Development & Implementation of a Structures Management System for a P3 Contract

Connie Stairs, P. Eng. Brun-Way Highways Operations Inc.
Mike Corbett, P. Eng. Brun-Way Highways Operations Inc.

Paper prepared for presentation

at the ________________ Session

of the 2007 Annual Conference of the
Transportation Association of Canada
Saskatoon, Saskatchewan

ABSTRACT

On February 4, 2005, Brun-Way Highways Operations Inc. (BHOI) entered into a 28 year and one month contract with the Provincial Government, to operate, maintain and rehabilitate (OMR) approximately 275 kilometres of 4-lane highway in New Brunswick. The contract consists of approximately 261 kilometers along Route 2 between Longs Creek, just north of Fredericton to the Quebec border, and the remaining 14 kilometers along Route 95 at the intersection of Route 2 in Woodstock to Maine, USA. A significant requirement of the contract was the implementation of a Structures Management System (SMS) for bridges, overpasses, underpasses, drainage structures with a span length greater than 3 meters and overhead sign trusses within the highway corridors. The objectives of the SMS were to achieve asset preservation to ensure all structures are well maintained throughout the duration of the contract to exceed the design life expectations and meet the contractual requirements for the minimum remaining life at the contract termination date.

SNC Lavalin ProFac (SLP), one of the BHOI partners, has significant experience with the management and maintenance of buildings and has developed asset management systems specifically for these facilities. Initially BHOI intended to purchase off-the-shelf asset management software but instead worked with SLP to modify the existing system for buildings to suit the needs of a highway facility. This included providing a central applications database capable of inputting, storing, assessing, forecasting and reporting on approximately 150 separate structures. The development of this database included gathering tombstone data, conducting structure inspections following the AASHTO Bridge Inspection Standards and developing a condition rating for each component to establish an overall Health Index for each structure.

This paper describes BHOI's SMS, the challenges encountered during the development, the associated advantages and disadvantages of adopting such a system, recommendations for future considerations compatible with this system and conclusions assessing the effectiveness of this system.

1.0 INTRODUCTION

Brun-Way Highways Operations Inc. (BHOI) is a partnership between SNC Lavalin ProFac (SLP), the operations and maintenance division of SNC Lavalin Inc. and Atcon Construction Ltd., a large road construction firm in New Brunswick. In 2005, BHOI entered into a 28-year and one month agreement with the Provincial Government for the Operation, Maintenance and Rehabilitation (OMR) of portions of Route 2 and Route 95 in New Brunswick. Figure 1 displays the contract limits and shows the portions of highway each organization became responsible for on June 1st, 2005, the start of the contract.

