

**Application of an Integrated Maintenance Management System for
Highways Operations**

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Paper prepared for presentation

At the

**Current Issues and Developments in Highway Maintenance and
Construction Session**

**of the 2006 Annual Conference of the
Transportation Association of Canada
Charlottetown, Prince Edward Island**

Abstract

Brun-Way Highways Operations Inc. (BHOI) has contracted to operate, maintain and rehabilitate 275 km of Route 2 in New Brunswick. To administer the OMR Work, BHOI has instituted a response-based organization supported by three patrol districts. The corporate office has responsibility for:

- Policy and procedures development;
- Finance, fiscal management and control;
- Engineering and contracts;
- Corridor management and control;
- Claims administration;
- Information and communications; and
- Quality assurance and audit compliance.

BHOI utilizes an enterprise resource planning system to manage all key functions:

Financial Reporting	Procurement
General Ledger	Contract Management
Accounts Payable	Maintenance Management
Accounts Receivable	Asset tracking
Job Costing/Project Management	Work order dispatch/tracking
Call Centre Management	

The system operates either as a standard Windows client or allows user functions to be presented through a web browser. It is configured to match a variety of business processes and has automated workflow capabilities. It also integrates with Microsoft Office (Outlook, Excel and Word) and web browsers. The power of the system lies in the integration of all core functions accessing a common database, allowing business decisions that are based on more accurate information.

The J. D. Edwards One World Call Centre module is used to manage and monitor Operation Call Centre (OCC) activities. The OCC provides support services to highway users, operations and maintenance. More than a customer help desk, the OCC integrates contract administration, purchasing, preventive maintenance, administration, accident and incident tracking with work request receiving, dispatch and closing to create an efficient maintenance management operations hub.

The concept behind this operations and maintenance management help desk is an end-to-end handling of customer requests. The OCC staff has the technical ability to address issues and work collaboratively with Area Managers to deliver timely, cost effective and appropriate response to service requests. The team of professionals covers shifts 24 hours 7 days a week. They are accessible via a toll-free number and supported by a single platform customer service application. This leading edge technology adds workflow automation tools and integrated voice response to reduce handling and delay of call dispatching and follow-up. The integration of purchasing and asset information into the workflow of the OCC produces efficiencies in administration of the payments and preventive maintenance recording processes surrounding the call taking activity.

1 MANAGEMENT OF THE PROJECT

1.1 Project Overview

Brun-Way Highways Operations Inc. (BHOI) is a partnership between SNC Lavalin Profac and Atcon Construction Ltd. In 2005, BHOI entered into a 28-year and one month Agreement for the Operation, Maintenance and Rehabilitation (OMR) of portions of Route 2 and Route 95 in New Brunswick. On June 1st, 2005, BHOI took over OMR of the existing 4-lane portions of the highways, amounting to 130 km of highway.

The present 130 km of highway includes the sections from the Quebec border to east of Grand Falls, a short section bypassing Perth Andover, 2 km of Route 95 and a section from Woodstock to Pokiok, NB. In 2006, approximately 32 additional km of 4-lane presently under construction by the New Brunswick Department of Transportation (NBDOT) between Pokiok and Kings Landing west of Fredericton will be added. This will connect to another OMR contract, the Fredericton Moncton Highway, presently operated by Maritime Road Development Corporation. This will be followed by the addition of the remainder of Route 95 (12 km, also under construction by NBDOT) and approximately 98 km of Route 2 between Grand Falls and Woodstock (under construction by Brun-Way Construction Inc.), in 2007.

BHOI is responsible for the OMR of the highways, including the usual summer and winter operations, regular inspection of all the assets, corrective maintenance and repair to meet OMR standards, preventive maintenance to ensure the extended life of the assets, and eventual rehabilitation to meet hand back standards.

The OMR standards ensure that the assets are maintained at a high level of service during the OMR period, and the hand back standards ensure that the assets have sufficient remaining life at the end of the OMR period. The overall Project, including the Design-Build portion of the work, is administered for the Province of New Brunswick by the Trans Canada Highway Project Company (TCHP Co).

