TAB 4

SPRINGDALE / LITTLE BAY SYSTEM IMPROVEMENT

(02/07/31)

A JOINT REPORT OF
NEWFOUNDLAND & LABRADOR HYDRO
AND
NEWFOUNDLAND POWER

Executive Summary

Newfoundland Power (NP) has reviewed the condition of its Springdale feeder that supplies Newfoundland & Labrador Hydro (NLH) Little Bay system and determined that the feeder is deteriorated to the point it requires substantial upgrading or replacement. This joint planning study by NLH and NP establishes that the least cost solution is to rebuild the feeder along the road. This solution proposes that NP build the feeder at 2 phase with a neutral to St. Patricks. NLH will rebuild its 4.16 kV system to 25 kV and take supply from NP at St. Patricks. The Little Bay Substation will then be retired. The estimated cost of the project is $690,000.

Introduction

The Springdale area of the province is one of the many areas where NLH and NP systems interact. In such cases both utilities jointly plan their systems to the benefit of all customers which results in a more cost effective solution.

The need for this review comes about as a result of NP's review of the Springdale feeder, arising from a significant feeder outage earlier this year.

The SPR-03 Service Territory

The SPR-03 feeder supplies three NP customers and NLH's Little Bay service territory. This includes the communities of St. Patricks, Coffee Cove, Shoal Arm, Little Bay and Beachside in Notre Dame Bay. The area is typical of rural Newfoundland and includes a small fish plant that is not currently operating. As of 2001 there were 224 domestic customers and 24 general service customers in this service territory.

Both the load history and load forecast for the NLH area are shown in Table 1. The load history shows there has been a decline in load in the area since 1995, and the forecast projects a largely stable but slightly declining load over the near term. While the fish plant has not operated for a number of years, allowance will be made in planning the system that should it return to operation, the electrical system will be able to accommodate it.

TABLE 1

Little Bay System Load History & Forecast

Year	Peak Demand (kW)	Annual Energy (kWh)	
1995	680	2,626,180	
1996	688	2,614,480	
1997	704	2,594,640	
1998	720	2,570,160	
1999	672	2,509,040	
2000	592	2,310,960	
2001	632	2,269,200	Actual
2002	623	2,310,000	Forecast
2003	622	2,306,000	
2004	620	2,302,000	
2005	619	2,297,000	
2006	618	2,294,000	

The SPR-03 Electrical System

The electrical system supplying the SPR-03 area originates at the Springdale substation. This substation has four 25 kV feeders supplying the Springdale area. Figure 1 indicates the route that SPR-03 follows in servicing the NLH area.

The NP SPR-03 feeder begins at the Springdale substation and extends cross country towards NLH's service territory. There is a 4.1 km section from the Springdale Substation to the Davies Pond Tap. The Davies Pond tap is 0.5 km and services NP customers. Also from the Davies Pond Tap, the feeder extends 3.5 km through some rough country to where the feeder crosses the road near St. Patricks. The feeder then proceeds cross country for a further 7.0 km to NLH's Little Bay Substation. Prior to entering Little Bay substation, ownership of the electrical system changes from NP to NLH at a metering tank.

The NP portion of the feeder was initially built in 1965 as a long span 266.6 MCM ACSR single pole three phase line without neutral by The Bowater Power Company to supply the Whalesback Mine near the Little Bay substation. The mine was shut down in 1975. The line with the associated substation continued to be used to supply the local communities.

At the Little Bay Substation there is a 25 / 4.16 kV, 1.0 MVA transformer. The NLH 4.16 kV system exits from the Little Bay Substation and divides into two sections. One section proceeds through Little Bay, on to St. Patricks. It consists of 0.3 km of 3-phase, 4.2 km of 2-phase and 2.2 km of 1-phase feeder. The second section consists of 0.4 km of 3-phase and 0.3 km of 2-phase feeder operated at 4.16 kV. The voltage is then stepped up to12.5 kV for the remaining 6.3 km 2-phase line to Beachside. A NLH system diagram for this area is shown in Figure 2.

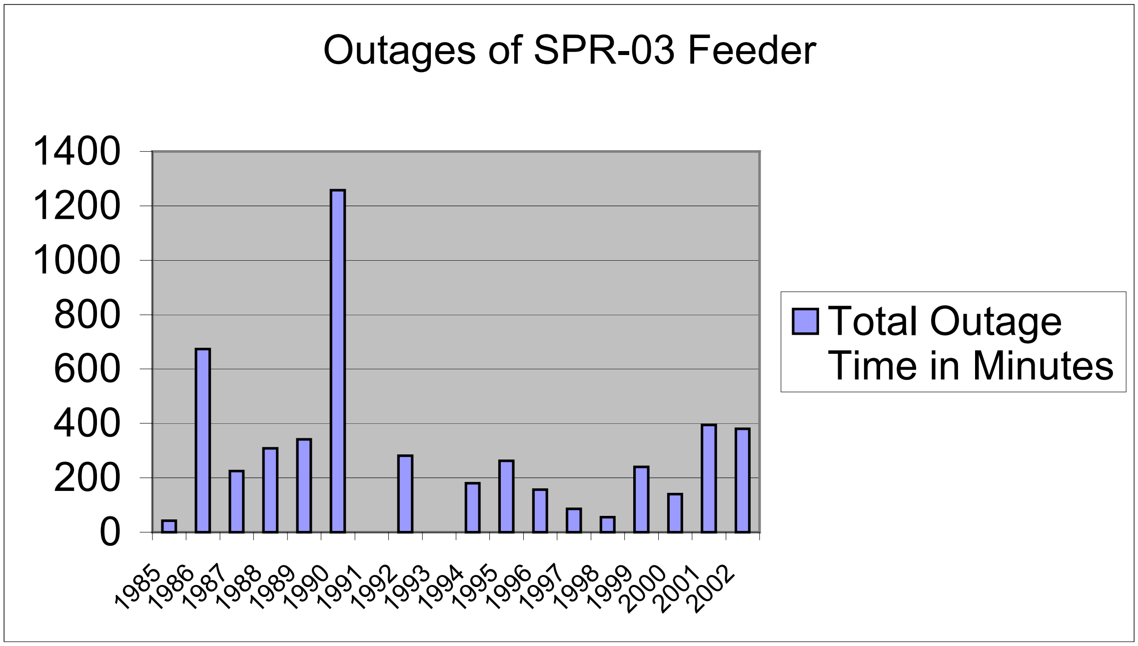
The Requirement To Rebuild Portions of SPR-03

While the line has performed reasonably well over time, it has deteriorated significantly due to age. Its location, mostly in country, makes it difficult and time consuming to locate and repair problems as they occur. As the line has no neutral, faults and insulator failures are usually not discovered until the pole is burnt beyond repair and must be replaced. The deterioration of the line makes it necessary to replace SPR-03 at this time. Figures 3 through 11 give an indication of the terrain, the construction and some of the problems associated with the NP portion of the line.

Table 2 indicates the total minutes of outage that have occurred to the portion of SPR-03 supplying the Little Bay area over the past 18 years. There were significant outages in 1990 and earlier. From 1990 until recently performance improved. However, in the past 2 years performance has begun to degrade. Of significance is the recent outage that occurred on February 11, 2002, where insulator failure removed the line from service for 380 minutes or 6.3 hours. Even though the access distance was not significant, the outage was long due to the nature of the rough terrain associated with the particular location, which is typical of many sections of the line.

Given the age of the NP section of the feeder, its recent performance and the time to repair problems, the existing situation is not considered acceptable.

TABLE 2



Alternatives To Rebuild SPR-03

In developing alternatives, rebuilding the feeder cross country was determined to be both more expensive to build and maintain, relative to building along the road. Further, the time to locate and repair a problem associated with the feeder would likely be greater with the cross country feeder. Given the higher cost and lower reliability of the line, the alternative of rebuilding the feeder across country was not further considered.

Of the alternatives considered, all include rebuilding the feeder along the road to St. Patricks at 25 kV. Although, the line can be rebuilt with the existing 3 phase configuration, two phase construction is another alternative. Beyond St. Patricks, one alternative is to build 25 kV along the road to Little Bay Substation and just energize the remainder of the system from the Little Bay step down substation, as is done now. A further alternative is to convert the load between St. Patricks to Little Bay Substation to 25 kV and not have a 25 kV and 4 kV system along the same road. This concept can be taken further and convert the whole 4.16 kV system to 25 kV, and removing the Little Bay Substation.

The following are the alternatives considered:

1) NP builds 3 phase to St. Patricks & then on to Little Bay Sub.
   NP rebuilds the feeder from Springdale substation to St. Patricks with 3 phase and neutral using 25 kV construction. It continues with this construction to the Little Bay Substation.

2) NP builds 3 phase to St. Patricks & NLH upgrades all 4.16 kV system to 25 kV
NP rebuilds the feeder from Springdale substation to St. Patricks with 3 phase and neutral using 25 kV construction. NLH converts the entire 4.16 kV portion of the existing system, from St. Patricks to the Beachside Sub, to 2-phase, 25 kV. This includes converting the Town of Little Bay to 25 kV. NLH replaces the 2.4 – 7.2 kV transformers at the Beachside Substation with 250 kVA, 14.4 – 7.2 kV transformers. NLH also removes the existing Little Bay Substation.

3) NP builds 2 phase to St. Patricks & then on to Little Bay Sub
NP rebuilds the feeder from Springdale Substation to St. Patricks along the road at 2-phase and neutral using 25 kV construction. It continues with the same 2 phase construction with neutral on to the Little Bay Substation and supplies NLH there. NLH makes modifications to its system to accommodate the 2 phase supply.

4) NP builds 2 phase to St. Patricks & NLH upgrades all 4.16 kV system to 25 kV
NP rebuilds the feeder from Springdale Substation to St. Patricks along the road at 2-phase with neutral using 25 kV construction. NP supplies the NLH system at St. Patricks instead of Little Bay. NLH converts the entire 4.16 kV portion of the existing system, from St. Patricks to the Beachside Sub, to 2-phase, 25 kV. This includes converting the Town of Little Bay to 25 kV. NLH replaces the 2.4 –7.2 kV transformers at the Beachside Substation with 250 kVA, 14.4 – 7.2 kV transformers. NLH also removes the existing Little Bay Substation.

The Alternatives are costed in the following Table 3.

TABLE 3

Alternative	**NP Capital Cost**	**NLH Capital Cost**	**Total Capital Cost**
1. NP build three phase to St. Patricks and then on to Little Bay Sub	$855,000	Nil	$855,000
2. NP build 3 phase to St. Patricks & NLH upgrade all 4.16 kV system to 25 kV	$442,000	$325,000	$767,000
3. NP build 2 phase to St. Patricks & then on to Little Bay Sub	$743,000	$66,000	$809,000
4. NP build 2 phase to St. Patricks & NLH upgrade all 4.16 kV system to 25 kV	$390,000	$300,000	$690,000

Analysis & Recommendations

Load flows calculations were done to determine the adequacy of system voltage through out the feeder for each alternative. Each provided adequate voltage.

A concern with the two phase alternatives was the ability to supply the three phase fish plant load. The plant has not operated for some time. However, the possibility exists that the plant could be re opened. An investigation has determined that the plant can be supplied three phase power from the two phase system. However, there is a possibility that the three phase motors in the plant would have to be enlarged to account for any voltage unbalance. This was not considered an impediment or a significant cost to the two phase alternatives.

It is recommended that the two phase alternative #4 proceed based on least cost and good accessibility. The metering tank would be relocated from Little Bay substation to the point at which the reconstructed feeder meets the existing NLH feeder near St. Patricks. A system drawing for the proposed system in shown in Figure 12. It is further proposed that this construction be completed in the 2003 construction season.