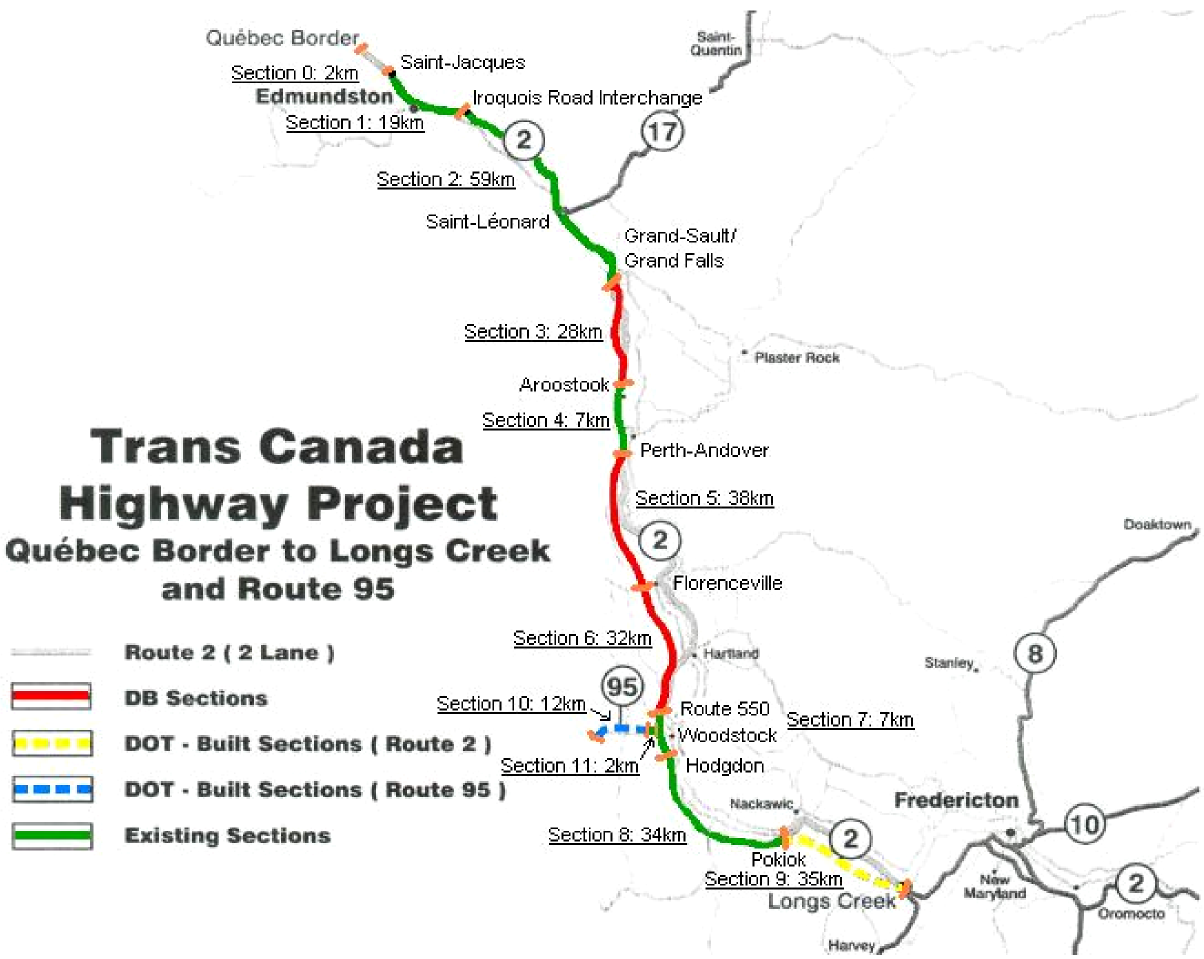

Figure 1 – Map of the project

BHOI became responsible for the OMR of the existing 4-lane sections between Kings Landing, just west of Fredericton to the Quebec border, totaling to 130 kilometers of 4-lane highway. This included the sections from the Quebec border to east of Grand Falls, a short section bypassing Perth Andover, 2 kilometers of Route 95 and a section from Woodstock to Pokiok. In 2006, approximately 32 additional kilometers of 4-lane highway was added to BHOI's contract. This section, between Pokiok and Kings Landing, was under construction by the New Brunswick Department of Transportation (NBDOT) at the time of contract award to BHOI. By November 1, 2007, the remaining 12 kilometers of Route 95, also under construction by the NBDOT, and approximately 98 kilometers of Route 2 between Grand Falls and Woodstock, being built by Brun-Way Construction Inc., will be opened to traffic and transferred to BHOI to operate, maintain and rehabilitate. For the remainder of the report, the 4-lane operational sections of the highway will be referred to as the Facility. Figure 2 shows the relationship between the NBDOT - the owner, Brun-Way Construction Inc. – the highway developer and BHOI – the highway operator responsible for maintenance and rehabilitation. The overall contract, including the design-build portion of the project, is administered for the NBDOT by the Trans Canada Highway Project Company (TCHP Co), a Crown Corporation formed specifically for this public / private partnership contract.

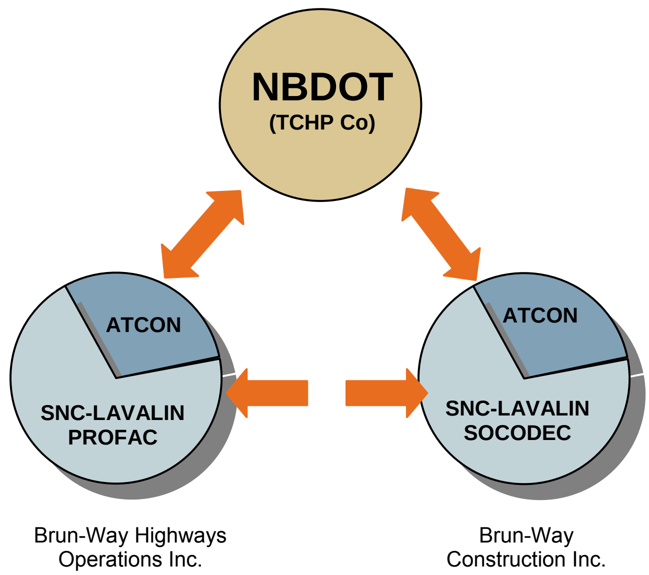

Figure 2 – Relationship between the parties involved with the contract

BHOI is responsible for the OMR of the highway corridor. This includes all summer maintenance activities such as sweeping, debris pick-up and line painting, and winter activities such as snow plowing, salting, and pothole patching. BHOI is also responsible for regularly inspecting all the assets. Such inspections include slopes, drainage features, guiderail, asphalt and structures. When required, BHOI must perform corrective maintenance and repair to ensure the assets meet the OMR Standards and contract specifications. This ensures that the assets are maintained at a high level of service throughout the duration of the OMR contract. Before repair becomes the only option, preventive maintenance methods are implemented to extend asset longevity. Such methods include structure cleaning and washing, crack sealing and microsurfacing. These prolong the eventual rehabilitation necessary to meet the prescribed standards at the time of hand-back to the Province of New Brunswick. These hand-back standards are specified in the contract and state the required condition for each asset at the end of the contract. These standards ensure that the assets have sufficient remaining life at the end of the OMR period, at which time all the assets within the highway corridor are turned over to the Province of New Brunswick. Table 1 lists BHOI's structural assets and the minimum remaining life that is required for each, when the Facility is transferred to the Province of New Brunswick in 2033.