To administer the OMR Work, BHOI has instituted a response-based organization with a core corporate office staff supported by three patrol districts. The corporate office has responsibility for:

- Policy and procedures development
- Finance, fiscal management and control
- Engineering and contracts
- Corridor management and control
- Claims administration
- Information and communications
- Quality assurance and audit compliance
- Operations Control Centre (OCC) (call centre)

BHOI utilizes an enterprise resource planning (the “ERP”) system to seamlessly manage all key functions or “centres of excellence”. BHOI utilizes the J.D. Edwards One World software suite for the following business and operational functions:

Financial Reporting	Maintenance Management
General Ledger	Equipment tracking
Accounts Payable	Work order dispatch/tracking
Accounts Receivable	Property Management
Job Costing/Project Management	Lease Management
Procurement	Call Centre Management
Contract Management	

J.D. Edwards is a client server based product that can operate either as a standard Windows client or allow user functions to be presented through a web browser. It can be configured to match a variety of business processes and has superior automated workflow capabilities. It also seamlessly integrates with Microsoft Office (Outlook, Excel and Word) and the World Wide Web. BHOI selected J.D. Edwards as a best-in-class ERP system, particularly for its specific applications, which are unique to facility and operations management.

In addition to its specialized software modules such as property management and maintenance management, the system is based on the integration of all core functions accessing a common database. This integration allows productivity gains and better business decisions that are based on more accurate information.

1.2 OMR Centres

The OMR centres consist of one corporate office for management and Operations Control Centre (OCC) staff in Fredericton plus three maintenance yards to be constructed as the bases for delivery of the OMR Work.

While the exact locations have yet to be finalized, three year-round staffed maintenance centres are planned:

- North District - Centred in the Saint Leonard area (complete)
- Central District - Centred in the Florenceville area
- South District - Centred in the Meductic area

1.3 OMR Program Management

The three patrol districts have direct responsibility for delivery of all operations and maintenance activities to meet the requirements of the Agreement. Each patrol has an Area Manager and an Operations Technician for systems and technical support, plus the required patrol and operator staff to carry out the on-road activities.

The corporate office acts as the receiver and coordinator of all operational and corridor management processes while the patrol district are the field representatives and observers to ensure compliance.

All offices are connected electronically to ensure immediate dissemination of data and availability of response. This computerized network also connects to the advanced road weather information system (RWIS) network that is key to the delivery of the proactive winter maintenance strategy.

1.4 Operations Control Centre (OCC) Management

The J. D. Edwards One World Call Centre module is used to manage and monitor OCC activities. The OCC provides support services to customers, operations and maintenance. The OCC integrates contract administration, purchasing, preventive maintenance, administration, accident and incident tracking with work request receiving, dispatch and closing to create an efficient maintenance management operations hub.

The concept behind this operations and maintenance management help desk is an end-to-end handling of customer requests. The OCC staff has the technical ability to address issues and work collaboratively with Area Managers to deliver timely, cost effective and appropriate response to service requests. The team of professionals covers shifts 24 hours 7 days a week. They are accessible via a toll-free number and supported by the single platform customer service application. The integration of purchasing and equipment asset information into the workflow of the OCC produces efficiencies in administration of the corrective and preventive maintenance recording processes surrounding the call taking activity.

The OCC continuously monitors operations, communicates with external agencies, receives and logs road report conditions and public complaints and inquiries and coordinates incident response action plans. During winter, OCC staff also monitor the RWIS during forecast events, and confirm that all patrol staff also have accessed the current and forecast weather data.

Where the Road Patroller reports non-emergency deficiencies in as deficiencies to the OMR standards, they are logged by the OCC into the database through the Computerized Maintenance Management System (CMMS) for planned corrective scheduling to meet the required Minimum Response Time (MRT).

With access to the Automated Vehicle Location (AVL) on-line system of all winter equipment, the OCC continuously monitors actual winter and summer equipment operations and performance. This data in conjunction with regular cycle of radioed Facility reports from the Road Patrollers is used for advising the public and media of the Facility condition in compliance with the overall Facility communications plan.

2 FACILITY CONDITION MONITORING

The key component of the annual maintenance plan is the continuous on-road monitoring of pavement and weather conditions. This is carried using the following methods:

Road patrol as per OMR Standard 801 of the OMR Standards

RWIS

OCC operations

Planned periodic asset component inspections with results recorded in CMMS

Detailed asset inspections related to Key Performance Indicators (KPIs)

2.1 Road Patrol

The primary function of the road patrol is to monitor the Facility for operational and traffic safety hazards and observed system conditions that do not meet the required OMR Standards.