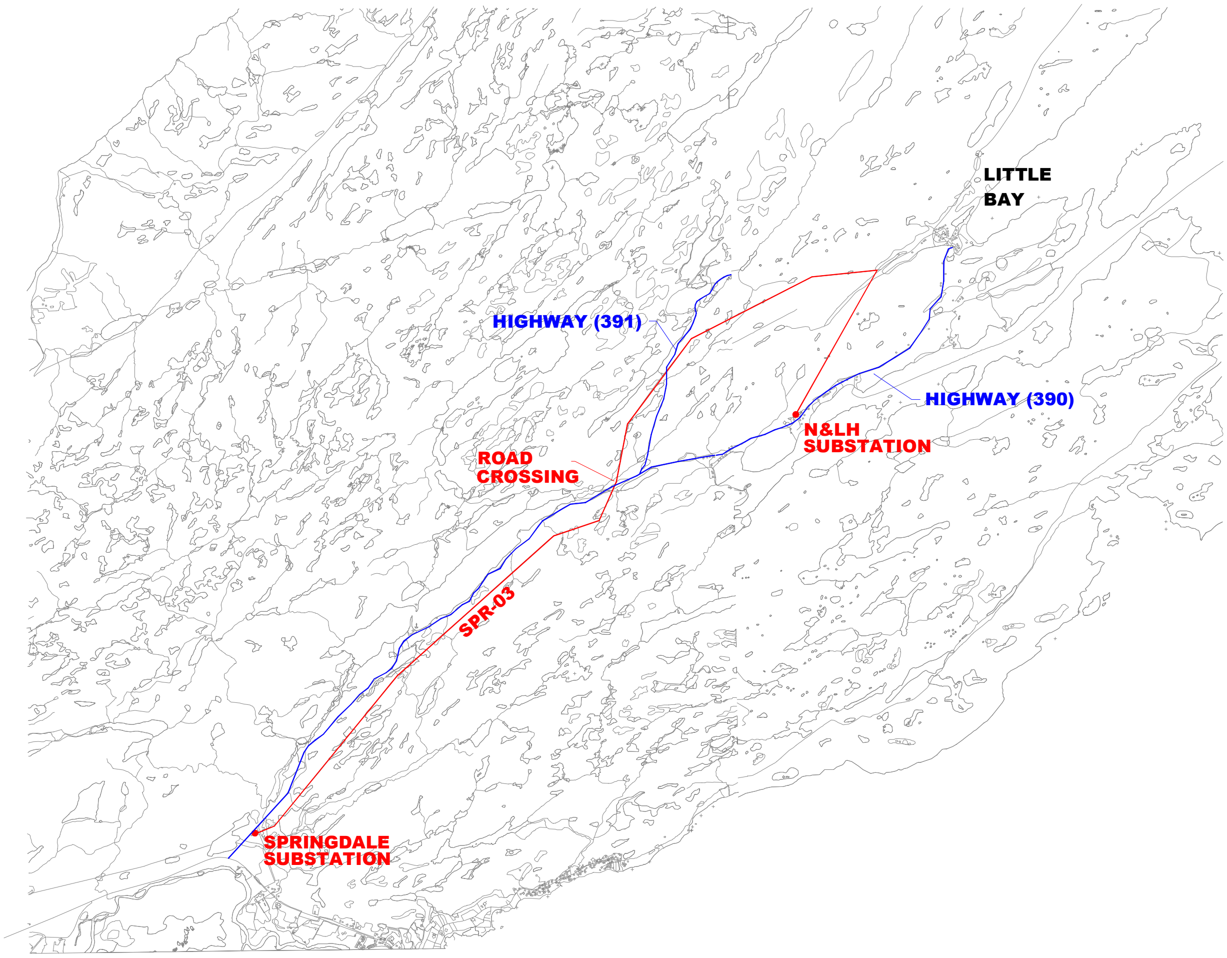
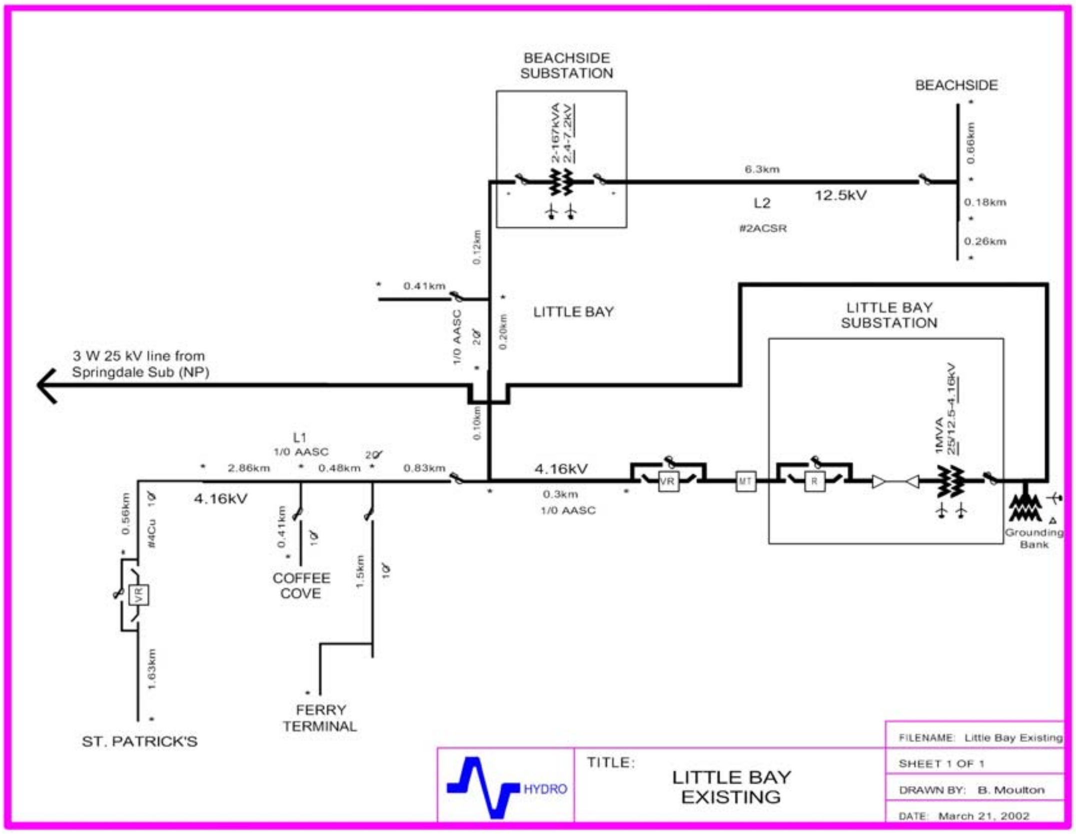


Figure 1
SPR-03 Feeder Route



<u>Figure 2</u>
Existing NLH Little Bay Electrical System

Figure 3
Shows long span single pole coonstruction at one access point to the first section with rugged hills and valley terrain. Note two pole structure beyond single pole.

Figure 4
Note span length

Figure 5
Old Whalesback mine substation site

Figure 6
This and following 3 figures show a split pole with repair by bolting second pole

Figure 7

Figure 8

Figure 9

Figure 10
A second structure with a repair by bolting second pole

Figure 11
First 3 feet of pole replace in 2001. The top was completely hollow with bird's next inside

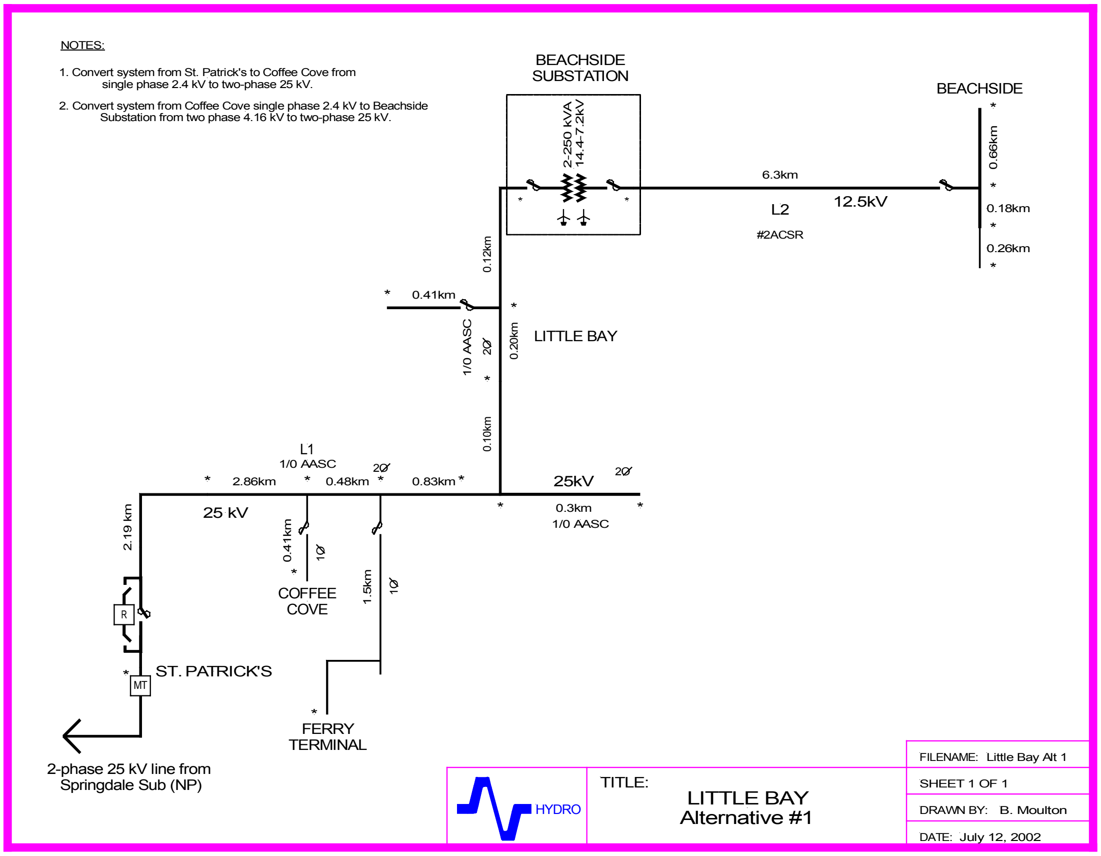


Figure 12
Proposed Little Bay System

TAB 5

Newfoundland and Labrador Hydro
(NLH)
Energy Management System Assessment
Final Report

August 23, 2002

KEMA Consulting

4377 County Line Rd.
Chalfont, PA 18914

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1. Executive Summary

This Report defines the strategic and functional capabilities of the present Energy Management System (EMS) and identifies a plan for replacement that is coincident with NLH's original life cycle expectation for that system.

The present EMS has met the original functional needs of NLH and has met or exceeded the requirements for availability, reliability, performance and response to date. However, equipment age and availability, changes in NLH organization and the availability of skilled support personnel all significantly compromise the ability of the EMS to continue to reliably meet the current and future requirements or to adapt to future mission changes.

The Harris M9200 EMS that is in place is no longer manufactured and no new spare parts are available. In addition, the manufacturer no longer provides training or maintenance support for the system. The system is not upgradeable, only replaceable. Used parts available from third party sources are typically older than the original system delivered to NLH. These parts will therefore likely experience higher than normal failure rates once installed, resulting in a higher probability of repeat (failed part is replaced with a part that fails in a short time) and secondary (failure causes another component to fail, due to power, temperature, or repeated cycling) failures.

The current EMS is based on proprietary technology of the 1980's. These systems depended heavily on vendor specific knowledgeable support staff operating in a dedicated role and presumed that the EMS was an "Island of Technology" that did not communicate with the rest of the organization. In the present and presumably future environment of NLH, neither of these situations can be tolerated. A customized Operational Information System was added to the EMS to extract data for distribution to the organization, but this has further imbedded the requirements for dedicated support staff and does not provide the necessary fault tolerance and availability that is now required for this feature.

The recommendation is to replace the existing EMS over a three-year project time frame. This is an aggressive plan that if started in late 2002, will provide a new system in-service date in late 2005, which is coincident with NLH's original 15-year life cycle expectations for the existing system. Startup delays, or delays after project initiation (unforeseen vendor problems, changes in requirements, Force Majeure, etc.) will result in the replacement system not being commissioned until 2006 or 2007, well past the stated life cycle of the M9000 EMS. Delays also decrease the value of this report. Specifically, its external cost projections (changes in exchange rates, vendor competitive factors, available system suppliers and their respective major component suppliers) may be affected. The recommended approach to the project may also need to be reviewed, based on changes to NLH mission, available technologies, etc.

It must be noted that with the existing system reaching its planned "end-of-life" in mid-2005, a catastrophic failure of the system occurring past that point (perhaps in conjunction with a major power system outage) may be inexcusable in the eyes of Hydro's internal, and external customers. It is for this reason that the replacement project is recommended to begin without delay.

2. Introduction

This System Assessment provides a review of the current situation regarding the Newfoundland and Labrador Hydro (NLH) Energy Management System (EMS) and summarizes the strategic and functional requirements for the future EMS. KEMA Consulting is also submitting a Requirements Definition report to Churchill Falls (Labrador) Company at the same time as this report. The rationale for this is to assess any benefits to the Hydro Group of Companies to implement a joint procurement.

2.1 Project Overview

Newfoundland and Labrador Hydro is an electric power utility that owns and operates facilities for the generation and transmission of electricity to utility and industrial customers and distribution to 35,000 commercial and residential customers in rural areas of the Province of Newfoundland and Labrador (The Province). Churchill Falls (Labrador) Corporation (CF(L)Co) is an electric power producer that operates facilities for generation and transmission of electricity to NLH and two industrial customers in the Labrador portion of The Province and for export to a neighbouring utility. Both entities form part of the Hydro Group of Companies (Hydro).

In August 1990, NLH placed in-service its existing Energy Management System (EMS) with a projected 15-year operational life. With the NLH EMS now in its twelfth year, combined with changes in technology and a need to better integrate enterprise and operational systems, NLH has engaged KEMA Consulting to review and assess the current operating performance and capability of the EMS. The purpose of the NLH assessment is to determine and identify:

- Whether the EMS still meets the functional needs of NLH
- Whether there are any risks to NLH in continuing to use the system
- When consideration should be given to replacing the system
- The functional capabilities of a replacement

CF(L)Co has also engaged KEMA Consulting to review and assess the current operating performance and capability of their SCADA system. Hydro sees an opportunity to optimize support requirements if both companies use systems from the same vendor.

2.2 Background Information

KEMA Consulting was awarded a contract on March 7, 2002 by NLH to assist in the determination of current and future EMS needs. The first task was to determine the viability of the present EMS. To accomplish this, KEMA Consulting prepared a questionnaire to guide NLH in assembling pertinent data for analysis (See Appendix C) and subsequently key employees were interviewed on April 29 and 30, 2002. The objective of the information-gathering meeting was to interview key NLH personnel to obtain their inputs for developing the needs for the future EMS.