Facility Asset	Minimum Required Remaining Life
Beams, piers, foundations & abutments	45
Steel painted	15
Deck - asphalt	6
Deck – waterproofing membrane	6
Deck - concrete	45
Joints	10
Bearings	45
Railings	10
Culverts > 3 meters	45
Overhead signs - base	30
Overhead signs - truss	20

Table 1 –Minimum remaining life for BHOI's structural assets

2.0 ASSET MANAGEMENT

The concept of asset management is not new, yet for years it has not been the focus of highway agencies. Due to limited funds and the increased demand for asset longevity, government agencies are now allocating more resources for asset preservation. They are doing this by developing their own asset management systems and entering into private contracts with organizations that are researching products and implementing innovative methods to extend the life of assets. BHOI's contract is lump sum over a 28 year and one month period, so it is extremely important for BHOI to invest in systems which aid in the systematic planning and scheduling of maintaining and repairing assets. These assets include signs, lighting, guiderail, culverts, asphalt and structures. These all require maintenance and repair throughout the contract term, so it makes sense to invest in a system that supports this.

The BHOI SMS is a module of the SLP Asset Management System (AMS), which is a suite of tools and reports complete with interfaces to corrective maintenance software, which allows management of complex assets including highway infrastructure, buildings, hospitals and power plants at the facility, regional, or portfolio wide level. The AMS is comprised of 4 separate modules that include the SMS, Drainage Management System (DMS), Pavement Management System (PMS) and a management system for other Facility assets such as signs, guiderail, lighting, etc.

The AMS contains links to:

- JD Edwards - Contains tombstone data on asset characteristics such as structure type, kilometer marker, year of construction, number of spans, dimensions, clearances, structure name and other characteristics.
- Asset Inspections - The inspection reports provide the technical basis and validation for the Capital Replacement Program. All the inspections contain specific details regarding the elements, quantities, conditions, comments, recommendations, Element Health and Health Index. The inspections also contain the current status such as completed, in progress or draft.
- PeopleSoft – Corrective maintenance asset management software that contains asset information, work orders, maintenance requests, plant and equipment maintenance, Corrective Maintenance Management System (CMMS) reports, and field Area Managers and Operations Technicians comments.
- Capital Replacement Program – This program is an objective comprehensive analysis tool designed to enhance the facility and portfolio capital planning process.
- Project Justification - Projects can be created with justifications from a site, inspection or Capital Replacement Program.

Figure 3 displays the inputs to the various systems included in the AMS. It also displays the interaction between the AMS, corrective maintenance and Capital Replacement Programs.

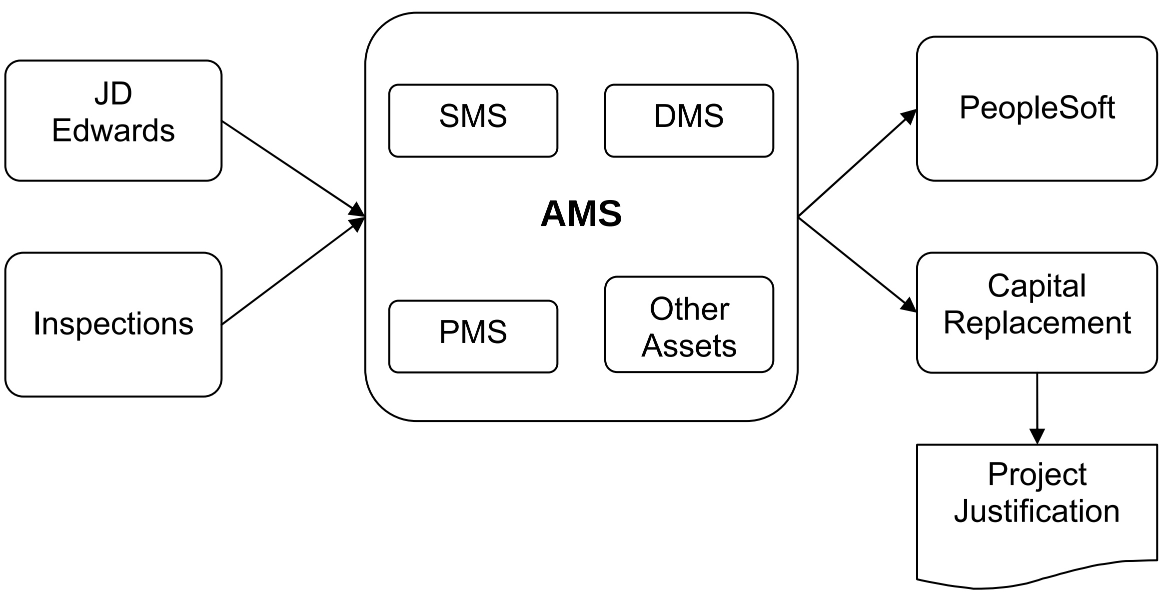

Figure 3 – Interaction between the various systems associated with the AMS

3.0 STRUCTURES INVENTORY

Within the Facility, there are several different types of bridges, overpasses, underpasses, culverts greater than 3 meters and overhead sign trusses that are included in BHOI's SMS. Throughout the remainder of the report, these are referred to as the Structures. Table 2 identifies the types and the quantity for each.