During the winter maintenance season, a continuous 7-day – 24 hr road patrol shift is used for each of the planned three patrol districts. The primary patrol function involves inspection of all Facility Sections at least twice per day per direction and at least one per day of interchange ramps. The Facility patrol inspection assesses Facility conditions thus providing first hand knowledge and continuous reporting on observed Facility conditions and operational activities through BHOI's dedicated communications network for the Facility. In addition to the planned Facility inspection cycle, continuous Facility patrolling is initiated immediately in advance and during winter storm conditions.

The Road Patroller has the authority to immediately implement the winter spreader and/or plowing response operations to meet the required Winter Standards.

Each road patrol vehicle is equipped with two-way radio communications, air and pavement temperature thermometers with in-vehicle display, and an on-line computer access of the Facility RWIS network. Each patrol district office base is also equipped with an RWIS computer display. All such on-line system outputs ensure the Road Patroller has continuous ready access to all current and forecast weather data for the Facility on both the patrol district directly responsible for and conditions for adjacent Facility patrol districts.

This comprehensive information system enables complete informed winter response decisions to be made on a continuous 24-hr basis to meet the many unique localized Facility and weather conditions, and in particular bridge surface conditions, throughout the entire Facility.

During the summer maintenance season, the Facility is inspected daily (7 days), with one patrol per week to be conducted after dark to check for Facility lighting outages, sign reflectivity, pavement marking visibility, and other matters.

Where non-emergency condition deficiencies are identified that are beyond the corrective action capability of the Road Patroller, they are immediately reported to the OCC for entry into the CMMS for planned corrective scheduling to meet the required MRT.

Where emergency conditions that have the potential to impact the immediate safety of the travelling public or the structural integrity of the Facility, then immediate corrective action is initiated through communication with the OCC. The OCC then initiates and co-ordinates the required action response plan to address the immediate issue in compliance with the OCC's procedures manual.

3 ASSET INSPECTIONS

The key process of ensuring compliance with all OMR Standards is through a process of Facility inspection of all asset components of the Project.

Such Facility inspections are undertaken through three (3) systematic processes:

- Regular road patrol inspections as per OMR Standard 801 of the OMR Standards
- Planned periodic asset component inspections with results recorded in CMMS
- Detailed asset inspections related to KPIs

The primary function of the road patrol is to monitor the Facility for operational and traffic safety hazards and observed system conditions that do not meet the required OMR Standards.

3.1 Planned Periodic Asset Component Inspections

Many of the OMR Standards require a specific annual visual condition inspection of key assets of the Facility:

- Shoulders
- Drainage systems
- Planted vegetation
- Fencing
- Roadside slopes
- Pavement markings
- Highway illumination (conventional and high mast)
- Barriers

District patrol staff familiar with their local sections of the Facility carry out the annual inspections of these assets. The details of the annual inspection of each asset component, as detailed in the appropriate OMR Standards, are recorded and logged (including digital photos) in the CMMS. The condition of each asset is recorded in the appropriate asset management system module of the J.D. Edwards system.

The results of the various asset conditions rating reports and outputs from the CMMS provide the basis for the planning of both the current summer maintenance and repair program and the subsequent annual budget preparation process.

The annual Facility operations and maintenance program budget process contains a resource allocation for each OMR Work component. Therefore there is a direct correlation between annual asset inspection needs to achieve the OMR Standards and the actual program budget allocation.

BHOI financial process provides an expenditure tracking process of the activity costs against each activity of the OMR Standards e.g. OMR Standard 410 Maintenance of Earth Slopes and Roadsides. This activity based fiscal system in turn provides a planned to actual fiscal comparison for review against the results of the maintenance management system for ongoing fiscal accountability and performance review.

Additional specific inspection cycles are implemented in addition to the annual process to meet the unique requirements of specialized OMR Work - such as the monthly and semi-annual inspections of high mast lights.

3.2 Detailed Asset Inspections Related to Key Performance Indicators

Detailed asset inspections are carried out on major Facility components such as:

- Asphalt concrete pavements (OMR Standard 103 of the OMR Standards)
- Bridges and structures with a span equal to or greater than 3 metres (OMR Standard 501 of the OMR Standards)

3.2.1 Asphalt Concrete Pavement Inspections

The asphalt pavement of the entire Facility will be inspected annually on a detailed section-by-section basis. The results are analysed under the three KPIs as specified in Schedule 17:

- Road Roughness (IRI)
- Surface Distress (SDI)

- Pavement Rutting (mm)

The observation data required for the annual pavement inspection is generated by internal district patrol staff on a detailed pavement section by section basis using data input forms. An expert consultant is retained to collect the remaining specialized ride quality data.