KEMA Consulting has analyzed the input gathered via the written responses to the Questionnaire as well as the interviews. The purpose of this document is to present the findings of the assessment, recommendations and a proposed plan for going forward. It is an interim step to bridge the gap between the information-gathering task and the specification preparation task. Functional requirements are presented in outline form with the detail behind the outlined items to be provided in the specifications. The results of these efforts are documented herein as a general set of requirements that can eventually be translated into an EMS procurement specification.

2.3 Report Organization

This report is organized as follows:

Section 1 is the Executive Summary.

Section 2 provides the introduction to the project and a summary of report contents.

Section 3 provides an assessment of the current situation at NLH in terms of control center computers, operations, substation equipment, interfaces to internal and external systems, communications to support the systems, and functions performed.

Section 4 presents driving forces for change in terms of specific NLH system goals and objectives and modern-day EMS capabilities.

Section 5 presents alternatives based on the assessment and driving forces to change, and provides estimated cost and projected benefits for the alternatives.

Section 6 provides a comparison of the alternatives and associated recommendations.

Section 7 describes the recommended future system in terms of system functional requirements such as SCADA, information storage & retrieval, user interface, applications, communications, and documentation. It also presents recommendations regarding staffing.

Section 8 provides an implementation plan for the recommended alternative.

3. Assessment of Existing Systems and Processes

This section presents a description of the existing NLH system, with special attention to its basic capabilities and shortfalls relating to SCADA, applications, and integration with other enterprise systems.

Please note that the EMS is working as designed, and unless otherwise noted below, is satisfactorily performing all functions.

3.1 NLH General System Assessment

The present NLH EMS is a Harris M9200, purchased in 1988 and commissioned in August 1990. The system is comprised of two Harris H1200 computer systems with a failover system to control the on-line and standby operating modes of these computers. When both computers are operational, several functions (including Report Generation and Advanced Power Network Applications) are allowed to run in the "standby" computer. This balances the resource utilization of the two processors, and optimizes user response for all functions. A third Harris H1200 computer is installed for the development and testing of database, display, report and software modifications.

The software provided with the Harris system did not easily accommodate access to data from outside the EMS. For security reasons, access to these systems is restricted from the corporate LAN. To improve the capability to share EMS data with the rest of the enterprise, NLH added an OIS (Operations Information System). This included special software from Open Systems International (OSI) to access real-time data from the EMS, and provides trending, reporting and a browser-based User Interface. It includes a Sybase relational database for historical data storage and reporting. The OIS also provides an interface for real-time data exchange (with Newfoundland Power), and the acquisition of environmental data from external sources.

Exhibit 3.1-1 illustrates the current configuration of the EMS and OIS. Note that the present EMS has the capability to support a Operator Training Simulator. This application is currently not used by NLH due to resource limitations.

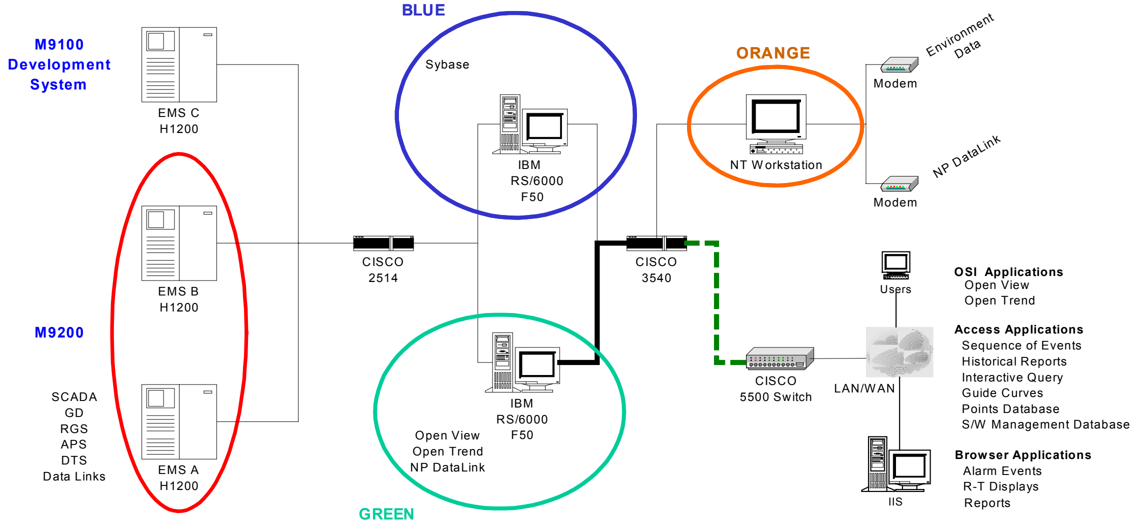


Exhibit 3.1-1 EMS & OIS Overview

3.1.1 Reliability

Historically, the reliability of the EMS has been acceptable. The system has a history of being very stable with minimal loss of critical functionality due to system down time (overall availability from commissioning in 1990 to date is documented at 99.984%). Much of the recent recorded downtime has resulted from external actions, i.e. not directly attributable to "system" failures per se. This is indicative of the lack of trained and experienced technicians (due to attrition) to service the system, as well as the end-of-life for many components (especially power supplies).

3.1.2 Maintainability

Maintenance has recently become problematic. Despite the general availability of spare parts, several maintenance problems are beginning to arise due to the age of the system. As one example, parts and consumables for the systems' impact printers are becoming increasingly expensive and difficult to obtain. The system cannot be modified to allow the attachment of modern laser printers.

An immediate concern is the lack of trained technicians to service the system. Training has not been available from the vendor for some time. Outside expertise may be able to be located and called in, but would likely be several days in arriving.

3.1.3 Security

Security is not a problem with the current system, as it is relatively “closed”, with few external hardware connections or software capable of sophisticated data transfer to other external systems.

3.2 SCADA Assessment

3.2.1 Basic Functions

3.2.1.1 Physical Facilities

The present ECC Control Room is equipped with three consoles, three PC workstations and a mapboard. The two consoles closest to the mapboard are the System Operator and the Shift Supervisor and are operated on a 24/7 basis. The third console is used on a periodic basis by Operations Engineering and EMS Support staff for such tasks as outage (load flow) studies, EMS changes, point commissioning and to assist during emergency conditions. This console is raised above the other consoles to ensure visibility of the mapboard. On the second floor, overlooking the control room is a fourth console used for training and studies.

Each console displays EMS data on three limited graphic CRT displays, while EMS data entry and selection is performed using a keyboard and trackball. Each console contains a phone turret, designed to integrate into one console three methods of voice communications in use: VHF, Operational Voice (NLH) and the public switched network (Telco). Operators may also use these turrets during power system disturbances to record messages on one of ten lines, one for each customer service area.

A networked personal computer is located next to each of the three consoles in the Control Room. The setup of each is identical. PCs have the following applications:

- Switching Order database
- Bay d’Espoir Efficiency Monitoring
- Email, Internet
- Lightning Tracking (Ltrax)
- Reporting/Queries
- Trending
- Bay d’Espoir Unit Commitment
- Sequence of Events
- Equipment Outage database
- Generation Performance (Canadian Electrical Association and internal reporting)

The operator is presented with two mechanisms to enter and view EMS data: the CRT Displays, trackball, keyboard and the PC, mouse, keyboard.

A voice-recording device is provided to record all conversations with Energy Control Center staff. The device uses primary and backup tapes to record and store conversations.

There is a real time system frequency recorder that is used during system disturbances. This device uses pen and paper recording technology.

3.2.1.2 Displays

Due to the limited graphic nature of the CRT displays, trending and "world" (total system) view displays are not available on the EMS consoles. Displays tend to be alphanumeric and are linked so that the operator can "page" through the displays. The format of these displays is predefined, and contained in the system display files.

A group of displays may be defined to be a set. Thus the displays for a particular system may be logically divided into sets as required. The display editor provides the necessary tools to enable the user to build and modify these display pages and display sets in the system display files.

OpenTrend (OSI International) is software used on the control room PCs for data point trending. Data is transferred from the EMS to Operations Information System (OIS) every 10 seconds and stored in a trending archive. 100 points may be defined for trending. The time scale for point display is limited (8 hours for some values). Data is available online for approximately one year. Approximately 85Mb disc space is required to store a month of data.

3.2.1.3 Alarm Management

One of the custom modifications implemented by Harris as part of the original purchase of the EMS involved the elimination of any paper logging of alarm or event messages. Instead, seven (7) alarm/event logger files are maintained on-line which the system operator can view. These files cover the current day plus six previous days (unless there is a message overflow) and these files are regularly archived to tape. In addition, the capability was provided to search these logger files for messages matching certain criteria such as station name, date/time range, etc., as well as append comments to messages that can be printed along with the selected messages. There is an archive logger file that allows any archived event log to be retrieved and viewed. NLH has modified this custom since system delivery to increase the maximum number of messages in each logger file from 5040 messages (140 display pages) to 18144 messages (504 display pages). Details of the alarm and event customs can be found in Harris Corporation documents "Alarm/Event/Logger Custom", document # 014-4202-031 and "Alarm/Events Demand Custom", (reference NLH Transmittal # N-014-2002 04 12).

NLH has enhanced the Alarm application to suppress selected field event individual alarms in the EMS and present a pseudo alarm to the system operator.

The Energy Control Center is also responsible for monitoring intruder and /or fire type alarms from NLH terminal and generating stations, area offices, and Information Systems and Telecommunications (IS&T) remote communications facilities.

Alarms received at the Energy Control Center arrive from multiple sources. Some alarms are autodialed into the Energy Control Center using voice-messaging technology, while others appear as a point change on the Harris EMS.

3.2.1.4 Data Acquisition

Four RTU scan rates have been implemented; 2 second, 4 second, 8 second and 16 second.

All generating plants are scanned at 2-second rates, although data values such as reservoir levels are defined to be scanned at the 16-second scan rate. The scan rate for terminal stations is variable depending on the communications bandwidth available. All RTUs are scanned using the Harris protocol.

A local RTU is used to provide status, alarm point and analog information from local equipment. No control output is used. Information is input from such sources as UPS, diesels, air conditioners, transfer switches, room temperature monitors, etc.

RTU communication errors are sent to the Report Generation Subsystem (RGS) for reporting purposes. Hydro has modified the standard DAC Communications Analysis report to provide an error summary on an RTU basis (reference Section 3.2.2.6).

3.2.1.5 Sequence of Events

NLH has developed a custom software application to enhance the standard Harris supplied Sequence of Events (SOE). It allows online retention of 7 days of SOE messages. Changes were made to the standard SOE processing so that the messages are retained to disc. A viewer application was created for the SCADA/EMS to allow viewing the messages. Reference “Sequence Of Events Logging Custom Detailed Description” (Transmittal # N-048-2002 04 26) “Sequence Of Events Logging Custom User Guide” for more information.

SOE data is also available through a browser-based query and MS Access. Date/time, stations, point name, etc. are available for filter conditions. Reference “Sequence of Events Transfer to Information Delivery System Detailed Description” (Transmittal # N-049-2002 04 26) for more information.

3.2.1.6 Remote Supervisory Control

NLH has remote control over most of its equipment. Not all devices can be controlled, including a limited number of locations without an RTU and some motor operated disconnects. NLH shares some of its status and analog points with Newfoundland Power and Deer Lake Power.

NLH has remote control over parts of its distribution systems. Typically, this includes remote control of the station reclosers and feeder breakers as well as some distribution line reclosers.

The majority of NLH generation and transmission system equipment is controlled either remotely from the Energy Control Center or from staffed generating plants, Bay d'Espoir and Holyrood.

3.2.1.7 Mimic Diagram

The mimic diagram located in the control room is a SACO tile board consisting of a static representation of the NLH power system with integrated indicator lamps, digital meters and bar graphs. The mapboard is intended to be used by the operators as a quick overview of the state of the power system, during restoration after a major disturbance and to discuss maintenance and outages with field crews. Unfortunately, the operator positions are located too close to the mapboard, making it difficult to see the entire power system status. The board does not show sufficient detail to be of much use during system restoration activities.

The indicator lamps provide a real time display of the following functions.

- Major Station Alarm
- Minor Station Alarm
- Transformer Alarm
- Transformer Outage
- Line-End Outage
- Line Outage (Transmission Line Name)
- Generator Status

Various meters display megawatts, frequency and voltages at key locations in the power system. Digital meters that display voltage are located within each station box for each voltage level at 230 kV, 138 kV and 66/69 kV. A group of operator assignable digital meters is located next to the frequency strip chart recorder.

Each multi-unit generating plant has a circular bar graph to indicate current plant generation as a percentage of maximum plant generation for on-line units. In addition, there is a larger circular bar graph for system generation and digital displays for system time, standard time, time deviation and frequency located in the upper right corner of the mapboard.

3.2.1.8 Real-time Calculations

The NLH EMS includes a "Calculated Points" subsystem that was standard in all Harris M9000 systems. This subsystem uses an "interpretive" or macro language that provides basic arithmetic and logical operators that can be used to define calculations using database points or registers as inputs and outputs. Calculations can be associated with a RTU, such that when the calculation is automatically triggered upon certain RTU conditions (status change or limit violation). Other calculations may be periodically executed, or executed by program request or special database triggers (i.e., associated with pre-specified alarm conditions).

NLH has made extensive use of this facility; please refer to Transmittal # N-007-2002 03 15 for a description of the defined calculations.