Structure Type	**Quantity**
Prestressed Concrete Beam	81
Prestressed Concrete Bulb Tee	30
Steel Plate Girder	21
Rigid Frame	10
Reinforced Concrete Beam	5
Steel Rolled Beam	2
Reinforced Concrete Slab	1
Composite Beam	1
Concrete Box Culvert	8
SPCSP	3
Overhead Sign Truss	9

Table 2 – Quantity of each type of structure on the Facility

This list includes all the structural assets that existed on the operational sections of highway prior to the start of the contract, the structural assets that were built by the NBDOT and turned over to BHOI during the design / build period of the contract and the structural assets that will be turned over to BHOI prior to November 1, 2007.

As the highway corridor was constructed in various phases over several years, the age and condition of the structural assets vary greatly. On the sections of highway that were already open to traffic and transferred to BHOI at the contract commencement date, the Structure ages range from 2 to 46 years old. Table 3 lists the quantity of Structures built in each period that BHOI became responsible to maintain and rehabilitate commencing June 1, 2005.

Decade	**Quantity**
1950's	1
1960's	6
1980's	14
1990's	53
2000's	26

Table 3 – Quantity of Structures built in each decade at the contract commencement date

The remaining Structures were built during the design / build portion of the contract, between 2005 and 2007.

The bridges, overpasses and underpasses within the highway corridor vary in size ranging from one span to 10 spans. The single span structures and multiple span structures over roadways can be inspected without the use of specialized equipment, while the multiple span structures over water, require inspection with the use of a mobile bridge inspection unit. 29 of the 151 structures require inspection with the use of such a platform.

4.0 INSPECTION PROGRAMS

To ensure the early detection and reporting of problems, which if left unnoticed, could lead to more costly repairs or endanger the public, BHOI has 3 distinct levels of inspection. These include routine visual inspections, annual routine inspections and detailed biennial inspections.

4.1 Routine Visual Inspections

As part of the daily road patrol activities, BHOI conducts routine inspections of all the bridges, overpasses and underpasses. The inspection items should include pavements, shoulders, barriers, expansion joints, deck drains and all other visible structure components, which can be seen from the patrol vehicle. These items are inspected by the patrol staff in compliance with specified requirements described in the OMR Standards. Deficiencies observed are recorded in the SMS for the Structural Engineer to review and provide recommendations.

4.2 Annual Routine Inspections

Due to the critical nature and high level of asset investment for the structures located in the highway corridor, BHOI also performs a scheduled annual inspection of each structure. This annual inspection is conducted by the management team at the maintenance facilities and provides awareness of the issues identified during the daily road patrol activities. This annual inspection also provides an up-to-date evaluation of the condition rating of the structure’s components. The items inspected are in compliance with specific requirements described in the OMR Standards, paying particular attention to the condition evaluation described in the most recent biennial structure inspection. Items inspected are the same as for the routine visual inspections that are conducted by the patrol staff. Deficiencies observed are recorded in the SMS for the Structural Engineer to review and provide recommendations.

4.3 Detailed Biennial Inspections

In addition to the routine visual inspections and the annual routine inspections, BHOI also conducts a detailed inspection for every Structure every 2 years. The detailed inspection process is based on that provided by the AASHTO Bridge Inspection Manual. A minimum of 2 employees knowledgeable in structures, one being a Professional Engineer must conduct the inspection. The results of the detailed inspections are reviewed by a Structural Engineer and details and recommendations entered into the SMS. The recommendations and/or repairs will be undertaken within the lesser time frame as:

- specified within the approved structure inspection report or
- prior to the end of the next construction season

Should a biennial inspection reveal a significant deterioration of any major structure component, a further specific detailed inspection conducted with a Structural Engineer will be immediately scheduled for determination of the required repair and rehabilitation action. Figure 4 shows a structure being inspected by BHOI staff with the use of a mobile inspection unit.

Figure 4 – Biennial structure inspection with specialized equipment

5.0 STRUCTURES MANAGEMENT SYSTEM JUSTIFICATION

BHOI is required by contract to have an SMS. This requirement was specifically included in the contract to provide a level of comfort to the Province of New Brunswick that the structural assets would be maintained to specified standards. These standards specify a minimum tolerable condition that is allowed for each structure component, before repairs must be undertaken. They also specify the maximum response time that must be met if repairs are to be performed. For BHOI, implementing a SMS allows for a consistent method of evaluation of the asset and the retrieval of current condition information to assess asset performance. Also, as an added benefit, the SMS aids in the long range planning for repairs and rehabilitation to ensure the requirement for the minimum remaining life for each structure component, as specified in the Hand-Back Standards is achieved.