Following inspection, analysis of all pavement inspection data is completed and the annual pavement rating report for the entire Facility is prepared. This report is then forwarded to the Subsidiary and used by BHOI as the basis for immediate (same year) and long-term operational and maintenance program planning. The results of the annual pavement inspection program also establish the annual pavement rehabilitation and treatment program.

3.2.2 Bridges and Structures Inspections

Bridges and structures with spans or combined spans equal to or greater than 3 m are inspected in compliance with specific requirements of OMR Standard 501 of the OMR Standards.

The inspection process is comprised of two distinct processes:

- Routine visual inspections
- Detailed biennial inspections

OMR Section 501.2 of the OMR Standards details the requirements for the every two (2) year cycle for the detailed inspection of all components of each bridge. The detailed inspection process is based on that required under the AASHTO Bridge Inspection Manual.

The results of the detailed inspections are reviewed by the structural engineer and details and recommendations entered into the Bridge Management System module of the J.D. Edwards system. This module is a custom module developed by SNC Lavalin ProFac as a prototype. The recommendations and/or repairs will be undertaken within the lesser time frame as:

- Specified within the approved bridge inspection report or
- Prior to the end of the next construction season

Should a biennial inspection reveal a significant deterioration of any major bridge component, a further specific detailed inspection will be immediately scheduled for determination of the required repair and rehabilitation action

The majority of the above internal staff maintenance work activities will be routine annual base work plan requirements associated with regular known, planned activity demands.

3.3 Asset Management Tools - Pavement, Bridges and Structures Preservation

A sound asset management approach requires objective, high-quality data, presented to decision makers and other stakeholders as understandable, useful information. It is a systems analysis challenge to catalogue the many stakeholders and their information requirements, find the simplest analytical and presentation methods that meet as many stakeholder needs as possible, and design data collection processes that efficiently feed the analyses with an acceptable level of quality. In this context, information technology is a tool to support asset management, not an end in itself. BHOI has implemented the J.D. Edwards OneWorld – Maintenance Module as the CMMS system.

3.4 Communication System

The OMR Work requires a comprehensive communication system covering all offices and Road Patrollers and which will allow for direct communication between all facets of BHOI's operations and the provincial mobile communication centre. BHOI provides daily reports on Facility conditions to the public, regulatory agencies and police authorities upon request and to the provincial mobile communication centre by 6:00 a.m., 10:00 a.m. and 2:00 p.m. in winter and as conditions change. BHOI has installed and operates the following systems to ensure the effective delivery of all Facility related programs:

- Voice Communications
- Computer Network
- RWIS network
- Global Positioning System and Automatic Vehicle Locating System

3.4.1 Voice Communications

The communications systems are comprised of landlines and wireless mobile stations located in all locations and wireless communications systems in the vehicles. The voice communications network is coordinated through the 24 hour OCC to respond to major incidents and manage and coordinate response action plans.

3.4.2 Computer Network

The computer network installed in each location, utilizes a central server located in the SNC Lavalin ProFac office in Toronto, with backup in Ottawa. The computer network accommodates all management information systems including:

- ERP software for finance and reporting (Enterprise Resource Planning)
- HRIS software (Human Resources Information Software)
- GIS software (Geographic Information Systems)
- CMMS software (Computer Maintenance Management System)
- CAMS software (Claims Administration and Management System)
- RWIS software (Road Weather Information System)
- AVL/GPS software (Automatic Vehicle Locating System/Global Positioning System)
- CAD software (Computer Aided Design)
- E-Mail and Internet Server

Patrol vehicles are equipped with hardened notebook computers connected via wireless to the CMMS. The touchpad screen allows easy entry of inspection results and automatically identifies the location and identity of the asset using the GPA and AVL systems aboard the vehicle.

3.4.3 Advanced Road Weather Information Systems

A network of five (5) RWIS sites will be installed along the Facility. Three are presently installed. The final locations will depend on a detailed technical and meteorological analysis necessary to gather the most critical varied weather and microclimate zones that prevail along the Facility, and especially those influenced by the proximity to the Saint John River Valley and watershed.

Preference is given to locating the sites in close proximity to major structures so specific site data on the thermal surface differences of the Facility can be continuously monitored. Pavement data,

obtained by pavement sensors, is particular critical in anticipating early bridge deck icing conditions and the initiation of potential proactive liquid anti-icing procedures.