3.2.1.9 Control Validation

The Harris M9000 also provides a standard facility to validate designated control action requests (based on various monitored system conditions) prior to transmitting the control command to the remote device. The validation can either be performed through the execution of a designated real-time calculation (reference Section 3.2.1.8) or an application program specially written for the function. NLH has also made extensive use of this capability; please refer to Transmittal # N-007-2002 03 15 and N-017-2002 04 16 for a description of the control validation functions and the associated calculations.

3.2.1.10 Disturbance Data Collection

The NLH EMS from Harris includes a Disturbance Data Collection and Logging (DDCL) subsystem that collects specified telemetered and calculated data quantities for pre-disturbance, disturbance, and post-disturbance periods and provides the ability to produce a report (reference Section 3.5) showing the state of these important real-time variables. Alarm and event logs are also collected and included in the report.

3.2.2 NLH Applications

NLH has developed a number of additional custom SCADA applications to assist ECC staff. These applications are described in the following sections.

3.2.2.1 Auto Restoration Scheme

The Auto Restoration Scheme function is to restore power to an oil refinery on loss of power. This application will follow defined sequences of opening and closing breakers, as well as checking various alarm point statuses. The stations involved are Come-By-Chance, Western Avalon, Sunnyside, and Bay D'Espoir.

3.2.2.2 Dam Breach

The Dam Breach application is designed to monitor the reservoir elevations at Hinds Lake, Meelpaeg, Great Burnt Lake, and Long Pond. The application will provide an alarm on the dispatch consoles when either of the reservoir elevations drops by a configurable amount within a 24-hour period.

This application will determine the total elevation drop in each reservoir over the previous 24 hours by summing any elevation drop form one hour to the next. The 24 hour accumulated drop in reservoir elevation will not be reduced for any rise in reservoir elevation detected during the 24 hours. If the elevation drop over the 24-hour period exceeds a configurable delta, an alarm will be logged to the A&E subsystem and the station major alarm lamp will be activated.

This is a custom application implemented on the EMS by NLH. The complete design is documented in the document DamBreachDesign.doc (Transmittal # N-018-2002 04 16).

3.2.2.3 Multiple Breaker Operation

This function allows operators to open several breakers with one control operation. This reduces the number of control operations that system operators must perform during a restoration or outage situation. The grouping of breakers is done at a database editing level by programmers/engineers. Reference NLH document "Load Shed/Restoration - Customs Document", Document Number NLH-03 (Transmittal # N-020-2002 04 16) for a copy of the design document describing the function.

This function was implemented by NLH through modification to the standard vendor Load/Shed Restore application.

3.2.2.4 Tandem Tap Control

This function allows simultaneous operation of several transformer taps. System operators can operate the grouped taps with a single control raise/lower operation. This feature does not prohibit operation of individual transformer taps in a group. The grouping of transformers is done at a database editing level by programmers/engineers. Reference NLH document "Load Shed/Restoration - Customs Document", Document Number NLH-03 (Transmittal # N-020-2002 04 16) for a copy of the design document describing the function.

This function was implemented by NLH through modification to the standard Harris Load/Shed Restore application.

3.2.2.5 Mapboard Lamp Assignment Display

NLH has developed a display and associated application to provide data that allows viewing of the current mapboard lamp assignments on the system. All points that are assigned to a mapboard lamp can be viewed. An option is available for only viewing lamps that have points assigned that do not have an abnormal state defined. This feature is useful for determining which points on the system have had their abnormal states removed and are causing erroneous mapboard information.

Reference NLH document "Mapboard Lamp Assignment Display Program – Detailed Description", Document Number NLH-17 (Transmittal # N-043-2002 04 25) for a detailed description of this function.

3.2.2.6 DAC Communications Error and Statistics Logging

NLH has made changes to the standard Harris M9000 Data Acquisition and Control error reporting capability (known as DAC Communications Analysis) to remove unnecessary information and provide additional summary information. Please refer to Document Number NLH-06 (NLH Transmittal # N-023-2002 04 18) for details of the modifications.

NLH also modified the standard M9000 DAC Communications Statistics facility to transfer the data to the M9000 Report Generation Subsystem (RGS) database. Once in that database, specially created RGS reports calculate daily, monthly, and yearly totals. Please refer to Document Number NLH-07 (Transmittal # N-023-2002 04 18) for a detailed description of this function.

3.2.2.7 Intranet Access to Real-time and Historical Information

The Harris system sends historical information to the Sybase database on the OIS. Custom software was developed to implement this data transfer. Once in the Sybase database, MS-Access, Excel and Browser applications retrieve the information for use by corporate users.

External browser applications provide an interface to both historical and real-time information. Browser applications that show real-time information retrieve the information from the OpenView database on the OIS which is refreshed every 10 seconds from the Harris system.

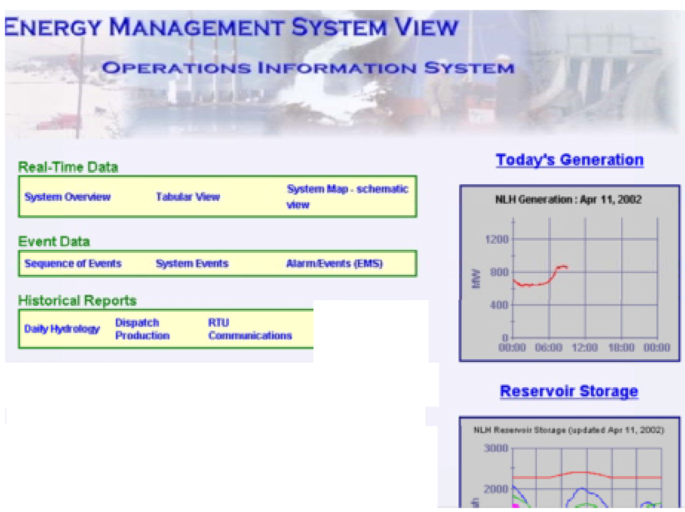


Exhibit 3.2-1 Sample Browser display

3.3 Generation Dispatch Assessment

3.3.1 Automatic Generation Control (AGC)

The Energy Control Center staff is responsible for AGC operation while the IS&T department is responsible for supporting AGC and maintaining its parameters tuned for operations.

Automatic Generation Control for the provincial power system is accomplished using the Harris M9200 EMS function AGC. AGC minimizes the area control error using four of NLH's hydraulic generating plants: Bay d'Espoir, Upper Salmon, Cat Arm and Hinds Lake (11 units in total). There are no tie line controls required, only system frequency and time error.

At times there are frequency stability problems during lightly loaded periods with no thermal generation on line.

NLH and Harris both developed a number of custom applications to provide the required AGC functionality. These are described in the sections that follow.

3.3.1.1 Harris Supplied AGC Customs

Loss Calculation: AGC acquires system losses from the EMS database to perform real time loss/load calculations. The systems losses are updated by the Real Time Security Analysis routine.

ACE Trip Limit: AGC will trip to MONITOR mode whenever the magnitude of smoothed ACE exceeds a limit entered by the system operator.

Unit Condensing Mode: Defines condensing mode (COND) as a unit operating status for condensing units.

Unit Ramp Start Time: Displays the unit ramp time and ramp start status on the Unit Detail Display.

Unit Calculated Breaker Status: Monitors the unit breaker status and AGC trips unit to UNAV mode if the breaker is open.

Selectable Unit Time Constant and Controller Gain: AGC will select one of two sets of unit time constants and controller gains based on the telemetered unit governor mode.

System Loss Calculation: AGC will calculate the system loss based on a percentage of the system loss factor.

High Voltage DC Line Control: The HVDC line is monitored as a generator in AGC.

Display Unit Up/Down Time: Calculates and displays the time each AGC unit has been in the current mode of operation, either on-line or off-line.

3.3.1.2 NLH Implemented AGC Customs

Frequency Source Display: AGC displays the frequency source currently in use.

Maximum Unit Loading: To reduce the risk of having insufficient load available for under frequency load shedding and avoid the potential of the system stalling, the system operator can change the high economic limits of units greater than 85 MW.

Regulation Factor Limit: Works in conjunction with Maximum Unit Loading to limit the value of inverse slope that a unit can be assigned, thus limiting regulation to that unit.

3.3.2 Economic Dispatch (ED)

The Energy Control Center staff is responsible for the Economic Dispatch of up to 11 hydraulic units, while the IS&T department is responsible for supporting the Economic Dispatch application.

Economic Dispatch of NLH's hydraulic generating units is accomplished using the Harris M9200 EMS function, Economic Dispatch. ED calculates base points for generating plants at Bay d'Espoir, Upper Salmon, Cat Arm and Hinds Lake (11 units in total) and is based strictly on economics. The economics are determined based on the Incremental Water Rate curves of the hydro units and a calculated cost of water for each plant.

The incremental heat rate/water rate curves are the responsibility of the System Operations Department. However, there are currently no field-validated heat rate curves for the Holyrood plant.

There is an hourly reporting tool used through a PC based program which provides the operator unit efficiency information by hours, shift and day to assess hydraulic production efficiency.

A number of custom applications have been developed by Harris to support the required Economic Dispatch functionality as follows:

3.3.2.1 Harris Supplied ED Customs

Unit Incremental Cost: AGC will calculate the unit incremental cost ($/MWHr) corresponding to the actual generation of the on-line units. Units in synchronous condenser mode are excluded from the calculation.

Wicket Gate Limits: Telemetered wicket gate limits are automatically adjusted for high operating and economic limits. These are calculated based on a set of operating and economic reference limits and a wicket gate to MW scale factor corresponding to a wicket gate limit of 100% for each unit.

3.3.3 Reserve Monitoring

Generation reserves (real power) are categorized into regulation reserves and other reserves to give the total spinning reserves. Regulation reserves are monitored using the "Generation by Unit" display page on the Harris M9200 System. Regulation reserves consist of hydraulic units in ECON or BASE.

Units in MANUAL do not get added to the regulation reserves and are categorized into other reserves. In addition, thermal generation, Paradise River and NUGs are categorized as other generation reserves when they are online. If an individual generating unit is loaded above a limit that, if lost, would result in significant load loss, then the ECC operator is warned by an alarm on the Harris M9000.

In addition to standard reserve parameters, the Harris provided Reserve Monitor program calculates additional reserve parameters, primarily relating to Mvar reserves, and alarms any deficiencies.

3.3.4 Production Costing

No online or daily production costing is currently monitored due to the high hydraulic component of the generation and there is no validated heat rate curve data available from the Holyrood plant. Production costing is accomplished only on a monthly basis through fuel usage reporting.

Both Harris and NLH have developed a number of custom applications to support the required Production Costing functionality as follows:

3.3.4.1 Harris Supplied Production Costing Customs

Two Units on a Single Penstock: One set of IWR curves will be selected whenever a single unit is on-line on a common penstock and a different set of IWR curves will be selected when both units on a common penstock are on-line.

Switch IWR Curve Based on Head Level: The current head level of a Hydro Plant will specify one of five IWR curves that will be used.

3.3.4.2 NLH Implemented Production Costing Customs

Water Price Adjustment: Provides a means to adjust the price of water depending on the IHR/IWR curve that is in use. This ensures that all plants have equal incremental cost at their most efficient load points when operating at maximum gross head.

3.4 Power Systems Applications Assessment

The Harris M9000 was purchased with a complete, integrated set of Harris standard advanced power network analysis software including typical device (i.e., transformers, transmission lines, generators, buses, breakers, shunts and loads) modeling capabilities. The information can be accessed by the system operator via station one-line diagrams or in tabular format for each item in the hierarchical list. The analysis of the network can be performed in either real-time mode (Real-Time Network Analysis) or in study mode (Study Network Analysis).

It was noted that the application "Power System Simulator for Engineering" (PSS/E) from Power Technologies, Inc. (PTI) is used outside the control room environment as an operations and system planning tool. But this network model must be maintained separately from the network model used by the M9000, and there is no method to exchange model information or data between the M9000 and this application.

3.4.1 Real-Time Security Analysis

The Real-Time Security Analysis (RTSA) function uses the current state of the power system. Static model data, describing the electrical properties of the power system's devices, is combined with dynamic measurement data obtained from a snapshot of the real-time SCADA data.

The major components of Real-Time Security Analysis include:

- Network Configurator
- State Estimator
- Contingency Analysis / Contingency Selection
- Optimum Power Flow
- Penalty Factor Calculation

The Network Configurator (NC) maintains the model that defines how all equipment in the power system is interconnected. This model is automatically updated with any change of state of a switching device.

The State Estimator (SE) provides the system with a reliable and complete view of the power system by correcting inconsistencies and errors in the real-time data. Bad measurements in the SCADA system are flagged and approximations are calculated by processing a set of redundant measurements. A secondary function of SE is to provide a solved solution for areas of the network that do not have telemetry.

The Contingency Analysis (CA) function checks the security of the power system by simulating a set of pre-defined contingencies ("what-if" scenarios). For each contingency, a set of monitored devices is checked for violations that would occur as a result of the contingency – out of range bus limits, overloaded lines and overloaded transformers. A detailed report is generated to show all violations and contingencies are ranked based on the number and severity of violations. The system operator may then decide to resolve the security violations of a particular contingency by copying the real-time snapshot into a study case.

In real-time, a continuous evaluation of system security is provided through different triggering mechanisms (which can be individually enabled or disabled by the system operator):

- Event triggers, such as changes in breaker states or limit violations on analog points
- Chi-square test trigger that determines if the state of the system has changed significantly from the last execution of network analysis
- Time trigger (periodic execution)
- System operator request

The Contingency Selection (CS) function is a pre-processor that has been designed to screen the critical contingencies from the non-critical. This reduces the number of full solution load flows required to assess the steady state security of the power system.