The SMS monitors the condition of Structures over time for the systematic planning of preventive maintenance measures, repair or rehabilitation. This is a proactive approach so that conducting preventive maintenance preserves and prolongs the life of these assets. Also, when repairs are necessary, the ability to perform similar methods to separate structures in the same time frame may be possible, thereby minimizing costs. For example, if patching repairs are required to the abutments of one structure, then perhaps all the structures in that vicinity should be analyzed to determine if their concrete components such as ballast walls or barrier walls are going to require patching in the near future.

Initially, BHOI explored the option of using the AASHTO Pontis System, which is a fully developed SMS used by numerous government agencies. Soon into the investigation, BHOI discovered this system was only available for use by government agencies and although this contract was a public / private partnership, BHOI was not considered part of the Provincial Government. BHOI then explored the option of purchasing a SMS from a supplier who specializes in developing this type of data management software. When exploring this option, BHOI discovered the cost of such a system that would meet the contractual obligations, far exceeded the budget. Also, the schedule for this system to be developed and fully functional was very aggressive, so aggressive that suppliers could not guarantee the system would meet all the performance requirements prior to the deadline specified in the OMR Agreement. BHOI then determined that modifying the existing AMS used for the management and maintenance of buildings by SLP, would be the most viable approach.

6.0 SYSTEM DEVELOPMENT

The SMS uses the Commonly Recognized (CoRe) Elements concept developed by the American Association of State Highway and Transportation Officials (AASHTO) to break down the various structure types into easily quantifiable components for inspection. An element refers to structural members (beams, pier columns, decks, etc.), or any other features or components (railings, expansion joints, approach panels, etc.) commonly found on a Structure. By dividing a Structure into separate elements, and rating the condition individually, an element-based inspection format provides a detailed condition evaluation of the asset. AASHTO has designated 98 nationally recognized CoRe Elements that are commonly found on structures throughout the United States and Canada. These CoRe Elements have pre-defined condition states associated with them to provide the inspectors with a consistent method of evaluating each component. The intent of establishing these CoRe Elements is to provide a uniform basis for data collection, and to enable data sharing among agencies. This also provides a standard method of evaluating the elements associated with each structure type to prioritize periodic maintenance activities and plan for and schedule repairs.

6.1 CoRe Elements for BHOI's Assets

The components are specific to each structure on the Facility. The majority of the components associated with each of the different structure types are the same. For example, most of the elements associated with prestressed concrete beam structures are the same, although depending on the design, there are slight differences. These may include the type of bearings, expansion joints, type of railings, etc. The first step in developing the SMS was when collecting tombstone data, to identify the different types of structures BHOI was responsible for. Once these were determined, the next step was to identify each of the elements associated with each structure on the Facility. This was done through on-site inspections and reviewing the design drawings for each structure. Knowing the elements for each structure, then allowed BHOI to provide the associated condition states, as specified in the AASHTO CoRe Elements to the program developer for inclusion into the system. Table 4 identifies the CoRe Elements that exist in BHOI's structure inventory.

Description	Element #	Unit of Measure
Concrete Deck – Bituminous Overlay & Membrane	14	m^2
Concrete Slab – Bituminous Overlay & Membrane	40	m^2
Unpainted Steel Girder or Beam	106	m
Painted Steel Girder or Beam	107	m
Prestressed Concrete Girder or Beam	109	m
Reinforced Concrete Girder or Beam	110	m
Unpainted Steel Through Truss – Bottom Chord	120	m
Unpainted Steel Through Truss – Upper Members	125	m
Reinforced Concrete Column	205	each
Reinforced Concrete Pier Wall	210	m
Reinforced Concrete Abutment	215	m
Reinforced Concrete Footing	220	each
Unpainted Steel Piling	225	each
Reinforced Concrete Cap	234	m
Steel Culverts	240	m
Concrete Culverts	241	m
Strip Seal Deck Joint	300	m
Poured Seal Deck Joint	301	m
Elastomeric Bearings	310	each
Pot Bearings	314	each
Disk Bearings	315	each
Concrete Bridge Railing	331	m
Combination / Miscellaneous Railing	333	m

Table 4 – CoRe structural elements that exist in BHOI's inventory

6.2 CoRe Element Quantities for each Structure

After identifying the elements associated with each structure, BHOI then had to provide the developer with the total quantities of each element for each Structure to populate the system. Initially, this information was collected by counting items and scaling dimensions from the design drawings. If the drawings were not available, as was the case with some of the older structures, then measurements in the field were recorded.

6.3 Condition State Weighting Factor

The CoRe Elements are each rated on a predetermined scale of 1 to 3, 1 to 4, or 1 to 5, depending on the element type and material. For each element, condition state 1 is defined as the best condition and condition states 3, 4 or 5 being the worst. Elements expressed as an each quantity must be rated under only one condition state. Elements expressed as a unit of measure can be divided and therefore distributed under more than one condition state. As an example, for an overpass with prestressed concrete beams, the distribution of the total length of all the beams over the 4 predefined condition states could be as follows:

50% of the element quantity could be rated as condition state 1,
30% as condition state 2,
20% as condition state 3, and
0% as condition state 4

In order to properly distribute the total element quantity over the applicable condition states of each structure component, a weighting factor was adopted. This weighting factor for each condition state is displayed in Table 5.