All RWIS sites are connected to a meteorological service from the Weather Network for routine Facility and weather forecasting for each specific location; with specific forecast updates for major changes to previous forecast outputs. All Facility RWIS data and video images from cameras at the RWIS sites are provided by BHOI to NBDOT with an allowable distribution license.

3.4.4 Global Positioning System and Automatic Vehicle Location System

All BHOI vehicles are equipped with Global Positioning System (GPS) and Automatic Vehicle Location (AVL) systems to allow recording of all patrol and winter equipment operations and related data tracking to provide complete record of “what, where, when and how” the maintenance plan is carried out. Subject to communication coverage, on-line display of all operations and Facility conditions is available to the OCC.

All assets are identified and located using GPS coordinates and the information is included in the Equipment Module of the CMMS. Inspection data entered by patrollers is automatically downloaded into the CMMS using touchpad notebook computers connected wirelessly to the system and identified using the GPS and AVL systems.

4 CORRIDOR MANAGEMENT

The Facility and all related assets are the responsibility of BHOI. In addition to the direct delivery of the program related to the operation and maintenance of the Facility, the additional functions related to the operation and management of the Facility requires appropriate organization and program delivery processes in the following areas:

- Claims Administration
- Advertising Signage
- Commercial Signage
- Highway Usage Permits
- Traffic Counters
- Incident Management
- Over Size/Over Weight Vehicles
- Project Management
- Winter Operations

4.1 Claims Administration

The operation of the Facility requires a claims administration process, which focuses on third party claims resulting from vehicle accidents as they form the majority of claims. This process has the following objectives:

- Provide an efficient claims settlement process for third party claims;
- Minimize BHOI’s exposure to risk and liability;
- Keep insurance premiums at reasonable levels;
- Avoid late reporting to insurers, which could invalidate insurance coverage.

As soon as possible following an incident that could give rise to a claim, BHOI gathers the information and performs a preliminary investigation surrounding the incident. BHOI will have all relevant

operational records available and accessible to both facilitate the investigation and respond to the claim.

The investigation is condensed into an incident report with all relevant attachments, pictures, weather reports and all other data and the operations relevant to the incident. The incident report is in a standard format and is copied to the concerned parties as required. Following the initial investigation the administration of the claim will be forwarded to BHOI's insurer or its appointed adjuster who then takes over the administration of the file.

In addition to any other reporting obligations it may have, BHOI compiles and issues to the Subsidiary a status report of all active files being administered or defended by BHOI's insurer and its legal representatives on a quarterly basis.

4.2 Advertising Signage

BHOI is responsible for the administration of standardized advertising signage in accordance with NBDOT polices and procedures, the Highway Act (including the Highway Advertising Regulations) and current NBDOT Destinations Information Signage Program. BHOI is responsible for enforcing the Highway Act in relation to all advertising within the Facility Lands including the prohibition of privately owned advertisements within Facility Lands.

4.3 Commercial Signage

BHOI has put in place a corridor management system that tracks and records all approved existing and additional signage on lands on and adjacent to the Facility Lands. The system contains a copy of the approval permit for the signage and a digital dated image of the sign. This inventory system is used by the district patrol staff to ensure only approved signs are in place and maintained adjacent to the Facility.

Through the road patrol inspection process, any identified commercial signage that has not been approved or differs from the permit conditions is digitally date photographed and a report, plus the photo image, forwarded to the Subsidiary for further administrative action.

4.4 Highway Usage Permits

BHOI administers a Highway Usage Permit system to track and record the issuance of all permits for installation of physical plant (utilities for example) on Facility Lands in a similar manner as is carried out by NBDOT.

The district patrol offices are supplied with copies of all permits and conditions of approval. Area Managers then inspect all encroachment installations and ensure full compliance with the conditions.

4.5 Traffic Counters

BHOI is responsible to maintain both the traffic counters to be installed in the Design-Build Sections and those currently installed in the Existing Sections.

4.6 Incident Management

The OCC, which is operational on a 7-day 24-hr basis, receives all calls related to incidents. An OCC incident management control manual details response action plans for all incident types. The manual

also contains all current contacts that may be required, including police, fire, external agencies, government departments, utility agencies, Subcontractors, suppliers and service agencies, as well as all the TCHP Co and internal staff emergency contact numbers.