Optimal Power Flow (OPF) assists operators in making the best use of supply and control facilities to eliminate or minimize limit violations. At the same time OPF attempts to maintain operating economy. The system operator is free to choose the optimization objective, the control facilities to be utilized and the constraints to be observed.

One of three objectives is selectable by the system operator. These include minimizing production costs, minimizing transmission losses and minimizing control actions. Any of the following controls are available to be used in the realization of the desired objective:

- MW Generation
- Mvar Generation
- Capacitor/Reactor Switching
- Transformer Tap Adjustment
- Transformer Phase Shifters

In addition, OPF enforces the following constraints in deriving a solution:

- Control Device Switching
- Generation Reserve Requirements
- Bus Flow Limits
- Network Flow Limits

However, should a feasible solution not be found, limit constraints may be relaxed in order to achieve a solved network model.

Penalty Factor Calculation (PFC) calculates penalty factors for each on-line generator. These factors are used by Economic Dispatch to minimize overall production cost. The penalty factors bias the unit cost curves such that more economical units pick up a larger portion of losses. Penalty factors are an indicator of transmission line losses attributed to each generator for delivering power to the load center. The PFC function is used in both real-time and study modes. A historical average of penalty factors based on internal load and net interchange is maintained in a penalty factor grid. In the event that a load flow solution is not obtained by RTSA, then approximate penalty factors may be obtained from this grid.

3.4.2 Study Network Analysis

The Study Network Analysis function allows the system operator to initialize a study case from the real-time case from a stored study case or from schedule data. Once the study case has been initialized the system operator can interactively manipulate it in order to analyze present and future operating conditions. The study functions include the same applications as the real-time security analysis, with the exception of State Estimator, which is replaced by a Dispatcher's (i.e., system operator's) Load Flow (DLF). Note also that the Economic Dispatch function does not use penalty factors that are calculated in study mode. However, the system operator may manually add them to the penalty factor grid.

DLF permits the system operator to determine the operating state of the power system under current (real-time) or hypothetical conditions. A total of 12 cases may be stored for future analysis. The system operator can examine the DLF results via station one-line diagrams or device tabular displays. The following actions may be performed:

- Switch transmission lines, transformers and/or buses in or out of service
- Change the on-line/off-line status of generating units
- Change the MW and/or the Mvar values of generators or loads
- Open or close circuit breakers to set up the anticipated configuration
- Modify any individual parameters defining the operating state of the system by entering a new value

Once the model is defined to represent the desired conditions, the system operator can execute the Load Flow.

3.4.3 Custom Power System Applications by Harris

Harris added the following features as customs to the baseline Harris M9000 suite of advanced applications. Additional details may be found in Transmittal # N-053-2002 04 26.

- Normal Breaker Status – All breakers can be initialized to their "normal" state through a selection point on the Study Control Page
- Transformer Tap Position Estimation – State Estimator provides the capability to estimate transformer tap positions
- Three Dimensional Penalty Factor Grid – A three dimensional (5x5x2) penalty factor grid was maintained based on the status of HVDC (in/out of service), system interchange range, and system load range
- Breaker Outage Within Contingency Analysis – Both real-time and study CA provide the capability to simulate the opening of a breaker
- Generator Reactive Limit Monitoring – CA monitors the reactive limits of generators. CS considers the generator reactive limit violation during the screening process
- Bad Data Quality Code – SE sets a quality code in the real-time SCADA database for any telemetered value that it determines is bad

- Equipment Outage Scheduler (EOS) – This function was provided, supporting up to 2000 scheduled outages on lines, transformers, generators, and breakers. This function was never used
- Use of Unit Limits – Unit Economic and Operating limits are retrieved from the real-time database and used as Normal and Emergency limits in the network applications
- Model Update – The system operator has the capability to specify the pseudo measurements to be initialized from the schedules, or the output of the last Complete Model Estimator (CME/SE) execution
- Loss Calculation – The Real Time Security Applications update the system loss information to the EMS database after every execution
- HVDC Modeling – The power network models were updated to support HVDC lines. Real and reactive losses for HVDC lines are calculated based on their configuration and actual power transfer
- Violation Colour Coding – All violated quantities are highlighted in colour
- Schedule Data Entry – All schedule data used by these functions is data enterable by the system operator through special displays

3.4.4 Custom Power System Applications by NLH

The following features were added as customs to the baseline Harris M9000 suite of advanced applications by NLH. Additional details may be found in Transmittal # N-055-2002 04 26.

3.4.4.1 Anomaly History Summary

This was a modification to the standard Harris function to provide a special summary display and report that provides the data/time that a measurement transitioned from good to bad (rather than good to suppressed) and from bad to good (rather than suppressed to good) as well as to record the number of times a measurement is bad (not the number of times it was suppressed).

3.4.4.2 Area Load Forecast Update

This was added by NLH, implemented through a set of real-time calculations (using the standard M9000 calculation subsystem) that calculate the area load values, writing them into pseudo-points. The calculations execute every two minutes. The function then automatically loads them into the power system database during the execution of the Network Configuration application.

3.5 Report Generation Assessment

Information from the NLH Power System is gathered by the EMS and reported by the EMS and/or OIS in several ways:

- **Report Generation Subsystem (RGS)**. This is the standard Harris M9000 data collection and reporting subsystem provided as an integrated component of the original EMS. The application typically executes on the backup EMS processor and collects selected data at periodic intervals (1 minute, 5 minute, 1 hour, 24 hour etc). RGS maintains 40 days of data online. After that period, data can be archived to tape, but it can only be read by the RGS system. A character-graphics based Report Editor is used to create and modify reports. Some basic report calculation capability (e.g., summations, averages, min/max identification, etc.) is provided. Ad hoc queries (and associated data analysis) are essentially impossible. Like other M9000 functions, RGS is only available to system operators, and it cannot share data with the rest of the enterprise.

- **EMS Applications.** Various EMS applications (baseline and/or custom) have the ability to directly print reports, either periodically or on demand, outside of the RGS. Examples of these include Data Acquisition and Control (DAC) Communications Analysis, Disturbance Data Collection and Sequence of Events Reporting. These were originally implemented on the M9200 within the associated specific application, using "hard-coded" techniques. In some cases (e.g., SOE), the data is now transferred to the OIS, where it can be more easily managed with broader accessibility to other enterprise users.

- **MS-Access/Excel.** Several reports exist in MS-Access and Excel, retrieving information from the Sybase Relational Database Management System (RDBMS) of the OIS.

- **Browser Application.** Several reports have been created as browser applications. A web server dynamically queries the OIS Sybase RDBMS for data, based on user selections.

3.5.1 NLH Specific Reports

The inability of the M9200 RGS to share data with the enterprise, coupled with its inflexible, character-graphics reporting tool, has resulted in most reports being implemented through the OIS. Over 100 such reports are now produced. These reports represent more complex data calculations and analyses of data beyond simple reproduction of real-time data. Details of these reports can be found in Transmittal # N-010-2002 03 20. Samples of the reports are shown in Transmittal # N-042-2002 04 25.

3.6 Data Exchange with Other Systems

SCADA communications with Churchill Falls (CF(L)Co) has been implemented using a "mailbox RTU" to pass CF(L)Co information to NLH for presentation on the NLH mapboard. The "mailbox RTU" converts Landis & Gyr RTU communications protocol to Harris RTU communications protocol.

The mailbox RTU between CF(L)Co and NLH uses the satellite communication link. The operation of the mailbox RTU is believed to cause the CF(L)Co system to occasionally "hang" and as a result, the mailbox RTU is often disconnected by CF(L)Co.

There is a data link between NLH and Newfoundland Power. Data is transferred on a continuous basis with approximately 630 points received from Newfoundland Power every 20 seconds and 200 points sent every 10 seconds. The link is over two dedicated data circuits at 9600 baud. One circuit is for sending data and the other is for receiving data. A simple protocol developed by Newfoundland Power is used.

3.7 Communications Assessment

3.7.1 SCADA Communications

SCADA communications between the ECC Harris M9000 and RTUs on the Island utilize a private system consisting of microwave and power line carrier (PLC). In some instances, the “last mile” is achieved through the use of public carrier leased facilities.

The map (Exhibit 3.7-1) shows the proposed communications plan evolution through Phase III. The Eastern end of the Island is served by an extensive high-speed microwave system, while the Western end of the Island will remain PLC equipped.

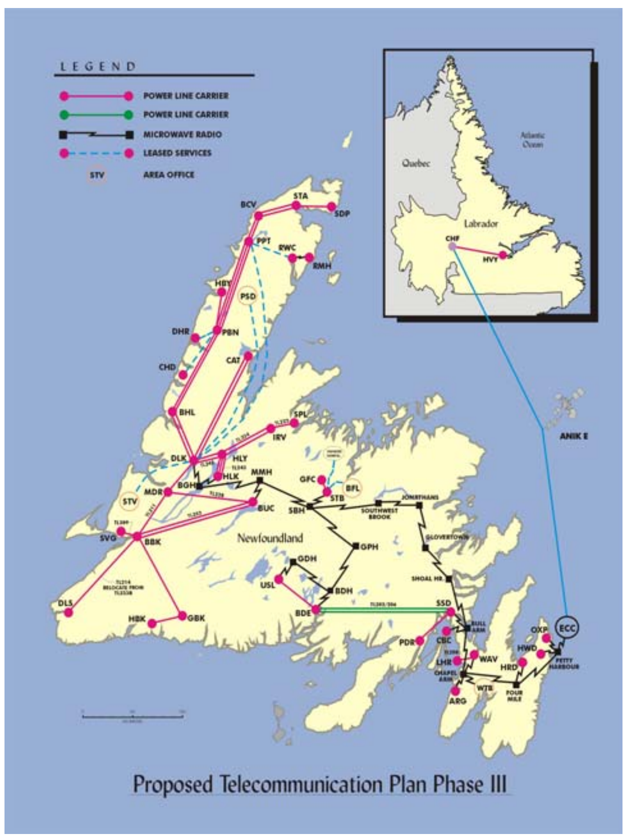


Exhibit 3.7-1 NLH Telecommunications Map

PLC equipped RTUs operate at very slow speed, typically 300 to 600 baud, while microwave connected equipment can operate at speeds up to 9600 baud. The scans are not synchronized. Communication between the ECC and RTUs in Labrador (Wabush and Happy Valley/Goose Bay) uses a combination of satellite link to Churchill Falls and PLC from Churchill Falls to the respective RTUs.

3.7.2 Voice Communications

ECC voice communications utilizes VHF radio to communicate with field crews; operational voice circuits to communicate with NLH operated stations and the public switched network (Telco).

A voice-recording device is provided to record all conversations with Energy Control Center staff. The device uses primary and backup tapes to record and store conversations.

Operators may use public switched network phone system during power system disturbances to record messages on one of ten lines, one for each customer service area.

3.8 SCADA/EMS Operations Training Assessment

Operator recruits undergo an extensive six-month training program before being placed in the System Operator shift rotation. Details of the training program are delineated in the document "Energy Control Center Operator Training Program", dated December 2001. The training consists of a mix of formal courses (internal and external), video series, site familiarizations, exercises, and reading material, with testing at the end of each major component. This program is a living one, with each operator recruit providing feedback during and following the training program. The total instruction time, including on-the-job training is 944 hours.

Staff training needs are identified each year and forwarded to NLH Human Resources Training Officer, who ensures requirements are met. The process of identifying training needs involves first identifying gaps in the staff's ability to perform Energy Control Center job duties. The Superintendent, Energy Control Center meets with each System Operator and Shift Supervisor to assess their capabilities and identify gaps in their level of competency with respect to task requirements. The Superintendent, Energy Control Center in consultation with the Human Resources Training Officer decide on the best training tools to fill discovered gaps.

SCADA, AGC, Advanced Applications (Load Flow, Contingency Analysis, Optimum Power Flow) and RGS training are provided using a console outside the Energy Control Center environment. SCADA/EMS support staff facilitates training in SCADA, AGC, Advanced Applications (Load Flow, Contingency Analysis, Optimum Power Flow) and RGS on the Harris M9200. However, this training environment cannot emulate any power system scenarios other than the present on-line status, resulting in the ability to train personnel on the features of specific functions and applications, but not applying them to disturbance or other scenarios that demonstrate the knowledge of the operator in handling these situations.

Work Protection Code, Reporting and Trending, Switching Orders, Bay d'Espoir Efficiency Monitoring, Sequence of Events, Ltrax (Lightning Tracking), Lotus Notes, Environmental Awareness and Unit Commitment training are provided using a personal computer and projection system located in a conference room setting. SCADA/EMS support staff provides training in Reporting and Trending, Switching Orders, Bay d'Espoir Efficiency Monitoring, Sequence of Events, and Ltrax (Lightning Tracking).

3.9 Existing Organization Structure and Staffing Assessment

3.9.1 ECC Organization

The Energy Control Center is operated by the System Operations Department. The Superintendent, Energy Control Center is directly responsible for the day-to-day operation of the ECC and reports to the Manager, System Operations. Shift Supervisors and Power System Operators report to the Superintendent. The Superintendent works closely with the Operations Planning Engineer and the Operations Accountant.

The Shift Supervisors and Power System Operators work a 24/7 rotating shift. The other positions within the ECC are day shift, with the requirement to attend power system disturbances whenever they occur.

