

Demonstration Bridge Information System for Connecticut

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The Connecticut Department of Transportation utilizes laser videodisc technology to store millions of frames of roadway images. The Photolog Laser Videodisc (PLV) System is a menu-driven PC-based workstation that is used to access images of any active state route. To maximize usage of the PLV hardware, the Department is actively developing other applications.

This report addresses the development of a Demonstration Bridge Information System (BIS) that makes use of the current PLV image-retrieval concept in conjunction with a relational database. The system was designed for storage and quick retrieval of both alphanumeric data and images concerning bridges.

The alphanumeric data is divided into four general areas on a bridge-by-bridge basis. Three areas contain static information such as structural dimensions, construction-project details, and on-site utility information. The fourth area chronologically lists events concerning a bridge, such as an inspection, rehabilitation, or maintenance activity.

Captioned and dated images of the bridge selected in the alphanumeric data areas are accessible as a menu selection. A hard-copy output of both the alphanumeric data and images are also available.

The entire State-maintained roadway system in Connecticut is filmed annually by The Connecticut Department of Transportation (ConnDOT). In 1985, the Department began using laser videodiscs to store its roadway images. (1)

A PC-based workstation, controlled by user-friendly menus, utilizes this technology to enable quick and easy access to images of any State-maintained roadway. This workstation is commonly known as the Photolog Laser Videodisc (PLV) System.

The PLV System has many users, primary among which is the Division of Pavement Management; this division conducts its pavement ratings of the State Highways with the System. Others, within and outside the Department, use the system to gather information about the roadway environs that would normally require field investigation. The images are also used to document past roadway conditions.

In April 1988, a PLV-based system dedicated to bridges was proposed. The proposal identified the inherent problems of the "metal file" system of storing and retrieving bridge-related information at ConnDOT. These problems have been accentuated by a major growth in this type of information, resulting from the State's 10-year \$6.2-billion Infrastructure Renewal Program (IRP). The proposal called for the prioritization of available data, development of a methodology to store these data and retrieve them easily, demonstration of the feasibility of linking a database with corresponding images, while maintaining hardware compat-

ibility with the existing PLV system, and integrating the developed system into a proposed management system. The expected benefits of such a system include the ability to simultaneously view images of, and obtain comprehensive information on any of the more than 3,500 State-maintained bridges in a timely and cost-effective manner.

GOAL OF THE DEMONSTRATION SYSTEM

Sources of bridge-related data are currently maintained by several different units in a variety of formats. These include both computer- and paper-based files. A thorough review of all these sources was conducted, as were interviews with operations personnel in these units.

As a result of this research, the following goal was established for the Demonstration Bridge Information System: provide a comprehensive easy-to-access source for Bridge Information that would be compatible with existing PLV hardware, consisting of:

- a) a comprehensive history of what has occurred to a particular bridge, including references to inspections, construction projects, maintenance work, and any notable event related to the structure;
- b) a comprehensive source of structural data, such as dimensions and foundation information;
- c) a cross reference between bridge number and construction-project number;
- d) a dedicated area where emergency information would be located; and,
- e) access to video images of a bridge.

DEVELOPMENT OF THE DEMONSTRATION SYSTEM

Bridges Selected

Bridges of various type, size and age were selected for inclusion in the demonstration system in order to ascertain all the types of data that might be associated with bridges, and to demonstrate the image capability of a laser videodisc system for storing static photographic images. Personnel in the Department's Bridge Design, Bridge Safety and Evaluation (BSE), and Bridge Maintenance Units were asked to recommend candidate structures for inclusion in the Demonstration System. Forty-three bridges were selected on the basis of these recommendations. The demonstration bridges were distributed among the State's four Transportation Districts to allow inspection of each District's record-keeping methods, and to increase the likelihood that at least one structure on the

