CONNECTICUT'S BRIDGE MANAGEMENT INFORMATION SYSTEM

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ABSTRACT

Procedures for the storage and retrieval of bridge-related information at the Connecticut Department of Transportation (ConnDOT) had remained virtually unchanged since the Department began keeping records. In 1985 the Department began utilizing advanced technologies to store and retrieve highway photolog images which provided an integral element in the development of the Department's Pavement Management System. In 1988 ConnDOT, in cooperation with the Federal Highway Administration, began investigating the use of the same technologies for the storage and retrieval of bridge-related information. The investigation brought to light inefficiencies in the storage and distribution of bridge-related data within the Department. With the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, six management systems were mandated, including one for bridges. This paper briefly describes the development of an information system dedicated to bridges and how it is being modified to provide input to the Connecticut Bridge Management Information System (CBMIS), to assist in the processing of data, and to support the results of a network analysis on a bridge-by-bridge basis.

BACKGROUND

The Connecticut Department of Transportation began using laser videodiscs in 1985 driven by a personal computer to store photolog images of the 7,700 bidirectional-mile highway network. The system used to access these images consists of a personal computer and videodisc player. It operates using software written by personnel in the Department's Division of Research and a private software firm. The system is referred to as the Photolog Laser Videodisc (PLV) System. It provides quick and easy access to any cumulative-mile location on any state-numbered route. The system is used in eleven application areas: network-level pavement management, safety analysis, project development and design, highway-sign inventory, legal evidence, public hearings, construction documentation, planning and inventory, and maintenance. It is used in the daily operation of the several units that work in these areas within the Department. Over $800,000 is saved each year in the elimination of field trips by pavement raters and others who use the system. There are 15 PLV stations located throughout the Department and in the Federal Highway Administration (FHWA). The number of PLV stations is anticipated to increase to meet the expansion in transportation applications, which is consistent with the philosophy on which it was initiated, to share existing information with as many potential users as possible.

Because of the large investment made in hardware and software expertise with the PLV system, in 1988, personnel in the Division of Research began investigating ways to expand the use of the underlying technologies. The Demonstration Bridge Information System (DBIS) project was initiated to develop an information system exclusively for the states' 5,000 bridges based on the PLV technology. The system would maintain an imagebase using the laser videodisc capability and a related database using a personal computer.

SYSTEM DEVELOPMENT

The purpose of the DBIS was to show the use of integrated computer and videodisc technology for the storage and retrieval of bridge information. The system was to be user-friendly and require no computer knowledge to operate. Although unforeseen at the time, the resultant system now provides the Department with the means for later development of a key element of its Bridge Management System (BMS).

Interviews

The first action in the development of the DBIS was to interview Department personnel who were familiar with the PLV system and whose duties were bridge-related. The question was posed that, given a system like the PLV, what type of information would you ideally want it to contain. It was determined that the internal flow of bridge-related database-type information was based on an archaic and inefficient system. Most of the bridge-related units did not share information with other units and conflicts did arise where the same work was scheduled to be done by two independent units. Several persons viewed the database capability of a DBIS as the solution to these conflicts and the investigators were quick to realize the importance of this type of information. The ability to query a common system or database made up from all pertinent sources was viewed as a timely development that would effectively address some difficult operational problems. It was with suggestions from these interviews, and the fundamental idea that the system would be used to query information only, that the database modules of the DBIS were designed. The imagebase portion was designed so it could be accessed through any of the database modules. Each of these modules is briefly described below.

Database

Bridge Log

This module was to replace the hard-copy binder used to maintain basic static information about bridges such as route, length, width, etc. Several suggestions were made to include other data and they were incorporated into this module. This module includes all National Bridge Inventory (NBI) data incorporated into the DBIS through an annual updating procedure. Representative screens from this module are shown in Figures 1 and 2. All data in the DBIS can be output in a printed report through a menu selection.

Chronology

This module was designed to provide a common database where all bridge-related units would share information. It is a chronological listing of all past, present and future activity on a bridge-by-bridge basis. This module tracks data necessary to analyze long-term performance of all construction, maintenance and inspection activity on a bridge with associated details. For example, through this module a user can access a copy of the Department's latest official bridge safety inspection report. This module also provides a cross-reference between a bridge identification number and associated project identification numbers. A representative screen for this module is shown in Figure 3.

Project

The design of this module was based on providing details about bridge-specific construction projects and, as the Chronology module does, provides a cross reference between a project identification number and associated bridge identification numbers. Often, there is a one-to-many relationship between projects and bridges. A representative screen for this module is shown in Figure 4.

