b) more comfortable using PONTIS?” For (a) three chose 3, four chose 4 and two chose 5. For (b) three chose 3, four chose 4 and two chose 5. The questions speak most directly to quality of the end product.

Responses to the “short answer” questions indicate the future hurdle for local and county users of PONTIS — attendees’ perception regarding actual need for *any* BMS at those user levels. Although participants are interested in using PONTIS in the effective management of their bridge inventory, many of them expressed a lack of incentives to invest resources into learning and using PONTIS. The responses to the question “Before this workshop, what obstacles or deterrents to adopting PONTIS do you see in your organization?” are informative. One answer states “Staffing limitation. CDOT performs inspections and reports on +20' bridges. No requirement exists for systematic monitoring of sub 20' bridges.” Another says, “I am not set up to run PONTIS. Though I try to keep abreast with the program.”

The day before the workshop, a seminar on the project was presented over the TEL8 telecommunications network to several university and state DOT sites in USDOT Region 8 (see Appendix F). Nick Arenella conducted the defense of his thesis work, derived from this project, as part of the formal requirements for a master of science degree. This afforded an interactive, audio-visual opportunity to “test the water” with an interstate audience of students; educators; and local, county and state bridge management personnel. While not a workshop involving hands-on use, the demonstrations shown as part of the thesis presentation and subsequent Q&A activity, provided more insight into reactions of other potential new users, some of whom may have been unaware of the project.

Once this sequence of extensive testing and feedback was completed, *PONTIS Made S-I-M-P-L-E* was refined and submitted for outside review by Walter Mystkowski. Several minor changes were made according to his input and recommendations. His overall impression of the *PONTIS Made S-I-M-P-L-E* manual was an excellent document that met its intended goal as a reference and teaching tool for local and county bridge management officials considering implementing PONTIS.

AREAS OF FUTURE RESEARCH

Background to the Project

Before indicating possible areas of future research one must first understand the history of this particular project. In fall 1993, CSU researchers completed development of a prototype bridge inspection computerized tool (Austin, 1993). This tool, Bridge Rating (BRAT), performed load and sufficiency ratings using the approaches given by the American Association of State Highway and Transportation Officials (AASHTO) and the NBIS, respectively. The user interface was in a spreadsheet format. In addition to physical bridge information, which can be measured (i.e. span, width, approach length), the system also managed subjective information (i.e. deck deterioration and implications of section loss of a girder). An expert system component was combined with a spreadsheet program to create the BRAT system. The first prototype was limited to use by trained bridge inspection engineers.

To refine this system to satisfy the needs of inexperienced bridge inspectors, four approaches were taken to enhance BRAT:

1) Commercially available software was found that would serve as the user interface and the expert system shell. This software is called ESTA (Prolog Development Center, 1993).
2) Using ESTA, a menu-driven interface for all of the BRAT spreadsheet was created and greater "help" facilities were developed.
3) To make the system more appropriate for inexperienced inspectors, the expert system was expanded to include more questions to manage uncertainty of inputs through using fuzzy logic.
4) The second prototype also was expanded to include the option of writing comments, which would be of help to the individual reviewing the results.

The final result of this work was a prototype portable computer tool for bridge inspection called Bridge Rating and Analysis (BRAIN) (Trantham-Hevelone, 1995). It was "tested" via a series of hands-on workshops on evolving versions. The workshops were attended by interested local, county, and state bridge inspections and management personnel, including the Staff Bridge Engineer of the CDOT.

INTEGRATION OF PONTIS WITH PAST RESEARCH

BRAT, developed in 1993, basically was the prototype for BRAIN, developed in 1994. BRAIN was designed to be a highly user-friendly portable computer inspection tool that could be used by technical staff within a range of bridge inspection experience or capability. The motivation behind this was that in the rural west — particularly USDOT Region 8 — there are many bridges with spans less than 20 feet, often referred to as “sub 20' bridges,” which currently are not being inspected for inventorying purposes. The reason for this is two-fold.

For one, the local and county agencies that have jurisdiction over such bridges often do not have an experienced bridge inspection engineer to inspect the structures. An expert system-based tool like BRAIN leads them through interactively and documents the results via queries. Thus, unofficial preliminary inspections could be performed by less experienced technical staff. Fuzzy set theory and logic are used to account for the experience level initially indicated by the user. Second, related to this, is the fact that federal funding currently is not available for “sub 20' bridges.” Using BRAIN, it is feasible to inventory such bridges, albeit unofficially. The option to use less experienced personnel, or possibly maintenance personnel, gives local and county agencies more incentive for cataloging them. With such organized information available, jurisdictions also could promote use of state and federal funds for formal, official inspections, and repair and replacement funds.