TABLE 1 Bridges Included on Demonstration BIS Laser Videodisc

NUMBER	TOWN	LOCATION	TYPE	NUMBER	TOWN	LOCATION	TYPE
District 1				District 2			
448	Wethersfield	Rte 15/Berlin Tnpk	Steel frame	232	Westbrook	Rte 153/ Rte 95	Steel girder
807	Wethersfield	Ridge Rd./ Rte 15	Concrete frame	343	Guilford	Rte 1/ West River	Pony truss
808	Wethersfield	Rte 15/Folly Brook Blvd #3	Steel frame	346	Madison	Rte 1/ Neck River	Masonry arch
809	Wethersfield	Rte 15/Wolcott Hill Rd.	Steel girder	362	Stonington	Rte 1/ Mystic River	Leaf bascule
810	Wethersfield	Rte 15/ McMullen Av.	Concrete frame	484	Bolton	Rte 6 & 44A/RR	Concrete tunnel
811	Wethersfield	Rte 15/Hartford Ave. & RR	Steel frame	501	Killingly	Rte 395 NB/Rte 6	Steel girder
860	Middletown	Rte 17/ Main St. Ext.	Steel stringer	852	East Hampton	Rte 16/ Poco Creek	Concrete T-beam
1477	Newington	Rte 173/ Amtrak	Steel stringer	1138	Haddam	Rte 82/ Ct. River	Swing span
2163	Wethersfield	Rte 15/ Folly Brook	Concrete culvert	1385	Westbrook	Rte 153/ Amtrak	Concrete box
2299	Cheshire	Rte 42/ Ten Mile River	Concrete T-beam	1388	Old Saybrook	Rte 154/ South Cove	Timber beam
3031	Rocky Hill	Gilbert Ave./ I-91	Plate girder	1415	Lisbon	Rte 169/ Shetucket Rv.	Steel deck arch
3242	Vernon	Factory Walk/ Rte 74	Wooden truss	1918	Norwich	Rte 2/ P&W RR	Masonry tunnel
4315	Plainville	Rte 72/ Rte 177	Steel girder	3979	East Hampton	Rte 66/Abandoned RR	Plate arch
5231	Vernon	I-84 WB/ Rte 30 & 83	Steel girder	District 4			
5512	Southington	I-691 WB/ I-84	Steel box girder	464	Watertown	Rte 6/ Steele Brook	Prstrsd conc slab
5543	Meriden	Rte 15/ Abandoned RR	Concrete slab	972	Barkhamsted	Rte 44/ Morgan Brook	Concrete culvert
District 3				1164	Middlebury	South St./ I-84	Steel arch
196	Branford	Rte 95/ Rte 1	Rolled beam	1338	Sharon	Rte 128/ Hstnc. River	Covered bridge
709	New Canaan	Rte 15/ Rte 106	Concrete frame	1343	Bridgewater	Rte 133/ Hstnc. River	Thru truss
759	Stratford	James Farm Rd./ Rte 15	Concrete frame	1561	New Hartford	Rte 219/ Frmgn. River	Thru truss
770	New Haven	Rte 15/ Rte 243	Concrete arch	3349	Thomaston	Rte 8 NB/Rte 6 EB	Prstrsd conc gird
2475	Bridgeport	Rte 751/ Pequonnock Rv.	Lift Span	4385	Beacon Falls	Lopus Rd./Rte 8	Con. box beam
3772	Trumbull	Rte 25 SB/Private Rd.	Plate girder				

System would be familiar to a demonstration audience. The bridges are listed in Table 1.

Bridge Information Acquisition

As previously mentioned, bridge information within the Department exists in a wide variety of sources and formats. The value of this information is currently based on its use within individual units. The BIS is an attempt to assemble and centralize this information, and make it available to all units within the Department.

Construction plans were the first source of information reviewed for inclusion in the BIS. From these, structural information, such as skew angle, foundation type, etc., was accumulated. This information was stored in a large three-ring binder and later input to the BIS database. A complete listing of the attributes of the BIS database are shown in Table 2.

Although not comprehensive, a database dedicated to bridges already exists on the Department's mainframe computer. The information it contains is essentially static, i.e., location, route, span length, etc. Utilizing these data, the Department's Inventory, Planning and Data Section publishes a Bridge Log on an annual basis. This database was appended to the BIS database.

Original construction contracts were also reviewed. They are kept at the State Records Center in their original paper form and are often the only source for such diverse data as paint type and color, bridges included within a project, and contractor information. They are not readily accessible to ConnDOT personnel. The Record Center currently discards these contracts after 20 years.

Lists of all construction projects are available in one of two formats: on index cards kept at the Map & File Room, or on a sizable computer listing, generated by the Office of Scheduling and Monitoring, commonly known as the MIS.

These sources were reviewed. Any citations of relevance to the bridges in the demonstration system were recorded. In this way, a project history was established for each bridge.