Crisis

This module was based on the suggestion of a District Engineer who requested a source of information for off-hours use by an individual responding to an emergency. It lists recommended bypass routes for every route affected by closure of a bridge, and also utilities, local towns and DOT personnel to be notified. It is anticipated that an Incident Management System would derive benefit from ready access to this data. Representative screens for this module are shown in Figures 5 and 6.

Imagebase

This pictorial module, accessible from all database modules other than "project," consists of a still-image photo album for each bridge. Images depict views of 1) each elevation of the bridge, 2) roadway approaches, 3) substructure details, 4) underside of deck, 5) superstructure details, 6) conditions photographed by Bridge Safety Inspectors, 7) special features such as mechanical systems on moveable bridges, 8) upstream and downstream, where appropriate, and 9) any special signing on or adjacent to the bridge.

For the DBIS, Research personnel gathered photo documentation of 43 bridges representing a broad cross-section of bridge designs found in Connecticut. The representative computer screen for choosing this module from the Bridge Log is shown in Figure 7. Note that the video images are displayed on the video monitor concurrently with the captions displayed on the computer monitor. Video prints of all images displayed are available as output using a color video printer.

IMPLEMENTATION

Based on the findings of the DBIS project, the FHWA approved a request for the implementation of a full-scale Bridge Information System (BIS) within ConnDOT. A fully implemented BIS is viewed as the means to improve communication, reduce duplicative efforts and facilitate later development of a BMS.

The largest task associated with implementation was the computerization or re-engineering of the operational processes of many bridge-related units. This involved purchase of hardware and development of software so information regarding the day-to-day operation of each unit would exist in an acceptable format. Once in this format, the data could then be provided to a full-scale BIS. To provide current information and ensure its validity, the task of generating and maintaining a computerized data source would have to be integrated

Connecticut Department of Transportation — Bridge Information System

Bridge Log — Bridge # **196** — Historical Status **5**

District # **3** — Structure Type **STEEL STRNGR/MBEAM/GIRDER**

Town **BRANFORD** — Route **A095** — Ramp — Milepost **055.18**

Function **OP RTE US 1 (E. MAIN ST)** — Old #

Owned By **CONNDOT** — Maintained By: **CONNDOT**

CHOOSE AREA OF INTEREST

DIMENSIONS/CLEARANCES.... [D] BRIDGE NUMBER INFORMATION. [N]

BRIDGE MATERIALS/DESIGN.. [M] ROADWAY SITE INFORMATION.... [S]

WRITE AND FILE NOTES.......... [W] RETURN TO MAIN MENU................ [X]

VIDEO IMAGES.......... [V]

FIGURE 1 Bridge log module main menu.

BRIDGE DIMENSIONS/CLEARANCES

BRIDGE # **196** **I 95/ US 1**

INVENTORY ROUTE **A095**
MIN VERT CLEARANCE (FT/IN) **UNLIMITED**
MIN HORIZ CLEARANCE (FT) **36**

LENGTH (FT) **136**
MAX SPAN **51**
MAIN SPANS............ **3**
APPROACH SPANS.... **0**
SKEW ANGLE **26**
DECK WIDTH **72**
OUT TO OUT **104**
CURB TO CURB......... **72**

CURB OR SIDEWALK WIDTH (FT)
RIGHT **1.7** LEFT **1.7**
APPROACH ROADWAY WIDTH (FT) **98**
VERT CLEARANCE OVER BRIDGE ROADWAY **UNLIMITED**
LATERAL UNDERCLEARANCE LEFT (FT) **8.0**
LATERAL UNDERCLEARANCE RIGHT (X/FT) **H 8.0**
VERTICAL UNDERCLEARANCE (X/FT/IN) **H1408**
FOR X; H=HIGHWAY, R=RAILROAD, N=NEITHER

PRESS ANY KEY TO CONTINUE

FIGURE 2 Bridge log module submenu.

Connecticut Department of Transportation — Bridge Information System

Chronology Screen — Bridge # **196** — **I 95 / US 1**

Date	Description	Form/Project #	Note	Plan/Sum
11/12/58	Construction	319-001	Y	220-227/670
04/09/80	Inspection	BRI-18	N	15/8/5/0 5m0c
03/09/81	Inspection	Maint 15	Y	15/7/6/0 6m0c
11/18/81	Inspection	BRI-18	N	15/5/8/0 8m0c
12/22/82	Inspection	BRI-18	N	13/8/7/0 7m0c
10/23/84	Inspection	Maint 15	Y	12/5/9/0 9m1c
02/20/85	Inspection	BRI-18	Y	10/8/9/0 9m1c
03/03/87	Inspection	Maint 15	Y	5/7/7/n/n/7/5
05/28/87	Inspection	BRI 18	Y	8m2c
10/05/88	Inspection	Maint 15	N	10m2c
09/20/89	Install Keepers	Maintenance	N	9D243168
09/27/89	Reseal Joints	Maintenance	Y	9D243168

PRESS THE ↑ ↓ OR PgUp/PgDn Keys to Browse /Select
X= Exit P= Print Screen N= View selected entry notes

FIGURE 3 Chronology module main menu.