Number of Condition States	**State 1 (WF)**	**State 2 (WF)**	**State 3 (WF)**	**State 4 (WF)**	**State 5 (WF)**
3	1.00	0.50	0.00		
4	1.00	0.67	0.33	0.00	
5	1.00	0.75	0.50	0.25	0.00

Table 5 – Weighting factor for each condition state

During the biennial inspections, the condition of each element was evaluated based on the unit of measure. The above weighting factors incorporated into the SMS, were then applied to this quantity.

6.4 Unit Failure Cost

Another necessary input that the program developer required for the system to properly function was the Unit Failure Cost. This is the cost to replace each unit of the element. Since BHOI is a new company and had not yet performed rehabilitation on the structures within the Facility, they did not have any historical data regarding costs associated with structure repairs. BHOI collected this information by contacting local structural contractors and by utilizing their employees past work experience. As BHOI performs structure rehabilitation projects, these Unit Failure Costs can be updated to reflect current costs associated with structures specific to this highway project.

6.5 Element Health

BHOI required a method to compare the condition of a component associated with one structure to the same component on a different structure. The development of the Element Health allows for this comparison, taking into account the relative size of the components being compared. The Element Health for a structure component is a measure of the Current Element Value (CEV) to the Total Element Value (TEV). The CEV depends on the quantity in each condition state, the weighting factor applied to each condition state and the Unit Failure Cost. The TEV is the value of the component when new. The relationship is as follows:

$$\text{Element Health} = (\text{CEV} / \text{TEV}) \times 100$$

where:

- CEV is Current Element Value = Σ(Total Quantity in a condition state x Weighting Factor) x Unit Failure Cost of the element
- TEV is Total Element Value = Total Quantity x Unit Failure Cost

For new structure components, the Element Health is 100%, which means that TEV = CEV. The difference between the TEV and CEV is the Order of Magnitude Costing Estimate and serves as a project budget for element repair. This calculation was supplied to the program developers for inclusion into the system.

6.6 Health Index

In order to analyze and compare the maintenance and repair needs between different structures, BHOI developed a Health Index for each Structure. This is an essential output of the SMS, as it is a 0 – 100 ranking system for structure maintenance and repairs. This Health Index is a measure of the overall condition of the Structure, taking all elements into account. Therefore, the Health Index for each Structure is determined by:

$$\text{Health Index} = (\Sigma\text{CEV} / \Sigma\text{TEV}) \times 100$$

where:

- CEV is Current Element Value as defined above
- TEV is Total Element Value as defined above

For a newly constructed Structure, the Health Index is 100%. This makes sense, due to the Element Health for each new structure component being 100% as well. This calculation also was supplied to the program developers for inclusion into the system.

7.0 SYSTEM OUTPUT

Once the program developers input the CoRe Elements, total quantity for each element, condition state weighting factor, Unit Failure Cost, Element Health and Health Index calculations, the system was ready to receive structure inspection data. The tombstone data for each structure was uploaded from the JD Edwards system into the AMS and the structure inspection data was entered directly into the SMS. To manage this inspection information, the system is designed with an Inspection Module and a separate Project Module.

7.1 Inspection Module

The Inspection Module contains the data input, reports on the current condition of each element associated with each structure and stores the history data so that element and structure performance can be measured over time. This information can then be exported into a spreadsheet for a more detailed analysis. The data in this format can be sorted by identifying parameters to generate performance / deterioration curves. These curves track the condition of the structure or element over time so that future preventive or corrective maintenance and rehabilitation requirements can be forecasted. This is essential for budgeting purposes and the staff allocation process. With the Unit Failure Costs for each element, a life cycle cost analysis for each structure component can be conducted. This determines the most cost effective options and period to schedule repairs. Figure 4 displays an Inspection Summary Report generated from the Inspection Module for a bridge that is included in the contract.

brun•way

SNC•LAVALIN ProFac

Structure Inspection Summary Report

Asset Number:	5398063	Inspection Id:	1054	Inspected By:	Connie Stairs
Site Number:	563856			Inspection Date:	04/24/2006
	HWY 02 Structure 094	Description:	M-050, Madawaska River. O/P, WB	Reviewd By:	Mike Corbett
Location:	HW2 Dis1 ZN 1D WB Km 015.1	Status:	Complete	Reviewed Date:	
Structure Name:	Madawaska River	Created by:	Clark, Graham		
Structure #:	M050	Created On:	04/04/2007		
Year :	1983	Start Date:	04/24/2006		
Asset Type:	BR1 Bridge - Prestressed Beam	Due Date:	12/31/2006		