Bridge Maintenance Information

After BSE personnel conduct their inspections, any work that they identify that could be performed by State Maintenance crews is assigned a priority. These priority assignments are reviewed by the Bridge Supervisor and Superintendent before maintenance work is scheduled. Over 95 percent of maintenance activity is scheduled in this manner. Monitoring of this

procedure, aspects of which are already computer-based, proved to be the most effective way to track and document the Department's maintenance activity. After the scheduled work has been completed, a confirmation letter is sent to Staff Maintenance, and the work item is purged from the computer file that lists pending maintenance work. Copies of the original work request and the confirmation letter are kept in the respective bridge paper-file in each district, as well as in the Staff Maintenance office. In a spot check of one District's Maintenance files, no reference to known work on a particular bridge was found.

The BIS database could be used to maintain this information as a precursor to a bridge management system.

Images

Since no comprehensive database dedicated to bridges exists at ConnDOT, considerable freedom could be exercised in developing the database for the BIS. Although the BIS was required to be compatible with the PLV workstation hardware, key elements, such as the programming language and database structure were chosen primarily on their relative merits. Development of the image feature of the BIS required much closer alignment to ConnDOT's existing image storage and retrieval methods. As stated previously, ConnDOT uses videodiscs to store its Photolog roadway images. The Department oversees the annual production of fifteen, Phillip's format, double-sided, constant-angular-velocity (CAV) videodiscs each year. These videodiscs hold over 700,000 normal roadway images, as well as an equal number of enlarged views of the pavement. These images are accessed using Photolog Laser Videodisc (PLV) workstations. Eleven workstations are currently in use throughout the Department.

Since their introduction at ConnDOT, the PLV workstations have come under increased usage each year. Annual savings from their use is estimated at \$800,000. The idea of adding videodisc images to a comprehensive bridge database was based on the PLV System's success, and the desire to take greater advantage of the Department's existing PLV hardware.

Photographic images are an effective way of communicating complex technical information. Indeed, ConnDOT personnel and their consultants take thousands of bridge-inspection photographs each year. These photos are filed by the BSE unit and used as attachments to the Bridge Inspection Reports and circulated within the Department. The quality of the photocopied photographs is poor, often voiding the usefulness of the information they were meant to convey. In addition, the Department employs a photographer who, along with his other duties, obtains hundreds of unique bridge pictures each year. At present, the whereabouts of many of these photographs is not known, nor is there a medium for their distribution within the Department.

Videodisc Process

The Department photologs the entire state highway system using modified 35mm motion-picture cameras mounted in vans traveling at speeds of up to 40 m.p.h. The camera is

attached to a sensor which monitors the vehicle's wheel rotations and triggers the shutter at one-hundredth-mile intervals. The Photolog film is then comprised of individual sequential images of the roadway taken at 52.8-foot intervals.

Once a route has been filmed, the film is developed by a private firm and edited by ConnDOT personnel. After editing, it is sent to a video-production facility for pre-mastering. Pre-mastering involves reviewing the film, fixing color and exposure levels, setting cues and transferring the images to 1-inch videotape. The 1-inch tape is then forwarded to a videodisc-production facility.

Excluding the occasional effect of heavy canopy or blinding sun, the exposure level on photolog film varies little from one frame to the next. When the film is pre-mastered, color and exposure levels can be set for a length of film comprised of thousands of frames. Once these levels are set, the film is transferred to tape at the rate of 30 frames-per-second.

Forty-three bridges were included on the Demonstration BIS videodisc. They were photographed, by a two-man crew, using 35mm cameras loaded with color slide film. Images of the elevations, the deck approach and egress, joints, abutments, piers, bearings and any other feature unique to the structure were obtained. The number of images for each bridge ranged from fifteen for a small structure to over one hundred for a large, complex structure. The average number of images per bridge was twenty seven. Aerial photographs of bridges in complex interchanges are available and were included.

After all 43 bridges had been photographed, the developed slides were organized and taken to a videotape-production facility in New York City for pre-mastering. Subsequently, the videotape was forwarded to the videodisc-production facility. The total turnaround time between the start of the pre-mastering process and receipt of the completed videodiscs was about three weeks.

Although the production of videodiscs from slides requires the same pre-mastering process as motion-picture film, slides have a distinct disadvantage. Unlike motion-picture film, the slides must be individually fed into the video-transfer device and taped one-frame-at-a-time. Exposure and color levels on motion picture film often remain constant for long sequences; bridge slides require constant adjustment since the light level can vary significantly from one slide to the next. The additional time required for the transfer of slides was well illustrated during the production of the Demonstration BIS videodisc. Over three days of studio time were required to transfer two thousand slide images to 1-inch video tape, while thirty thousand images on motion picture film were transferred in one afternoon. These factors seem to preclude the use of slides as viable image-capture medium because of the prohibitive time and labor requirements for pre-mastering. Possible alternatives to slides are currently being investigated by ConnDOT personnel. These alternatives include the use of half-frame format cameras and still-video cameras. In-house duplication of slides to motion picture film stock is another possible alternative. The Demonstration BIS videodisc contained images of approximately 1 percent of Connecticut's bridges.