Upon notification of any incident, the OCC Representative logs the initial details into the CMMS. The OCC Representative then initiates and subsequently coordinates BHOI's response action plan as per the incident management control manual. For major incidents, a field site coordinator is appointed to attend the scene and act as BHOI's representative for implementation action.

As detailed in the claims process, all BHOI's costs incurred in responding to any highway incident are tracked and compiled in the CMMS for possible claim cost recovery.

4.8 Weight Enforcement

The Department of Public Safety provides a level of weight enforcement policing on the Facility similar to that provided on other provincial highways.

NBDOT administers overweight and oversize permits for vehicles using the Facility. BHOI is responsible for monitoring and reporting lane closures and restrictions, and reporting it to NBDOT, for the issuance of permits.

Upon issuance of any oversize or overweight permit by NBDOT, a copy is forwarded to BHOI for administration and control. Upon receipt by BHOI, an electronic copy is immediately issued to the affected district patrols, which observe the trip passage to monitor permit compliance.

4.9 Project Management

BHOI is responsible for the management of all major maintenance and rehabilitation projects. Using information obtained from regular inspections and from Asset Management Systems, overall budgets are developed and projects implemented, with the objective to maintain the assets in the high level of service required, and to meet the eventual hand back standards. The J.D. Edwards system ensures that all OMR requirements can be easily retrieved and analyzed to ensure that budgetary targets are achieved.

BHOI has implemented a corrective and preventative action process within its Quality Management System (QMS) that identifies conditions that will be rectified in accordance with the OMR Standards.

BHOI is required to submit the following Operator reports as identified in the Agreement:

- OMR operation and maintenance reports covering summer and winter activities and the year-to-date rehabilitation of the Facility
- Incident management reports that provide details on type of incidents, their classification, number of incidents, number of claims and costs to correct damage to Facility
- Environmental incident reports on a per occurrence basis that record the events involving hazardous substances
- Corridor control reports that record the number of permits issued
- Compliance with key performance indicators (KPIs) report that confirms that BHOI has complied with the KPIs established for the Facility

The management information systems implemented by BHOI facilitate the production of custom reports required to meet reporting standards identified above.

4.10 Winter Operations Plan

The winter maintenance plan addresses the requirements of the OMR Standards 600 series (the “Winter Standards”) of the OMR Standards and outlines the procedures necessary to achieve the required level of service on the Facility as a Class A facility throughout the winter season. The objectives of winter operations standards are to:

- Maintain safe, passable Facility for Facility users.
- Provide an acceptable level of Facility service at all times throughout the winter season.
- Reduce the hazards to the traveling public from icy and snow-covered road conditions.
- Reduce economic losses to the community, industry and commerce.
- Facilitate the handling of emergencies by fire and police officials.
- Minimize accident and liability risks to the user, the TCHP Co and Operator.

4.10.1 Winter Maintenance Plan Key Measures

The following key measures are incorporated in the winter operation plan and implemented throughout the winter maintenance season of November 1 to March 31:

- 7 day-24 hr winter road patrol schedule for each of the planned three districts with patrol trucks equipped with air and pavement temperature displays and loggers, GPS and AVL.
- 7 day-24 hr OCC to direct, co-ordinate and report and communicate the winter maintenance program.
- Complement of winter equipment (combination spreader/snowplow trucks, snowplow trucks, anti-icing liquid spreaders, loaders, graders) based at each of the three patrol maintenance depots along the Facility, with operator staffing to ensure all winter equipment is available to respond and be operational within at least one-hour of call out by the OCC.
- A network of at least five (5) RWIS sites located at strategic locations along the Facility to constantly monitor road and weather conditions. All sites will be connected to Environment Canada on-line weather road condition forecasting service.
- Implementation of a pro-active winter maintenance program to initiate operational action in anticipation of winter conditions, using road-weather forecasting from the RWIS and initiation of anti-icing methods in advance of snow and ice accumulations occurring.

4.10.2 Anti-Icing Plan

Within the context of the new focus on pro-active winter maintenance, BHOI has a definitive anti-icing plan for the Facility.

The general principles of the proposed anti-icing technologies are as follows:

- Full use of the on-line RWIS (five sites).
- Anti-icing used in anticipation of storm conditions.
- Anti-icing only be initiated when equipment can complete routes and return to base within approximately four (4) hours prior to actual storm conditions.
- Anti-icing only be implemented when pavement temperature forecast are forecast to remain above minus 5° Celsius within four hours of application.
- All anti-icing operations to receive prior approval of District supervisory staff.