It appears PONTIS will become the way in which many states manage bridges and request federal funding for repairs and replacement. As a result, a need exists for bridge management officials to understand how to use PONTIS for current qualifying bridges (length greater than 20 feet). However, the question about how to fund sub 20' bridges still remains. If local and county agencies can foster federal funding for their currently non-qualifying (sub 20') bridges, the problem still remains of the lack of experienced engineers to inspect them. It should be noted that PONTIS is a program that has been written for such trained bridge inspectors. The logical answer to questions about employing the user-friendly interface already are developed within BRAIN. However, rather than having it access the NBIS-based spreadsheet developed with BRAT, the BRAIN interface could be mated with the PONTIS software.

In her thesis (derived from the development of BRAIN), Trantham-Hevelone states, “Additional refinement would serve to make BRAIN faster, even easier to use in the field, and better at storing information.” One such refinement she suggests is that the “C++” language be used as an alternative to ESTA because the use of C++ “would provide the programmer more flexibility in designing the way questions could be asked and would reduce the amount of memory taken by the running of the program.” It should be noted that BRAIN currently requires 12 megabytes of memory to run. By today’s standards, this still is considered a large amount of memory.

PONTIS, too, is written in the “C” language. This suggests a natural implication that the questions, logic, and algorithm of the existing BRAIN interface could be recorded in C or C++ and be a seamless mate to the PONTIS software. That link would create a powerful, user-friendly, portable inspection tool. It could be used at all levels, from the municipality to state jurisdictions. At local and county levels it might be used by technicians, maintenance workers, interns, or junior engineers to conduct lower level, preliminary inspections of bridges. These would serve to begin documentation of inventory and to “red flag” bridges that need further study by a fully qualified inspector. Further, if done by a qualified bridge inspection engineer, the results would be in a format and on a basis accepted by federal agencies for inventory and funding requirements.

CONCLUSIONS

As the 21st Century approaches, there has been a dramatic shift in the way in which resources are used in the world's industrialized nations. As one can read about corporate downsizing and government restructuring, one also can expect that in the future even fewer funds may be available for the already overburdened infrastructure system. Regardless of funding levels, federal mandates assure that a higher level of bridge inspection database information be required from the states to receive federal funding. As of 1999, all 50 states will be required to request funds based on the outcome of a rational BMS. It is imperative that everyone responsible for bridge inventories at all levels be familiar with that process. In the case of Colorado, as well as many other states, this primarily consists of understanding PONTIS' capabilities and its implications to bridge maintenance and repair management. In some cases, the need to directly use PONTIS also exists.

PONTIS is a high quality and powerful, albeit complex, software package for BMS. Many bridge management officials could benefit from it use. Some initial fears of tackling this software can be allayed by the use of the "PONTIS Made S-I-M-PL-E" guide and tutorial and attendance at workshops similar to the one presented in this project. However, before resource-limited local and county bridge owners can justify the expenditure of resources for PONTIS, they must be convinced of the actual necessity of implementing BMS. This may evolve as PONTIS becomes more prevalent in state DOTs, and new local and county policies are created to accompany use of a BMS.

With the funding of the Mountain-Plains Consortium (MPC), researchers at CSU have provided potential means for local and county bridge management officials to more readily access future federal bridge funds. To date, two tangible tools have been created: the bridge inspection software, BRAIN, and the abbreviated *PONTIS Made S-I-M-P-L-E* manual. BRAIN serves as a practical tool for current NBIS inspections and can be modified to interface with the PONTIS database. *PONTIS Made S-I-M-P-L-E* facilitates bridge management officials' access to PONTIS and the federal bridge funding process associated with its use.

As the future unfolds, requirements are sure to change. Presently, this project's outcome provides a means to introduce local, county, and other bridge owners to the workings and potential of PONTIS. Presently, for sub 20' bridges, which are unofficial bridges, informal inspection and "red flagging" by the use of the NBI, database format already within BRAIN is possible and probably sufficient. BRAIN also can be customized to desired in-house formats. With these two powerful tools, local and county bridge management officials have practical solutions available for their current needs and researchers have strong, building blocks for efficiently meeting their future needs.

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APPENDIX A

LETTER SOLICITATING INTEREST

APPENDIX B

INITIAL QUESTIONNAIRE

APPENDIX C

PONTIS MADE S-I-M-P-L-E
(Cover Page, Peripherals and Table of Contents)

APPENDIX D

PUBLICITY FOR THE PROJECT AND WORKSHOP

APPENDIX E

PONTIS MADE SIMPLE - A WORKSHOP
(Program, Overheads, Questionnaire and Results)

APPENDIX F

TEL8 SEMINAR ANNOUNCEMENT