With its capacity to store over 100,000 images, it is estimated that a single, double-sided, CAV format videodisc

would adequately store the images for all ConnDOT maintained bridges.

Software Development

The software used in the development of the BIS was chosen because of its compatibility with both the existing PLV-system hardware and the database software used within the Department for the storage of bridge-related information. Another consideration was the ability to support a communications library for control of the videodisc player. The configuration of the existing PLV hardware employs a nonstandard method of communication between the Personal Computer and the laser videodisc player. To avoid the problems inherent to this nonstandard communication, a switch was added to the hardware allowing direct communication between these two components. With this configuration, a suitable database compiler, and a communications library, the hardware can be utilized as either a PLV or BIS workstation. The BIS can then be appended to any existing PLV workstation at minimal cost. The compiler chosen allows unlimited distribution of the executable program code with no licensing limitations or cost. The database files that currently exist within the Department are in the dBase format and are utilized and maintained by their individual units. The dissemination of information in these files, as stated previously, is the main function of the BIS.

THE SYSTEM

The BIS was designed to be user-friendly and requires minimal computer knowledge. It is menu-driven and easily operated. The program flow is shown in Figure 1. First, the user is asked whether the video option is desired. Access to the video images can be suspended to increase the speed of the program initially. The main menu becomes operational after this choice is made. It consists of two levels. The first level allows selection between areas titled "Bridge Log," "Chronology," "Project," and "Crisis." The second level allows three means of access to the Bridge Log, Chronology, and Crisis areas. These are by bridge number, bridge name, or route, town and intersecting feature.

The Bridge Log area holds information that is currently available in the Department's Bridge Log, which is supplemented with structural information now only available on construction plan sheets. Items such as foundation type, skew angle, deck-membrane type, and utilities carried by the bridge can be displayed on the computer monitor or output as hard copy. The video images are also available from this area as a menu selection. They are displayed on a video monitor adjacent to the computer monitor. Their captions appear on the computer monitor and are scrolled concurrently with the images using the computer keyboard.

The Chronology area lists events that have occurred with regard to bridges since their construction, on a bridge-by-bridge basis. Included in this area are references to any construction project, inspection, maintenance work, or other notable event concerning a bridge. Project numbers, inspection dates, and maintenance reference numbers, all provide a cross reference to other sources of information within the BIS