Element #	Element	Priority	Comment	Recommendation	Quantity	Unit	Total Value $	Current Value $	Element Health %
985	Slopes & Slope Protection	3			2.00	each	5,000.00	2,500.00	50.00 %
14	Concrete Deck - Bituminous Overlay & Membrane	3	Small area where asphalt and aggregate are not bonded good. At start of deck in passing lane.		1,202.00	sqm	45,676.00	45,676.00	100.00 %
331	Concrete Bridge Railing	3	Outside Barrier wall - condition 1 Median Barrier wall - condition 3		128.00	m	29,440.00	19,577.60	66.50 %
387	Concrete Wingwall (EA)	4			2.00	each	5,760.00	5,760.00	100.00 %
215	Reinforced Concrete Abutment (LF)	4	Minor efforvescence on south ballestwall. Minor efforvescence and corrosioni on north ballest wall.		24.00	m	91,200.00	91,200.00	100.00 %
205	Reinforced Concrete Column (EA)	4			3.00	each	30,000.00	30,000.00	100.00 %
234	Reinforced Concrete Cap (LF)	4	Minor vertical hairline cracking on 2nd pier cap from south end. Bearing pad on east side on 2nd pier cap - cracking(exposure to sun) 1st bearing block on 3rd pier is cracked- no corrosion- should be fixed with epoxy injections.		3.00	m	7,800.00	7,800.00	100.00 %

ONSERV **Bridge Management System**

Page 1

Element #	Element	Priority	Comment	Recommendation	Quantity	Unit	Total Value $	Current Value $	Element Health %
109	Pre-stressed Concrete Girder or Beam (LF)	4	Interior Beams - Condition 1 Exterior Beams - Condition 2 Minor spalling along upper edge of beam, where deck was modified for barrier wall addition. Efforvescence on 4th beam on the 4th span.		152.00	m	121,600.00	108,223.12	89.00 %
300	Strip Seal Deck Joint	4			44.00	m	52,800.00	52,800.00	100.00 %
310	Elastomeric Bearings	4			25.00	each	30,000.00	30,000.00	100.00 %
380	Secondary Elements	4			52.00	each	59,800.00	59,800.00	100.00 %

Structure:	563856 HWY 02 Structure 094	
Total Element Value $:	**Current Element Value $:**	**Health Index:**
$ 479,076.00	$ 453,336.72	94.63 %

ONSERV **Bridge Management System** Page 2 of 2

Figure 4 – Inspection Report for the westbound bridge over the Madawaska River

Since BHOI is a new highway maintenance and rehabilitation company, the first of it's kind for the partners, pre-established performance / deterioration curves from structure data, were not already developed. As BHOI collects inspection data to generate performance / deterioration curves specific to the structures included in this project, they are working with NBDOT to apply pre-established curves developed for the management of other structures in the province. These performance / deterioration curves provide valuable condition information over time, as they were generated for similar structure types, constructed by similar methods and exposed to the same environment as BHOI's structure inventory. Based on adopted performance / deterioration curves and those generated by BHOI over time, yearly and 5-year work plans are developed for the Structures.

7.2 Project Module

The Project Module is created from the Inspection Module. After analyzing component performance and determining that repairs must be conducted, a project is created. The Project Module is essential for planning, as it identifies the scope of work, parties involved, status, estimated costs and tracks actual costs associated with the work. Once a project has been completed, the new Element Health values are transferred to the Inspection Module to update the element's condition and overall rating of the structure's Health Index.

8.0 CHALLENGES DURING DEVELOPMENT

Throughout the development of the SMS, numerous challenges were encountered. The initial challenge for both BHOI and SLP was that the base model for the system was specifically designed for fixed assets that did not require maintenance intervention activities to increase asset longevity. This was a necessary component of the SMS. Also, the base model did not include parameters required for evaluation to establish a standard inspection program to determine which structure elements would be most suitable for repair and at what time during their useful life. This structure evaluation program was developed by BHOI and communicated to SLP, for the Structures specific to the contract. The program developers had to develop a system capable of analyzing and reporting on the data, while still operating in the confines of the base model system.

Another challenge realized at the onset of the development phase was the contractual requirement to have this system fully functional containing structure data specific to BHOI's inventory, within a 2 year period. This consisted of providing the developer with the inputs to the system which include the CoRe Elements and total quantity for each element for each structure, the condition state weighting factor, the Unit Failure Costs and the Element Health and Health Index calculations. In conjunction with this task, all of the most recent NBDOT Bridge Inspection Reports were reviewed to assess each structure's current maintenance needs and to collect pertinent specification data, which was also supplied to the developer. Finally, a detailed biennial structure inspection was conducted on each structure to evaluate the current condition and this information was manually input into the system. After all the inputs were incorporated into the system, the output then needed to be tested to determine if the system was functioning properly.

As added pressure for the system to be fully operational within the specified time frame, a financial penalty was imposed on the contractual requirement not being met. The financial penalty associated with this deadline not being met was $5000 / month / section of highway BHOI was responsible for. Since BHOI was responsible to maintain and rehabilitate the structures in 4 different highway sections at that time, failure to deploy the SMS by June 1, 2007 could have resulted in a financial penalty of $20,000 / month.