ECC staff, along with specific support organizations implement training and refresher training of on-shift ECC personnel. This operational structure, if maintained, does not support the additional resources required by an Operator Training Simulator (OTS) to define training scenarios, implement the training and maintain the OTS up to date.

3.9.2 ECC Support Organization

There is no single organization within IS&T that supports the EMS facilities used by the ECC.

RTUs and communications are handled by IS&T Network Services, regionally divided. The Harris M9000 and ancillary hardware is handled by IS&T Computer Operations, while IS&T Software Applications include support for EMS Applications, Business Applications and Enterprise Applications. IS&T Project Delivery Group is responsible for the management and implementation of new projects in the three areas.

4. Driving Forces for Change (Gap Analysis)

4.1 Government Directives

The Government of Newfoundland and Labrador, through the Energy Branch of the Department of Mines and Energy, has established an Electricity Policy Review process to provide advice about future directions for the Province's electricity infrastructure. The first step of the process was to complete a comprehensive review of the electricity industry in the Province (reference "Electricity Policy Review Paper", Government of Newfoundland and Labrador, Department of Mines and Energy, Energy Branch, issued March 2002).

The following are some of the key questions raised by the Government in the policy review paper:

Industry structure:

- Should Newfoundland and Labrador Hydro (NLH) buy Newfoundland Power (NP)?
- Should NLH be split up (but not sold) and new private sector competitors encouraged?
- Should the Province establish a "Power Pool" type system with an independent operator?
- Should NLH get out of the distribution business and pass its distribution assets over to NP?

Industry regulation:

- Should the Province create a competitive environment and allow the marketplace to regulate pricing?
- Should prices be set separately for generation and transmission (i.e. "unbundled")?
- Should Government retain the Public Utilities Board authority over NLH decisions, or take it back?

Future generation sources:

- How does the Province balance the different environmental impacts of various types of generating plants?
- Can some small-scale hydro projects be acceptable?
- Should private companies be allowed to develop these?
- What is the role of thermal generation using alternative fuel sources (wood, peat, waste)?
- Should the door remain shut on nuclear power?
- What role could be played by new technologies, such as fuel cells and solar power, which are not yet commercially available?

- Is conservation the best solution to projected future energy needs?
- How does the Province ensure that NLH is not in a conflict situation when it evaluates other proponents' proposals?

Economic development:

- How can the Province use its electrical resources for economic development?
- Do rate subsidies for new industries - which all consumers would pay for - help or harm the economy of Newfoundland and Labrador?
- What are the possibilities for interconnection with mainland Canada and the USA?

The results of this policy review may have a meaningful impact on the future Newfoundland and Labrador Hydro, including the facilities that will be operated and the manner in which they will operate.

Based on discussions at various levels of management within NLH, there is a consensus that certain elements of the policy paper have the potential to be implemented within the timeframe of this study.

Specifically, the following alternatives should be considered to assess the future operating control and monitoring of the NLH system as they could have the largest impact on NLH future operational tools and corporate information derived from operational data:

- NLH evolves toward an Independent System Operator (ISO) role and subsequently the ECC no longer has responsibility for distribution of power
- Privately developed and owned small-scale hydro projects and commercially viable new technologies, such as wind power, come on-line with the intent of establishing bilateral transactions

At the present time, the ECC System Operator and the Shift Supervisor perform the following functions on a 24/7 basis:

- Monitor and Operate the NLH Transmission System to maximize availability and reliability, while maintaining safe operation
- Ensures the safe, sufficient and economical delivery of energy from a range of hydraulic and thermal generation
- Ensures the availability of water to efficiently and economically produce power at various NLH owned and operated generation plants
- Ensures minimum time error for the Island of Newfoundland
- Minimize the use of thermal power and therefore emissions
- Manages NLH, NP and customer generation when shortages occur

- Purchases and sells energy as required
- Respond to power system disturbances and manage the restoration of NLH facilities
- Respond to residential power emergencies after normal business hours

Assuming the Government's alternatives are realized, then possible additional ECC System Operator and Shift Supervisor responsibilities that may be required include:

- Ensure the transmission system can support all current and planned bilateral energy transactions (i.e., transaction monitoring)
- Monitor and Operate the NLH Transmission System under "market driven" conditions to ensure acceptable availability and reliability, while maintaining safe operation (e.g. voltage, frequency and congestion monitoring, outage scheduling and contingency analysis, etc.)
- Purchase generation to alleviate generation shortages or to maintain a congestion free transmission system
- Direct the restoration of NLH facilities and manage the restoration of the NLH connection to all non-NLH owned facilities after a power system disturbance

In addition to these Government initiatives, future NLH power system control and monitoring systems must also address the functional needs as identified in the following sections.

4.2 NLH General System

4.2.1 Reliability

Although the SCADA/EMS has been historically reliable, the trend is that the frequency and duration of outages is increasing. Much of the recently recorded SCADA/EMS downtime is a result of the end-of-life for many components (especially power supplies). In addition, correction of problems can take longer to diagnose due to the lack of trained and experienced technicians (due to attrition) to service the system. The impact (frequency and duration) of these occurrences is likely to be come more severe.

As Harris no longer provides hardware and software training courses for the NLH system, NLH is limited to the ability of assigned support personnel to develop self-taught expertise. This is limited by the availability of documentation and personnel with extensive experience on the system.

Reliable replacement hardware components are becoming increasingly difficult to acquire. NLH is almost completely dependent on other Harris M9000 systems retired by utilities and resellers of such equipment.

The net result of the system's age, used replacement hardware, and the lack of trained and experienced support personnel significantly increases the probability that the future reliability of the system will be reduced to a level that will create unacceptable operating scenarios for NLH and their customers.

4.2.2 Maintainability

The EMS has essentially reached the point where it is no longer maintainable. While there are believed to be adequate spare parts on hand, all of the current reserve is "used" and its reliability questionable. Used parts are still available, although primarily from other users that are retiring M9000 systems (e.g., TVA and Landsvirkjun) and one commercial source, i.e., "VarTech Displays" (Baton Rouge, LA, USA).

Despite the general availability of some spare parts, several maintenance problems are beginning to arise due to a lack of reliable spare parts. For example, parts and consumables for the systems' impact printers are becoming increasingly expensive and difficult to obtain while the system's age and design prohibits the attachment of modern laser printers.

The probability of a serious equipment failure has increased, while the ability to react and repair such a failure has dramatically decreased. Such an outage could leave the system inoperable (or at least without a backup) for 6-8 hours (if a disk rebuild was required) to several days (if additional parts or an experienced third party technician were needed to be located and transported to St. John's).

4.2.3 Security

Due to the proprietary nature of the EMS, it is secure. Overall security for enterprise access of the data provided by the EMS/OIS has been provided and meets current NLH non-operational business needs. However, the inability to securely access and use the analysis tools within the EMS outside of the control room limits operations management and planning functions unduly.

4.3 SCADA

4.3.1 Basic Functions

4.3.1.1 Physical Facilities

The operator is presented with two differing environments to enter and view EMS data: the EMS CRT Displays, and their desktop PC. The use of two distinctly different input/output devices for the same data set reduces the efficiency of operation and may slow the response time when reacting to an emergency situation.

There is a real time system frequency recorder that is used during system disturbances. This device uses pen and paper recording technology. Post disturbance analysis suffers the inefficiency of retrieving frequency data from the chart paper and potential inaccuracies in interpreting chart readings. Paper charts are also difficult to store.

4.3.1.2 Mimic Diagram

The mapboard layout and detail requires improvement, especially to be of practical use during major system disturbances. The existing mapboard deficiencies include:

- Operator workstations are too close to the mapboard resulting in difficulty seeing power system status and alarm indicators
- The mapboard does not contain sufficient detail to use during a restoration process following a system disturbance
- Operator confusion can exist as to the normal and abnormal state of a status point. This can lead to loss of alarms as displayed on the mapboard or erroneous display of an alarm on the mapboard

4.3.1.3 Displays

Under normal circumstances, an experienced staff member would require approximately 5 hours to build the typical limited graphic, one-line SCADA or APPS display on the EMS. The same display, using full graphics, could be created for display on the control room PC in about 1 hour.

Other limitations with the current display facilities include:

- APPS and SCADA one-line displays have to be maintained separately
- Static text entries cannot be globally modified on a display page, within a display set, or across all displays
- If name change is implemented in the SCADA database, alarm displays are not automatically updated
- It is impossible to edit the parameters of a display point by selecting the point and accessing the edit tools
- Display sets are constrained to an upper limit of 16 pages
- Each page in a display set has to be manually mapped to an absolute page number in the disc space provided for display storage
- The character set and colour pallet are too limited to display all necessary information acceptably
- When changes are made to the online system these changes are not automatically propagated to the OpenView or EMS-View systems
- OpenView (Full graphic) changes must be done manually, while the EMS-View changes can be batched from the online system
- The display editor does not provide a cut/copy and paste function

- The display editor file formats are proprietary and therefore not usable outside the Harris environment

4.3.1.4 Alarm Management

Alarms received at the Energy Control Center arrive from multiple sources. Some alarms are autodialed into the Energy Control Center using voice-messaging technology, while others appear as a point change on the Harris EMS.

Alarms should be automatically received by the ECC in a consistent manner and displayed/stored in accordance with their importance.

4.3.1.5 Data Acquisition

The primary shortfall of current Data Acquisition is that communications bandwidth limits scan rates at some stations.

This shortfall cannot be overcome without modification to the present SCADA/EMS to RTU communication infrastructure. This may be provided in the future through present functional expansion plans to access RTUs through the corporate WAN. It is presumed that existing RTUs and planned replacements for older RTUs will be able to accommodate the communication protocol required for this function.

A new EMS would permit moving to WAN-based RTU communications as well adoption of advanced protocols such as DNP and UCA.

4.3.1.6 Sequence of Events

NLH has developed a custom software application to handle Sequence of Events (SOE). It allows online retention of 7 days of SOE messages. Changes were made to the standard SOE processing so that the messages are retained to disc.

Current SCADA/EMS architectures equipped with an IS&R system would inherently provide this function without customization, thus minimizing the need for support personnel with specific experience on the SCADA/EMS

4.3.1.7 Remote Supervisory Control

NLH has limited remote control over parts of its distribution systems. Typically, this includes remote control of the station reclosers as well as some distribution line reclosers. Not all devices can be controlled, including a limited number of locations without an RTU and some motor operated disconnects. This should be looked at for future expansion using modern RTU protocols and communications techniques.

4.3.2 NLH Applications

NLH has had to resort to the implementation of a number of custom applications to ensure the functionality of the present SCADA system. The extensive use of custom software has put additional demands on the support organization and demanded the requirement of specialized skills that are not applicable elsewhere in the organization. In a new EMS, these applications would either not be needed, or could be implemented using modern tools and APIs. The following sections define these custom applications.

4.3.2.1 Auto Restoration Custom

Its function is to restore power to an oil refinery on loss of power. This application will follow defined sequences of opening and closing breakers, as well as checking various alarm point statuses.

4.3.2.2 Dam Breach Custom

The Dam Breach application is designed to monitor. The application will provide an alarm on the dispatch consoles when any of the reservoir elevations at Hinds Lake, Meelpaeg, Great Burnt Lake, or Long Pond drops by a configurable amount within a 24-hour period.

4.3.2.3 Multiple Breaker Operation Custom

This function allows operators to open several breakers with one control operation. This reduces the number of control operations that system operators must perform during a restoration or outage situation. The grouping of breakers is done at a database editing level by programmers/engineers that are knowledgeable and experienced on the SCADA/EMS.

4.3.2.4 Tandem Tap Control Custom

This function allows simultaneous operation of several transformer taps. System operators can operate the grouped taps with a single control raise/lower operation. This feature does not prohibit operation of individual transformer taps in a group. The grouping of transformers is done at a database editing level by programmers/engineers that are knowledgeable and experienced on the SCADA/EMS.

4.3.2.5 Intranet Access to Real-time and Historical Information Custom

The Harris system sends historical information to the Sybase database on the OIS. Custom software was developed to implement this data transfer. External browser applications provide an interface to both historical and real-time information. Browser applications that show real-time information retrieve the information from the OpenView database on the OIS which is refreshed every 10 seconds from the Harris system.

Although this interface provides access to information acquired or calculated by the SCADA/EMS, it does not provide the capability to use the SCADA/EMS analysis tools to interpret the information.

The ability to interact with the EMS through a browser-based user interface would probably be inherent in a new EMS, obviating the need for this customization.

4.4 Generation Dispatch

4.4.1 Automatic Generation Control

At times there are frequency stability problems during lightly loaded periods with no thermal generation on line. This has required a number of custom applications to be developed by NLH and supported by personnel that have specific experience on the SCADA/EMS.

4.4.2 Economic Dispatch

The economic dispatch and unit commitment functions are not integrated. Further, the economic dispatching of units should permit modeling relationships using functions and not just table or point format.

4.4.3 Production Costing

No online or daily production costing is currently monitored due to the high hydraulic component of the generation and no current heat rate curve data available from the Holyrood plant.

Production costing and reserve monitoring displays are not used to their potential. It would be beneficial to use these functions to provide the operator greater awareness of operating costs associated with the dispatch of generation resources.

4.5 Power System Applications

From the perspective of operations and maintenance, these functions are fairly well integrated into the existing EMS. Their models and analysis capabilities represent the technology of the late 1980s and early 1990s. Correspondingly, the applications are now behind the state of the art and several shortfalls were noted:

1) Because of the proprietary nature of the user interface, there is no way for NLH enterprise users (e.g., Planning, P&C, etc.) to view the results of the real-time applications, or interact in any way with the study mode applications.