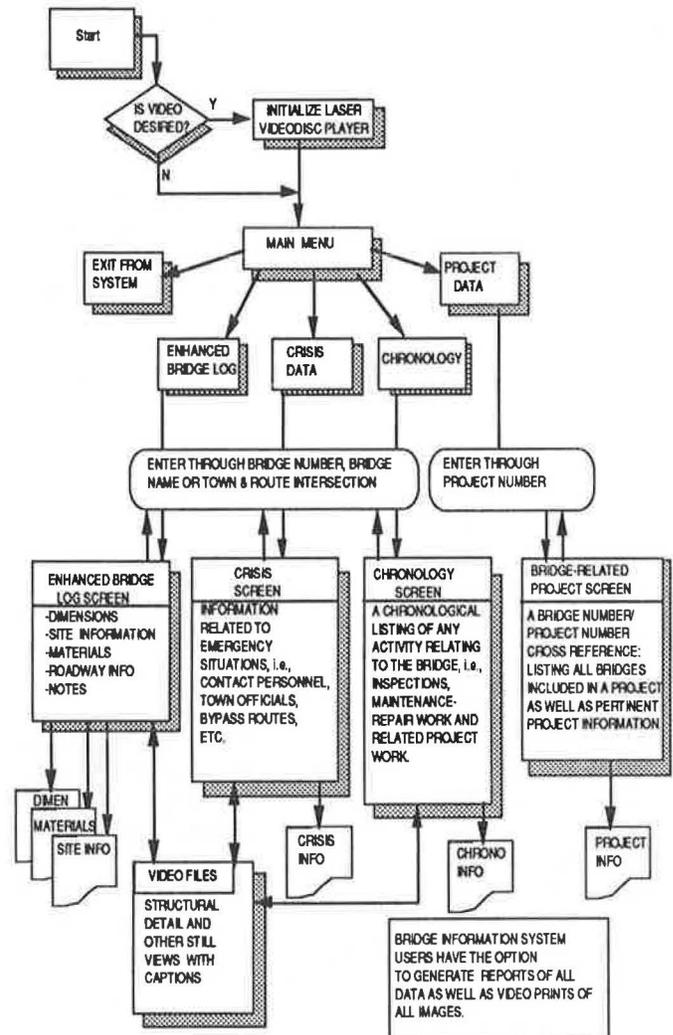


FIGURE 1 Bridge Information System Program Flow

and in other units supplying these data. Details of any particular event are also available as a menu selection. All the information described is displayed on the computer monitor and can be output as hard copy. The images can also be accessed by a menu selection in the same fashion as in the Bridge Log area.

As its name implies, the Project area contains specific information about particular bridge-related construction projects. The information is accessed by keyboard entry of the project number. Project information such as job description, designer, contractor, costs, and design specifications are listed. For projects involving many bridges, a listing of the bridge numbers is available.

The Crisis area contains information that would be required in an emergency situation. This includes telephone numbers of town officials, utilities, local and State police officials and Department operations personnel in the affected area. It also includes a list of on-site utilities, suggested bypass routes and storm-related design information, such as design flow for bridges over water. Images are also accessible in the previously described manner.

TABLE 2 Bridge Information System Data Attributes

Area 1 - Bridge Log		
Bridge Number	Previous Bridge Number	Date Present Number Assigned
Date Number Retired	New Bridge Number	Bridge Owner
Bridge Maintainer	Historical Significance	Town
District	Location	Feature Intersected
Longitude & Latitude	State Coordinates	Route Number(s)
Ramp Number	Milepost	Average Daily Traffic
Truck ADT	Year of ADT	Main Span Type
Approach Span Type	Posted Weight Limit	Design Live Load
Future Paving Allowance	Bridge Designer	Contractor Information
Construction Plan File No.	Number of Main Spans	Number of Approach Spans
Skew Angle	Flared Structure (Y/N)	Structure Length
Max Span Length	Right Curb Width	Left Curb Width
Curb to Curb Width	Deck Width, Out to Out	Approach Roadway Width
Number of Lanes on Bridge	Number of Lanes under Bridge	Median Type
Bearing Type	Bearing Location	Railing/Fence Type
Lighting Type on Bridge	Signs Located on Bridge	Wearing Surface Type
Membrane Type	Type of Drainage on Bridge	Type of Drainage near Bridge
Deck Type	Deck Protection Type	Deck Joint Types (A&B)
Length of Joint Types	Foundation Type	Number of Pins
No. Pin & Joint Assemblies	Number of Suspended Spans	Parallel Structure Number
Vert. Clearance Over Bridge	Vert. Clear. under Bridge	Inv. Rte Vert. Clearance
Inv. Rte. Horiz. Clearance	Lateral Clear. under Bridge	Utilities on/under Bridge
Area 2 - Chronology		
Year Built	Original Project	Maintenance History
Inspection History	Construction Project History	
Area 3 - Crisls		
Bypass Routes	Towns Impacted by Bypass	Emergency Contact Officials
Utility Company Contacts	Waterway Design Flow Rate	
Area 4 - Project		
Contractor(s) Information	Cost - estimated	Cost - actual
Bridge Number Cross Ref.	Date of Plans	Date of Completion
Federal Aid Number	Designer	State Form and Specification
AASHTO Soecification		

REVIEW OF GOAL

As a result of the demonstration of the BIS to personnel within the Department, it has been concluded that the goal of providing a easy-to-access source for bridge information with existing PLV technology was met. The system provides a historical record of all activity on a bridge, a cross reference between bridge number and project number, and captioned images of the structure. A dedicated area for emergency information is also provided.

a low-priority. With the vast amount of work being done under the IRP, little has changed to ensure that current information will exist 25 years from now. The same system that has tracked records for the last 100 years is being used to document the six-billion dollar IRP. The use of all available sources for bridge information, both textual and photographic, will provide an invaluable operational tool for every unit associated with bridges. The BIS will also establish basic information for use in the maintenance and design of bridges in the future.

CONCLUSIONS

The units responsible for routine maintenance work on bridges currently lack the resources to adequately document their work, while for project-level work, the documentation is given

REFERENCE

1. McQuiston, R., "The ConnDOT Photolog Laser Videodisc System," Field Trip Report, Pavement Division, Federal Highway Administration, Washington, DC., Nov. 1988.