The comprehensive weather forecasting coverage along the Facility (with the five RWIS sites) is key to the implementation of the pro-active anti-icing winter maintenance plan.

To maximize the effectiveness of the new focus on pro-active winter operations, the on-line web-based outputs from the Weather Network are remotely available in the road patrol trucks. The road

patrol trucks also record the air and pavement temperatures and when combined with the automated road patrol record, a complete road information record is transmitted via the GPS network for on-going monitoring and permanent record purposes.

In addition, all patrol units and pre-wetting and anti-icing spreaders are equipped with GPS positioning and data recording. The full implementation of such a GPS recording system provides on-line tracking and data management systems of all on-road operations including plowing effort, salt, sand applications and quantities.

5 ASSET MANAGEMENT TOOLS - PAVEMENT, BRIDGES AND STRUCTURES PRESERVATION

A sound asset management approach requires objective, high-quality data, presented to decision makers and other stakeholders as understandable, useful information. It is a systems analysis challenge to catalogue the many stakeholders and their information requirements, find the simplest analytical and presentation methods that meet as many stakeholder needs as possible, and design data collection processes that efficiently feed the analyses with an acceptable level of quality. In this context, information technology is a tool to support asset management, not an end in itself. BHOI has implemented the J.D. Edwards OneWorld – Maintenance Module as the CMMS system.

5.1 J.D. Edwards OneWorld – Maintenance Module

The J.D. Edwards OneWorld –Maintenance Module, or Computerized Maintenance Management System (CMMS) integrates all aspects of maintenance with the rest of Facility operations. This consolidated approach provides a maintenance strategy with consistent preventive maintenance routines, history record and standardized reports.

The most important objectives for proper asset management are to:

- Minimize repair costs. Equipment breakdown and road shutdown can cost millions of dollars in costs related to repairs, and poor quality.
- Maximize asset availability to ensure maximum efficiency and good service.

The CMMS can:

- Use master asset tables to record specification details, procedures and scheduling dates to create work orders for preventive and corrective maintenance.
- Record the results of these work orders including work performed, asset condition, estimated replacement year and estimated costs.
- Serve a myriad of departmental needs in financials, human resources, payroll and procurement. The different departments can work independently from each other while allowing integration for specific tasks.
- Generate reports that will assist with refining maintenance strategies and cost forecasts.

5.2 CMMS Interrelated Components

The major components of the CMMS are:

- Equipment Master
- Preventive Maintenance
- Corrective Maintenance
- Procurement

- Inventory Control
- Work Orders
- Reports

5.2.1 Equipment Master

The equipment(or asset) master (EM) is the backbone of the CMMS Module. EM information is the primary data associated with the tagging and identification of every component of the Facility. The EM establishes the basic information about an asset, such as the following:

- Identification numbers
- Description
- Category codes
- Account coding
- Dates (installation/replacement)
- Location
- Status

BHOI uses the information to search for equipment status, location and activity online, track historical, current and planned physical locations for a piece of equipment, relocate equipment, keep detailed maintenance and project logs, view maintenance equipment individually or in groups, revise necessary equipment relationships, or revise equipment status.

To manage equipment inventory, costs, warranties, billing, preventive maintenance and so on, an EM has been created for all maintenance assets. The Maintenance Module sets up assets for maintenance processing, sets up necessary relationships, tracks inventory, and links parts of the inventory to specific equipment.

5.2.2 Preventive Maintenance

A good preventive maintenance (PM) plan will mitigate the risk of further corrective maintenance activities. The CMMS is used to plan, monitor and complete routine maintenance operations. A sound PM plan also promotes quality assurance and control, increasing the life expectancy of the assets and thus allowing for reduced capital requirements or better use of capital in general.

The maintenance procedures employed by BHOI provide maintenance personnel with a systematic approach to completing their work while providing the data needs of the maintenance software. For each asset, maintenance procedures are input into the database for use in work order assignments. During the inspection and audit phase, all preventive maintenance activities and their frequencies are input into the PM database, which will generate a list of PM work orders for completion. The PM work orders generated can be a combination of weekly, monthly, semi-annual or annual activities. The weekly list ensures that approximately the same PM man-hours are required each week.