9.0 ADVANTAGES OF DEVELOPING THE SMS

As with any SMS, the ability to continuously monitor a structure's performance to effectively plan for maintenance and rehabilitation activities is a cost effective method of managing an organization's assets. Throughout the development and implementation of the SMS, BHOI has recognized several advantages of developing their tailor-made system.

The first advantage is that the system was specifically developed to measure a structure's performance based on the terms required by the Project Agreements. BHOI and SLP worked together to ensure that the format of the output from the SMS would address the criteria required by the owner. It was important for the output to be laid out this way, as TCHP Co would be performing regularly scheduled audits on BHOI's activities and records confirming system conformance would be required. Displaying the output in a way that addresses their concerns, minimizes the time required to collect the supporting documentation.

Another advantage of BHOI developing their own SMS is that it forced the system users to thoroughly understand each level of the program. From data input, manipulation, data output and effect on other related systems, BHOI is better able to recognize if the system is not functioning properly, as the output would not be what is expected.

An additional advantage of BHOI developing their own SMS is for future upgrades to the system. As assets potentially change, issues arise and the system requires upgrading, SLP is available to BHOI at no additional cost for technical support.

10.0 DISADVANTAGES OF DEVELOPING THE SMS

During the development and implementation of the SMS, BHOI also recognized some disadvantages associated with this system. The first is that data input is time consuming. The inspector records the condition of the Structures on hard copy in the field and then must enter this information into the SMS at a later date. The other disadvantage of this amalgamated system is that the PeopleSoft system which records the maintenance activities completed operates separately from the SMS that forecasts future maintenance and rehabilitation activities required. As routine and periodic maintenance activities are conducted, this work must be entered into the SMS separately to update the current status of the Structures. Therefore, routine and periodic maintenance work completed is entered into both PeopleSoft and the SMS because there is no direct link from the corrective maintenance system to update the information in the SMS. The flow of data between these 2 systems is only one way – from the SMS to the PeopleSoft system.

11.0 FUTURE CONSIDERATIONS

As the OMR of the Facility is required for 26 more years, BHOI is considering what options are available to improve the data collection and management processes associated with the SMS. Hand-held data collection devices programmed specifically for data input would minimize the effort and time required to enter the inspection information into the system. Rather than evaluating the structure's components in the field and entering the data at a later date in the office, evaluation and data input would be combined on-site. This would allow the inspector to calculate the current Element Health and Health Index on-site for visual verification.

As the system functions now, the Project Module estimates repair costs based on the initial Unit Failure Costs supplied. The Project Module also tracks actual costs associated with the project and these actual costs can replace the estimates. For now, this data transfer is done manually, but in the future, BHOI intends to have these estimated costs updated automatically to reflect current costs associated with the Structures specific to this highway project.

As the transportation industry moves towards public / private partnerships in the highway maintenance and rehabilitation sector, SLP and BHOI recognize the potential opportunities for growth. The process of developing, implementing and thoroughly understanding a SMS allows SLP and BHOI to increase client prospects and better prepare themselves for future contracts.

12.0 CONCLUSIONS

As previously stated, BHOI was required by contract to have a SMS in place to manage and report on the condition of bridges, overpasses, underpasses, culverts greater than 3 meters and overhead sign trusses and to effectively plan for the maintenance and rehabilitation needs of these assets. The system requirements are clearly defined in the contract and consist of:

- condition index for each structure component
- procedure to monitor the compliance with the structure component condition ratings
- establish intervention levels that will be triggered as a structure or it's components deteriorate
- provide TCHP Co with the inspections conducted as part of the SMS

Despite the challenges encountered, BHOI with the support of SLP was able to develop and implement a SMS that meets the contractual requirements and is an effective tool for the evaluation, project planning and life cycle cost analysis for the structural assets BHOI is currently responsible for and will be transferring back to the Province of New Brunswick in July, 2033.

REFERENCES

1. Thompson P, Shepard R. "AASHTO Commonly-Recognized Bridge Elements – Successful Applications and Lessons Learned", National Workshop on Commonly Recognized Measures for Maintenance (June, 2000).

2. American Association of State Highway and Transportation Officials (AASHTO). "AASHTO Guide for Commonly Recognized (CoRe) Structural Elements", Washington, D.C. (December, 1997).

3. American Association of State Highway and Transportation Officials (AASHTO). "Manual for Condition Evaluation of Bridges", Second Edition, Washington, D.C. (1994).

4. Trans-Canada Highway Project. "Project Agreements for the Design, Construction, Financing, Operation, Maintenance and Rehabilitation of Route 2, Between the Quebec Border and Longs Creek, and Route 95", Operation, Maintenance and Rehabilitation Agreement, Schedule 1, (February 4, 2005).

5. Trans-Canada Highway Project. "Project Agreements for the Design, Construction, Financing, Operation, Maintenance and Rehabilitation of Route 2, Between the Quebec Border and Longs Creek, and Route 95", Operation, Maintenance and Rehabilitation Agreement, Schedule 18, (February 4, 2005).