Connecticut Department of Transportation	Bridge Information System
PROJECT # 319-001	
Fed Aid # NONE	Awarded 04/15/56
Description Const. Rte 95/Rte 1	Date of Completion 11/12/58
Contractor M.A.Gamino Corp	of.... New Haven CT.
Designer Seelye,Stevenson,& Knecht	Date of Plans 10/31/55
State Form #808 1955	ASSHTO Design Spec 1953
Estimated Cost N.A.	Actual Cost $8,187,839.75
File # 317-01	Microfilm ID 317-01

Notes

F2:Continue/Exit F4:Bridges Included F5:Print F10:View Notes

FIGURE 4 Project module main menu.

Bridge Information System Crisis Information
Bridge # 196 Location Rte 95 JCT US 1, at Exit 55
I 95 / US 1

Town of	Branford	Police	481-4241	911 Available From Within Town of Concern
Nearby Towns......	Guilford	Police	453-8061	State Police Troop F 562-6066
	N. Branford	Police	484-2703	
	E.Haven	Police	468-3820	

Other Agencies-> Connecticut Light & Power 777-7268
S. New England Telephone 661 or 771-5200
Branford Public Works 488-4156

DOT DISTRICT 3
District Engineer (New Haven) 389-3020
Bridge Maintenance (Milford) 878-6309/6300

Press: R to View Bypass Routes ; P to Print all Information
V to view Video Images ; Any other key to continue

FIGURE 5 Crisis module main screen.

Bridge Information System Bypass Information
Bridge Number ...... 196 Town......... Branford
Location.......... I 95 / US 1

Rte 95 N.B.	Exit 54 to Cedar Street South to Main Street North to E. Main Street Enter Rte 95 at Exit 55
Rte 95 S.B.	Exit 56 to Leetes Island Rd. North to E. Main Street South to Entrance at Exit 55
I-95 Bypass	Extra Travel Distance 1 Mile, Est.Travel Time 30 Minutes
Rte 1 N.B.	Enter 95 at Exit 55 to Exit 56 Leetes Island Road North to Rte 1
Rte 1 S.B.	Enter 95 at Exit 55 to Exit 54 Cedar Street South to Rte 1
Rte 1 Bypass	Extra Travel Distance 1 Mile, Est.Travel Time 10 Minutes

Press [ESC] to Exit Print from Previous Screen

FIGURE 6 Crisis module bypass route screen.

Connecticut Department of Transportation Bridge Information System
Bridge Log Bridge # 196 Historical Status 5
District # 3 Structure Type STEEL STRNGR/MBEAM/GIRDER

Town BRANFORD Route A095 Ramp Milepost 055.18
Function OP RTE US 1 (E. MAIN ST) Old #
Owned By CONNDOT Maintained By: CONNDOT

Date Caption Use the ↑↓ or PgUp/PgDn keys to Scroll Images

10/27/89 North Elevation
10/27/89 North Elevation
10/27/89 South Elevation
10/27/89 South Elevation
8/15/89 N.B. Rte 95
8/15/89 S.B. Rte 95
8/15/89 Median Guide Rail
10/27/89 Abutment 1
10/27/89 Pier 1

Press F2 key to Exit This is image 1 of 26

FIGURE 7 Bridge log module screen while viewing video images.

into the daily operation of each unit. Clearly this must be an improvement in their work process rather than an additional data-entry duty.

An example of this effort was the computerization of the bridge inspection process with the use of laptop computers. Inspectors within the Division of Bridge Safety began using the computers in the field to record information during the normal biennial safety inspections that was formerly recorded by hand on paper forms. This served to improve the recording of bridge inspection information and provide a source of information that is compatible with the BIS. This source can now be uploaded to the BIS and made available to users of the BIS without any extra effort in the inspection process. Future biennial inspections will be carried out by overwriting the BIS inspection report that will be downloaded to the laptop computer. The signed hardcopy of the previous year remains the official inspection report. Efforts are currently underway to computerize the permitting of oversize/overweight vehicles so this information can be made part of the BIS. Within the Office of Engineering, a program to track a project through the design process is also planned not only for interoffice use, but for interdepartment use through the BIS.