All maintenance personnel are employed based on their extensive experience with highway maintenance equipment. However, where complex equipment is involved special training is provided to applicable maintenance personnel, and/or subcontractors will be assigned.

Tracking PM builds a maintenance history on the assets BHOI is mandated to take care of. When using the PM module to manage maintenance needs, the type and frequency of each maintenance task is defined for each asset in the Facility maintenance plan.

The PM cycle consists of the following tasks:

- Creating PM schedules for each asset
- Working with PM schedules
- Updating PM schedule information
- Changing the status of PM to complete

5.2.3 Corrective Maintenance

Corrective maintenance (CM) is associated with the repairs or restoration of the highway assets. CM can be planned or unplanned depending on the urgency of the situation. All CM is considered reactive and is performed in response to unacceptable asset conditions discovered by personnel inspecting the assets or by personnel performing Preventive Maintenance.

Service types reflect the trigger that initiates the work order for CM:

- PM Generated CM Work Order
- Operational issue
- Inspection, audits
- Codes compliance
- Others.

All CM is attached to a work order.

5.4 Work Order

The primary functions of the work order module are 1) to increase productivity by readily producing all information required to complete a work order, 2) automatically track labour and material costs to a work order and subsequently to any Facility asset, and 3) consolidate a repair history on each asset in order to establish predictive maintenance schedules.

The work order module accomplishes these functions by accessing extensive databases of asset data, parts information, repair procedures and material and labour costs. These databases are built during the pre-operational phase for each Facility asset.

Work orders are used to manage the workflow of maintenance tasks and projects including the following information:

- Creating work orders for preventive and corrective maintenance
- Committing inventory to a work order
- Scheduling multiple tasks and crafts, such as signage, line marking etc., to a work order
- Tracking the progress of a work order by status
- Tracking work order costs, such as materials, labour etc.
- Recording unlimited detailed information about a work order
- Completing and closing a work order

5.5 Workflow Management

Workflow management is based on of automating various components of the work order life cycle by following a set of procedural rules and triggering events and require minimal user involvement.

Within the J.D. Edwards system, BHOI uses workflow to do the following:

- Route a work order for approval
- Commit inventory to a work order

- Run the capacity plan for a work order
- Send messages to appropriate personnel regarding the progress of a work order
- Define as workflow processes as required
- Execute conditional processing, which is logic contingent upon supplied criteria, such as currency amount, status and priority

5.6 Maintenance Planning

Maintenance planning is used to accurately forecast material and labour resources needed to complete maintenance tasks and to minimize asset downtime by ensuring that the necessary parts, materials and maintenance personnel are available when an asset requires maintenance.

5.7 Reports

The types of reports and the information available from the maintenance module are as follows:

- Asset Master Reports
- Cost Report
- Work Order Report
- Maintenance Planning Report
- Preventive Maintenance Report

The maintenance program provides the requirements for:

- Work Orders
- Planning
- Procedures
- Preventative maintenance
- Predictable maintenance
- Maintenance training
- Materials management interface
- Preparation of budgets for major maintenance
- Purchasing and inventory control

5.8 Material Management Program

The Materials Management program provides the requirements for:

- Procuring materials and tools
- Warehousing
- Inventory levels and control
- Renewal of inventories
- Storage maintenance
- Staging of material
- Maintenance interface

The maintenance software package contains both a purchasing and an inventory module, maintaining a record of all purchase orders, purchases and all inventory warehouse functions.

6 CONCLUSION

The J.D. Edwards enterprise resource system provides BHOI with the means to control most if not all of the day-to-day functions required to run the business of running a highway. The seamless integration of all necessary functions ensures that there is less duplication of effort, and greater accountability in the management of resources and in meeting contractual obligations.

The ability to add modules such as the Bridge Management System and integrate the outputs from the system into the daily and yearly maintenance and rehabilitation programs has increased the efficiency of the system.

Customization of the system will continue, with plans to integrate the management of drainage assets including culverts, ditches, ponds, beaver dams, etc. Further, the system will be tasked with the management of other assets including environmental aspects such as rare plants, Appalachian Forest reserves and wetlands within the Facility.

Finally, as BHOI is not restricted to the operations, maintenance and rehabilitation of the Facility, the enterprise resource system will be called upon in the future to manage other OMR-type contracts such as municipal snow removal, pavement maintenance, building maintenance, etc. Given the experience to-date with the J.D. Edwards ERS, the integration of such contracts should be relatively simple.