2) Interaction with the models is cumbersome, as the UI is not intuitive (e.g., compared with the PTI tools, i.e., PSS/E and PSS/O; additional information can be found at the PTI web site http://www.shawgrp.com/PTI/software/index.cfm).

3) Multiple network models (i.e., Harris and PTI) must be maintained. The modeling of the external capabilities of the external network in the Harris system is weak.

4) There is no method to transfer the results of the real-time or study mode applications to an external system for further off-line analysis (e.g., export of the latest SE results to PSS/E).

5) The CA case set-up capabilities are viewed as cumbersome.

6) EOS is a short-term tool, compared to the NLH planning activities, which look at an annual plan. The manual-entry aspects of this function make it operationally ineffective.

7) While application results may be viewed on one-line displays that are similar to corresponding SCADA displays, these "application" one-lines must be maintained separately from the SCADA displays.

8) There is no integrated Load Forecasting capability. Scaling of loads in the model is difficult (compared to PSS/E).

9) Transformer Tap-estimation reliability is problematic (i.e., the function does not work).

4.6 Report Generation

The RGS capabilities are limited to a fairly rigid data collection and storage scheme coupled with proprietary reporting tools.

Note that while the RGS function (resident on the M9200) is redundant, and therefore highly fault tolerant, the OIS is not. This is by design, as the OIS was originally considered as a non-critical system, and was therefore designed as a non-redundant environment. However, its flexibility and accessibility has made it a critical resource to NLH operations and their internal customers. Users outside of the EMS have become accustomed to receiving reports and being able to analyze the data stored in the Sybase RDBMS. The potential for loss of this capability, even for short durations, due to several single points of failure is a serious deficiency in the current environment. It is not practical to add redundancy to this facility.

A modern EMS would provide the opportunity for more flexible and timely information sharing across the entire NLH operation, through such technologies as standard APIs or third-party middleware. This approach will enable programs to share data and to integrate the workflows within the EMS environment and various systems within NLH, with the following benefits:

- Provide a consistent view of information across the business systems
- Improve information flow
- Improve the relationship between information systems and business processes

4.7 Communications

4.7.1 SCADA Communications

PLC equipped RTUs operate at very slow speed, typically 300 to 600 baud, while microwave connected equipment can operate at speeds up to 9600 baud. Since the scans are not synchronized, there always exists the possibility of "data skew" across the system and disparate scan rates (and associated line speeds) may exacerbate the situation. The data for similar-size RTUs scanned using identical scan philosophies could be as much 5 seconds older from the PLC connected RTU. That will have some impact on accuracy of the applications using the data. In addition, limited bandwidth impacts the ability to implement other features and applications, e.g. SOE and accurate Disturbance Analysis, fault location, remote relay monitoring and maintenance of settings, etc.

Communication between the ECC and RTUs in Labrador (Wabush and Happy Valley/Goose Bay) uses a combination of satellite link to Churchill Falls and PLC from Churchill Falls to the respective RTUs.

4.7.2 Voice Communications

An improved method of interacting with NLH customers during a power system disturbance is required to reduce the workload on the operators so that they can concentrate on restoring the power system.

4.7.3 Data Exchange

The data exchange with both CF(L)Co and NP require custom applications that have been developed by NLH. This requires the continuing skills by IS&T support staff to maintain these custom applications.

4.8 SCADA/EMS Training

At present and in the near future, experienced ECC operators will be retiring and new recruits will have to be trained to fill the vacancies created. The reliability of the bulk electricity system has improved resulting in limited exposure to system disturbances. As the reliability of the bulk power system improves, the expectation will be one of continuous availability and faster restoration times when disturbances do occur. The present training program does not prepare new or experienced operators to realistically handle disturbances in the NLH bulk power system.

4.8.1 Operator Training Simulator (OTS)

Overall, a training simulator can be a valuable tool on several levels. Since the OTS environment would be nearly identical to the EMS environment (using the same displays, user interaction, and even the same applications), it can be used to introduce new trainees or personnel outside of normal EMS operations to the EMS so that they can experience the “look and feel” of the system without worry of disrupting actual system operations.

The simulator can be used to allow the system operators to experience a wide range of system conditions, providing “hands-on” training that replicates actual NLH power system operations, allowing them to recognize potential operating pitfalls and to practice various restoration methods. In order to achieve maximum benefit, a continual investment in maintaining the models and scenarios, and in managing the training activities (keeping records, evaluating performance, etc.). This can be an especially effective tool for a relatively “closed” system (i.e., few interconnections) such as NLH, but the accuracy of the models (especially hydro generating unit models) becomes even more important.

The OTS also provides an excellent platform for the testing of new database elements, and new or modified applications, under simulated system operating conditions with continuously changing data, for extended periods of time. This helps to insure the fidelity of software and database changes before actually bringing the changes on-line.

4.9 Organization Structure and Staffing

4.9.1 ECC Organization

ECC staff, along with specific support organizations implement training and refresher training of on-shift ECC personnel. The Operator Training Simulator (OTS) is not supported sufficiently to define training scenarios, implement the training and maintain the OTS up to date.

4.9.2 ECC Support Organization

The EMS and other facilities used by the ECC form an integrated set of tools that are required to be completely operational on a 24/7 basis. Often problems occur that do not obviously identify themselves to be attributable to one area: hardware, software or communications. In addition, the implementation and testing of changes and/or new features, whether hardware of software, have a more rigorous criteria than general business needs. To this end, the support organization does not include a dedicated “systems” level support organization that functions on an integral basis with the ECC staff and can respond immediately to issues raised by ECC staff, set priorities for repair and coordinate other support organizations to ensure effective and timely resolution.

5. Alternatives

Two strategic alternatives were considered for the NLH EMS. There may exist slight variations on each of these alternatives. During the course of negotiations with a system supplier, NLH should explore variations on the chosen alternative that may prove advantageous.

Note that costs described within the remainder of the document do not include the costs to create an Emergency Backup Control Center (including the associated communications costs). Costs to perform physical modifications to the existing Energy Control Center are also not included. Where feasible, estimates of the major optional hardware and software components (such as the Emergency Backup System, Operator Training Simulator, and Optimal Power Flow) have been called out. Actual system costs allocations differ widely from supplier to supplier, and should only be used as a representative example.

The specification for the new EMS should include projection screen support (and therefore is included in the costs that follow), however the actual price of the projection screens is also not included.

Note that these costs are estimated to be within 10% of the maximum expected external procurement costs (i.e., they do not include NLH internal costs). A conversion rate of $1 USD equals CDN $1.52 was used to produce these estimates, as most of the recommended suppliers are from the U.S.

5.1 Maintain Existing Systems and Processes

This alternative makes no changes in the current configuration.

1) Advantages:

    a) No effort is required beyond on-going maintenance.

    b) There are no immediate expenditures for implementation.

2) Disadvantages and Risks. The shortfalls described in Section 4 will continue. Specifically:

    a) The EMS hardware becomes increasingly more difficult to maintain. Reliability will begin to decrease and it will become vulnerable to extended outages.

    b) NLH will remain highly vulnerable to losing its current experience base. Replacement experts are no longer readily available.

c) Operations personnel dissatisfaction with the system and associated stress levels will continue to increase as they continue to be frustrated by the limited graphics and inflexible alarm presentation of the old system.

d) NLH has no ability to quickly react to possible changes in mission.

e) Communications limitations of the EMS remain. This includes ICCP and the ability to share data with the rest of the enterprise.

f) Extra effort must continue to be expended to maintain data consistency with the OIS.

g) The OIS remains non-redundant and susceptible to outages.

h) ED, Load Forecast, and UC functions are not integrated.

i) The power system applications are dated, interaction with off-line tools cumbersome, and cannot be used outside the control room.

j) Communications error and statistics reporting is limited and hard-coded within the M9000.

k) Many tools that operations could use will remain non-functional, or not used to their full extent, including OPF and OTS.

3) Costs. No new expenditures are required, only a continuation (and perhaps escalation) of current maintenance costs. It is likely that the cost of achieving a reliable inventory of spares will increase rapidly. Only NLH can assess the implicit or hidden costs of the above disadvantages, e.g., an extended outage of the EMS or its inability to quickly convert its mission to e.g., to that of Newfoundland Electric System Operator.

5.2 Replace Existing Systems and Processes

5.2.1 Standard Contracting Cycle

Assuming a fairly standard procurement cycle, the new NLH EMS would be expected to be ready for commissioning approximately 36 months after project approval (1 month to select consultant, 2 months for supplier pre-qualification, 4 months for specification preparation, 4 months for bid evaluation, supplier selection, and statement of work; 22 months for factory implementation and test; 3 months for field installation and cutover). While there are factors that can accelerate this schedule, delays (e.g., scheduling around winter peaks, vendor problems, etc.), must also be considered.

5.2.2 Implement New EMS Independent of CF(L)Co

This alternative assumes both NLH and CF(L)Co decide to procure new systems, but do so independently.

5.2.2.1 Advantages

1) The NLH procurement and installation schedules are not constrained by another organization.

2) The requirements for the new EMS can be unilaterally defined without seeking approval or concurrence from an independent organization (with different mission and different regulatory requirements).

3) The method of procurement can be chosen unilaterally.

4) The supplier for the new EMS can be selected using evaluation criteria determined solely by NLH.

5) Due to the reduced requirements of CF(L)Co compared to NLH (i.e., SCADA only), there would be more vendors that could reliably deliver and support a system for CF(L)Co. Consequently, CF(L)Co may achieve a lower price than could be reached under a joint procurement strategy.

5.2.2.2 Disadvantages

1) The price for a new EMS for NLH alone may be 10% to 15% higher than if two systems were simultaneously procured (from the same supplier).

2) Hydro would not experience any economies on the procurement project from purchasing two systems from the same vendor (e.g., a single project manager, or other implementation team members that could support both systems).

3) Hydro would not have the opportunity for further system acquisition savings through common equipment, e.g., development systems and OTS (unless the same supplier was independently chosen by both companies).

4) Hydro would not experience any benefit from having similar systems in operation (unless the same supplier was independently chosen by both companies). There are many aspects where synergy could be expected:

    a) Cross training of personnel (operations and support) to allow greater mobility between the two companies.

b) Stockpiling of spare equipment

c) Enterprise users that need access to system applications and data can employ common access methods.

d) The systems would employ common access methods to an enterprise-wide data warehouse (simplifying configuration and maintenance).

e) Sharing of common displays, models, etc.

5.2.2.3 Costs

The system procurement costs for the new EMS for NLH procured independently from CF(L)Co are estimated below. These costs include all the hardware, software and training to replace the currently existing NLH EMS functionality, including OTS and OPF. They also include the hardware and software to support an Emergency Backup System, although they do not include the costs to physically create an Emergency Backup Control Center. A basic development system facility is also included in the estimate. These costs exclude any NLH cost of money, overheads, taxes and NLH personnel costs.

Implementation includes costs typically included by the supplier in the price of the EMS for project management, factory and field testing, training, field installation, documentation, warranty, etc.

Consulting Services include typical support (and travel) to perform RFI and RFP preparation, and assist NLH with supplier bid evaluation and selection, and contract negotiation (approximately CDN $180K). Also included are typical Post Contract Consulting Services such as review of custom designs, documentation & Acceptance Test Procedures, attendance at project meetings, etc. (this amounts to approximately CDN $430K).

Description	Procurement Cost
Material - Hardware	CDN $1,800,000
Material - Software	CDN $2,425,000
Material - Implementation	CDN $1,770,000
Materials Sub-total	CDN $5,995,000
External Engineering - Consulting Services	CDN $ 610,000
Total	**CDN $6,605,000**

Exhibit 5.2-1 NLH System Procurement Costs (independent of CF(L)Co)

Deleting OPF would result in approximately CDN $115K reduction in software costs while deleting Load Forecasting would reduce software costs by approximately CDN $75K Deleting OTS would result in approximately CDN $75K software reduction, and approximately $115K reduction in hardware costs (this latter figure would be dependant upon how much dedicated user equipment was specified for this function). A non-redundant Emergency Backup System is included above, and if deleted would result in approximately CDN $325K in Hardware savings. The capability is now included in most vendors' software baseline. An integrated "Equipment Outage Scheduler" package may be included in the vendor's baseline (which was assumed), or may be additionally priced at approximately CDN $75K. Approximately CDN $60K has been included for Software Configuration Management tools.

Training costs of approximately CDN $225K are included under "Implementation costs". This represents approximately 250 training days at the vendor's site (typically classes are 3-5 days each). Additional "quantity" discounts of 20% to 30% may be arranged depending on how many students attend a given course. Alternatively, vendors can usually provide training at NLH's facilities, at approximately CDN $5000 per training day, plus expenses and travel time.

5.2.3 Implement new EMS together with CF(L)Co

This alternative assumes both NLH and CF(L)Co decide to procure new systems, and do so in a joint procurement.

5.2.3.1 Advantages

1) The price for a new EMS for NLH alone may be 10% to 15% lower than if two systems were independently procured (from the same supplier).

2) Hydro should be able to unify the project implementation teams such that their overall internal project support costs are lowered. For example, a single project manager and a single technical lead can be assigned full time, rather than four individuals part-time. Savings associated with travel costs for project meetings, testing, etc., can also be realized.

3) Hydro may have the opportunity for further system acquisition savings through common equipment, e.g., development systems and OTS. This potential savings has not been estimated (as sharing equipment for these purposes does not match current organizational philosophy).