The imagebase is being filled with 35 mm images taken by bridge safety inspection personnel during their normal biennial inspections. Prints are returned to bridge-safety personnel while developed negatives are forwarded to the unit responsible for PLV production. Images are recorded on a recordable videodisc "master." When enough images have been accumulated, a Philips-format videodisc is produced and replicated. Copies are then distributed to the 27 BIS viewing systems as an imagebase update.

BIS COSTS

With the continual decline in the cost of personal computers, it is difficult to provide a valid cost for a BIS workstation. The essential components in a complete workstation are: a personal computer with a minimum hard disk capacity of 120 Megabytes; a laser videodisc player that can be controlled by the PC through a serial port; and, a NTSC compatible video monitor. The cost of other equipment such as a modem, video printer and laser or dot matrix printer, depends on the features specified.

The labor cost of implementing a full-scale BIS is directly related to the level of computerization that exists within bridge-related units. The cost of operating such a system is difficult to estimate given its current implementation stage. Optimistically, the cost of operation should be minimal since the information that the system uses will be provided through the normal operation of bridge-related units.

BRIDGE MANAGEMENT SYSTEM

As defined in the *Federal Register*,

> "The primary purpose of these management systems is to improve the efficiency of, and protect the investment in, the nations existing and future transportation infrastructure,"

wherein,

> "The management systems are envisioned as part of an integrated transportation information system that would: facilitate coordination of the

management systems with related programs (e.g., HPMS, speed monitoring, air quality, etc.), facilitate the sharing of resources and data, improve communication among data users, and facilitate the coordination of the metropolitan and statewide plans and programs." (*1*)

While the BIS is not an "integrated transportation information system," it was designed as an integrated information system for bridges. Some problems discovered during the BIS project bring to light the importance of coordination, sharing and communication between data users. A common misconception is that a BMS is also a BIS. A major aspect of a BMS is a network analysis tool, such as Pontis or BRIDGIT. The validity of a network analysis is only as good as the data input to the program. The time spent actually doing a network analysis is insignificant when compared to the time and energy spent collecting and updating the required bridge-related data.

The data required for a BMS network analysis are essentially of two types: condition rating and inventory information. To collect Pontis condition ratings, a computer program was written for use on the laptop computers and augments safety inspection data collection. Inventory data will be gathered from many sources including several database files maintained on the Department's mainframe computer and other personal computer-based programs and data files. The BIS implementation project will provide an initial collection and updates of data for all bridges. The BIS data are available to a BMS analysis in the same way that mainframe data are. Further processing of some data, such as conversion of inspection-date format, to meet the requirements of a BMS analysis tool can be done within the BIS. The hardware used for the BIS meets the requirements of a BMS analysis tool such as Pontis and BRIDGET.

Operation

Operation of the BIS will address several issues related to an integrated transportation information system, such as, sharing data resources, improving communication among data users and coordinating the operation of bridge-related units within ConnDOT. This will be done through the distribution of computerized data files that are the products of the daily operation of the bridge-related units. These compatible data will then be processed and provided to a network analysis program as needed. The BIS will support the results of these analyses through the historical archive of information.

As with any system of this magnitude, several personnel will be responsible for ensuring that data are distributed and maintained. Software and hardware upgrades and maintenance also will be the responsibility of these personnel. These personnel also will be tasked with performing the network analyses.

Upgrades and Improvements

Several efforts are currently underway to expand and improve the use of laser videodiscs within ConnDOT. A "video windows capability" to view video images on the computer screen will eliminate the need for the video monitor and provide the full functionality of both the PLV and BIS. Future improvements will include the use of digital cameras during the inspection process. It is anticipated these images could be imported to upgraded laptop computers in the field and immediately integrated into the inspection report. Long-term storage and broad distribution of these digital images will then be efficiently provided using the laser-videodisc format currently used.

SUMMARY

Connecticut is fortunate to have been involved in a project of this type long before the mandated implementation of a BMS. A key element in the implementation of a full-scale BIS is the re-engineering of the information-process in affected units. The development of the BIS came at a good time, due to the availability of high performance personal computers and software. Many lessons learned during the project will aid in the implementation of Connecticut's BMS. The philosophy behind the Connecticut BIS is consistent with that of an "integrated information system," of which a BMS is a part. A true BMS should contain network analysis tools and BIS capabilities.

REFERENCE

1. "Management Systems; Proposed Rule," *Federal Register*, 23 CFR Chapter 1, 49 CFR Chapter VI, Volume 57, No. 107, pages 23460-23461.