4) Hydro should be able to experience many intangible benefits from having similar systems in operation. These include:

   a) Cross training of personnel (operations and support) to allow greater mobility between the two companies.

   b) Stockpiling of spare equipment.

c) Enterprise users that need access to system applications and data can employ common access methods.

d) The systems would employ common access methods to an enterprise-wide data warehouse (simplifying configuration and maintenance).

e) Sharing of common displays, models, etc.

5.2.3.2 Disadvantages

1) The NLH procurement and installation schedules must be coordinated with CF(L)Co.

2) Agreement must be reached with CF(L)Co on common requirements for the new system.

3) The two organizations must agree on the method and criteria of procurement.

4) The supplier for the new EMS must be selected in conjunction with CF(L)Co.

5.2.3.3 Costs

The system procurement costs for the new EMS for NLH purchased in conjunction with CF(L)Co are estimated below.

Description	Procurement Cost
Material - Hardware	CDN $1,700,000
Material - Software	CDN $2,205,000
Material - Implementation	CDN $1,600,000
Materials Sub-total	CDN $5,505,000
External Engineering - Consulting Services	CDN $ 500,000
Total	**CDN $6,005,000**

Exhibit 5.2-2 NLH System Procurement Costs (in conjunction with CF(L)Co).

This represents an estimated system procurement costs savings for NLH of approximately CDN $600K. Likewise, CF(L)Co would experience an estimated system procurement savings of approximately CDN $184K, for a combined savings to Hydro of approximately CDN $784K.

5.2.4 Internal versus Turnkey Project

An implementation alternative that might be considered is that of doing the new EMS implementation and installation as a "turnkey" project, i.e., with little to no involvement from NLH personnel. In this context, the following activities normally performed by the end user would become the responsibility of the supplier (or its sub-contractors):

- Database conversion and augmentation
- Display conversion or re-creation
- Report creation
- Database, display and report validation (i.e., field checkout)
- Site preparation and installation

It is assumed that NLH would still participate in Factory Acceptance testing, as waiting until the system was delivered to perform acceptance testing is extremely risky. It is also assumed that NLH must oversee all site preparation work, in order to insure that ongoing operations are not disrupted. The main advantage of this approach is that NLH personnel are not distracted or disturbed from their current responsibilities regarding the operations and maintenance of the present EMS. NLH internal labour and travel costs are deferred until late in the project, or even after final system acceptance. However, there are many disadvantages:

1) Acquisition Cost. The supplier must insure that all databases, displays, and reports are created. Often, this represents significant additional risk to the vendor, as well as additional labour. This is reflected in the price for these services. Database conversion alone would be approximately CDN $75,000. This would not account for additional parameters that would still need definition by NLH (e.g., new Areas of Responsibility, Alarm Presentation information, new data set definitions for inter-utility data exchange, etc.). Some level of training and familiarity with the database system would be required in order to properly define these additional parameters, negating some of the deferred expenses. Display creation can be as much as CDN $750 per display (assuming 109 one-line, this is more than CDN $80,000). Since checkout of the database and displays must be done in the field (potentially, using an early development system in order to expedite the schedule), the cost of checkout substantially increases the price (due to increased labour, risk, and remote travel and living expenses). Again, for a system of this complexity, these activities must be overseen by NLH personnel anyway, minimizing the benefit.

2) User Interface Acceptability. When moving from a character graphics system to a full graphics system, display conversion is usually only a temporary step. Ultimately, new display standards must be defined, and the displays interconnected into useable world displays. The turnkey vendor will either directly convert the displays, or have them redrawn to look exactly like they look now. While this might be desirable in the short term, users will quickly be discouraged in that the advantages of the modern user interface have not been employed. Eventually, the vendor-provided displays would require substantial re-work.

3) Overall User Acceptability. The less involvement NLH personnel have in the implementation of the new system, the less they will know about its internals, and the less comfortable they will feel in accepting the new system. The same training costs, will ultimately be expended, it will just occur later in the life cycle of the project. This will also impact formal factory and site acceptance testing (either some training must be done prior to FAT, or FAT itself will become a training period, lengthening its planned duration). Training of operations personnel must occur before system cutover can be accomplished. Again, these factors all negate the costs deferred by the turnkey approach.

For these reasons, the "turnkey" approach is not recommended for NLH. For the same reasons, it would also not be appropriate for a joint NLH and CF(L)Co procurement. It may be a viable alternative for CF(L)Co if they proceed independently.

6. Analysis & Recommendations

6.1 Comparison of Alternatives

Alternative 1 maintains the "status quo" of the EMS. Unfortunately, the age of the current system, coupled with the potential changes in its required functionality, make this an untenable choice for the long term.

The remaining two alternatives provide equivalent functional benefits. Alternative 3 holds the potential to save NLH approximately CDN $600,000 in external purchase-related costs over Alternative 2 (the total savings to Hydro is estimated to be CDN $784K including the associated CF(L)Co procurement cost savings). Additionally, choosing this alternative can also reduce Hydro's internal costs for implementation by allowing for a unified project implementation team.

For example, using the NLH project implementation staffing from Exhibit 7.13-1, the equivalent full time staff is 8.65 (including OTS). Assuming a 36-month schedule, this yields a total of 311.4 staff months to be expended by NLH. Using the same data from CF(L)Co, their equivalent full time staff would be 7.2. Assuming the CF(L)Co system is simpler and can be accomplished in 30 months, they would be expected to expend approximately 216 staff months. This is a total of 527.4 staff months expended by Hydro personnel for the independent acquisition of the new systems.

If the joint procurement alternative was chosen, a reasonable combined project implementation staffing strategy is shown in Exhibit 6.1-1. This strategy yields an equivalent full-time staff of 12.35 (including OTS). Assuming the entire project is 36 months, a total of 444.6 staff months would be expended by Hydro personnel. This represents a savings to Hydro of over 80 staff months. At an average burdened labour rate of CDN $2200/week, this reflects a savings of over CDN $760K.

Title	# Of Persons	% Load (each)
Project Manager	1	100
Project Technical Lead	1	100
Software Engineer / Specialists		
SCADA, UI, System Support Facilities	2	100
System, Database & Network Administration	3	50
Technology Architect	2	50
Power Systems Applications Engineers		
Generation Control/Hydro Applications	1	75
Power Network Applications	1	75
Technical Support (Database, Display & Report Creation)	3	100
Operations Personnel	3	20
TOTAL Full Time Equivalent Personnel	**11.60**	
Plus Operations support for optional OTS	*1*	*75*

Exhibit 6.1-1 Combined Implementation Project Staffing

The implementation project's travel budget would experience similar savings. The total number of trips to two vendors' sites would be substantially reduced, as shown by the example in Exhibit 6.1-2. This shows that to support two independent projects, a total of 146 trips would be made by NLH and CF(L)Co personnel. The total for a unified project team would be expected to be 98. Assuming each trip averages CDN $4500, the estimated savings to Hydro would be approximately CDN $216,000.

	NLH			CF(L)Co			Unified Project		
Purpose of Trip	Travelers	Occurrences	Total Trips	Travelers	Occurrences	Total Trips	Travelers	Occurrences	Total Trips
Project Meetings	5	12	60	3	8	24	5	12	60
FAT	18	1	18	13	1	13	19	1	19
Training	18	1	18	13	1	13	19	1	19
TOTAL			96			50			98

Exhibit 6.1-2 Implementation Project Travel

6.2 Recommendations

Alternative 3 (i.e., implement together with CF(L)Co) clearly represents the potential for substantial savings to Hydro. Based on the above examples, the estimated total savings of this approach over two independent implementation is approximately CDN $1,760K. Further, Alternative 3 has many intangible benefits that could provide additional cost savings to Hydro in the future. For these reasons, Alternative 3 is strongly recommended.

Assuming a fairly standard procurement cycle, the new NLH EMS would be expected to be ready for commissioning approximately 36 months after project approval (reference Section 5.2.1). Delays (e.g., scheduling around winter peaks, vendor problems, changes in requirements, etc.,) must also be anticipated. If the replacement project began in January 2003, an aggressive acquisition schedule might permit full cutover to the new system Fall 2005. Any delays could easily push this to Spring 2006. Therefore NLH is already faced with the prospect of having to maintain the present EMS for at least three, and maybe as long as four, more years. Postponing the acquisition by just one year implies the existing system must remain viable until Spring 2007 (or five years from now). Due to the increased risks that the system could face long-term outages, coupled with the risk that new functionality must be implemented prior to this time frame, this delay is not recommended.

6.2.1 Short Term Recommendations

Both NLH and CF(L)Co should immediately seek appropriate approvals to proceed jointly to procure their replacement systems. The cost to NLH for this alternative, thru system cutover and final system acceptance, is estimated to be as follows (note that detailed internal costs have been provided by Hydro):

Description	Cost
System Procurement Cost	CDN $5,505,000
Internal Costs	CDN $3,657,920
Total	CDN $9,162,920

Assuming the project can be completed in 36 months, the associated cash flow by fiscal year is projected to be as follows:

Fiscal Year	Cash Flow
Jan - Dec 2003	CDN $1,095,500
Jan - Dec 2004	CDN $3,674,400
Jan – Dec 2005	CDN $3,720,120
Beyond	CDN $ 672,900

Note that as this is an aggressive schedule, it may turn out that final system acceptance (i.e., completion of system availability test) is not achievable in CY 2005. Final payment to the vendor (typically 10% of contract value, or approximately CDN $540,000) would then be deferred to CY 2006. Note also that cash flows for Alternative 2, should it be selected, would be proportionally equal, as the project scope and time scales are similar.

6.2.2 Long Term Recommendations

Once new systems are installed and commissioned at NLH and CF(L)Co, Hydro should begin to exploit commonalities in the two control environments. As a start, operations and support personnel internal training activities should be unified, and opportunities for cross training on the unique aspects of each system should be created. For example, the OTS at CF(L)Co could be expanded to host the NLH database, models and scenarios, so that it could be used to familiarize CF(L)Co system operators with operating conditions at NLH (and vice versa). Alternatively, a single OTS facility at NLH could be employed, consolidating training management and support as well as reducing facilities and acquisition costs (including OTS related hardware, software licenses, and support).

Ultimately, Hydro should investigate further unification of the two operations. For example, while user interface workstations and data acquisition front-end processors would always be located at Churchill Falls, that system's applications could eventually be hosted at NLH, permitting a unified support team. Alternatively, the CF(L)Co SCADA system might operate with NLH in a hierarchical fashion, i.e., all of its data and displays shared with the NLH EMS.

If NLH continues to provide electric distribution functions, then the incorporation of advanced Distribution Management functions and associated applications should be investigated.

7. Future System Definition

7.1 Overall System Goals and Objectives

The overall system goals and objectives for the future NLH EMS are recommended to be:

- High Availability – The new EMS architecture should be fault tolerant so that any single hardware failure does not result in the loss of a critical function. An annual system availability of at least 99.95% for critical functions must be maintained.

- Information Presentation – As more demands are made on the power system, while at the same time experienced staff retire from their jobs, it becomes increasingly important that operators and engineers have easy access to a full range of high quality real-time and historical data, as well as the tools to interpret and analyze the data to aid the staff in performing their jobs.

- Compliance with Standards – Every effort should be made to procure a new EMS that conforms to industry standards, especially standards relating to interfacing and exchanging data between different systems.

- Open System Design - The new EMS should comply with widely accepted standards for open systems, both from standards organizations as well as de facto standards. This will enable NLH to select the best-of-breed hardware and software solutions for the new EMS and greatly enhance the new system's ability to communicate with existing enterprise systems and take advantage of web enabling technologies.

- Expandable/Scalable – The new EMS hardware and software should be easily expandable and scalable and provide the capability to upgrade and/or add additional processors, disk units, front end processors, etc., and expand application programs or add new functions without major disruption to the operation of the new EMS. All hardware purchases by the system supplier for the new system should be subject to NLH approval, and delayed as late as possible in the project schedule (to take maximum advantage of new hardware availability and price reductions).

- Security – The new EMS should have appropriate security features that prevent unauthorized users from accessing the new EMS and permit assigning various levels of privilege to authorized users.

- Minimal Customization – To the greatest extent possible, standard applications should be used to minimize customization to a supplier's standard products and thereby lower the risk of implementation schedule delays and reduce the costs of system procurement and system maintenance services.

- Integration with Enterprise Systems – Data, regardless of which system or department generates or collects it, is an enterprise resource. As such, it must be made available to the enterprise in the most efficient manner possible.

- New Functionality – As the NLH operational role may change and/or its power system is required to run closer to its physical limits, it becomes increasingly important to have good tools to ensure that the network remains secure and is operated as efficiently as possible.

- Responsiveness - Performance enhancements as they relate to the new EMS user interface, data collection, and program execution times are desired as well as the timeliness of making data available to the enterprise.

- Maintainability – State of the art audit, editing, display building, and database generation tools should be made available for maintaining the system. Replacement components should be readily available on the open market, with reasonably priced third party maintenance a viable option.

- Development System – A separate development and testing environment should be provided. This will provide NLH the capability to test database and application changes without impact to real-time operations. A method to populate this environment with changing real-time data, should be available to enhance the fidelity of the platform as a test-bed for new applications.

Additionally, the following functions are either not used or not included in the present EMS. They should therefore be considered as options (i.e., separately priced) and/or specified as a future add-on capability so that NLH can fully evaluate their cost/benefit:

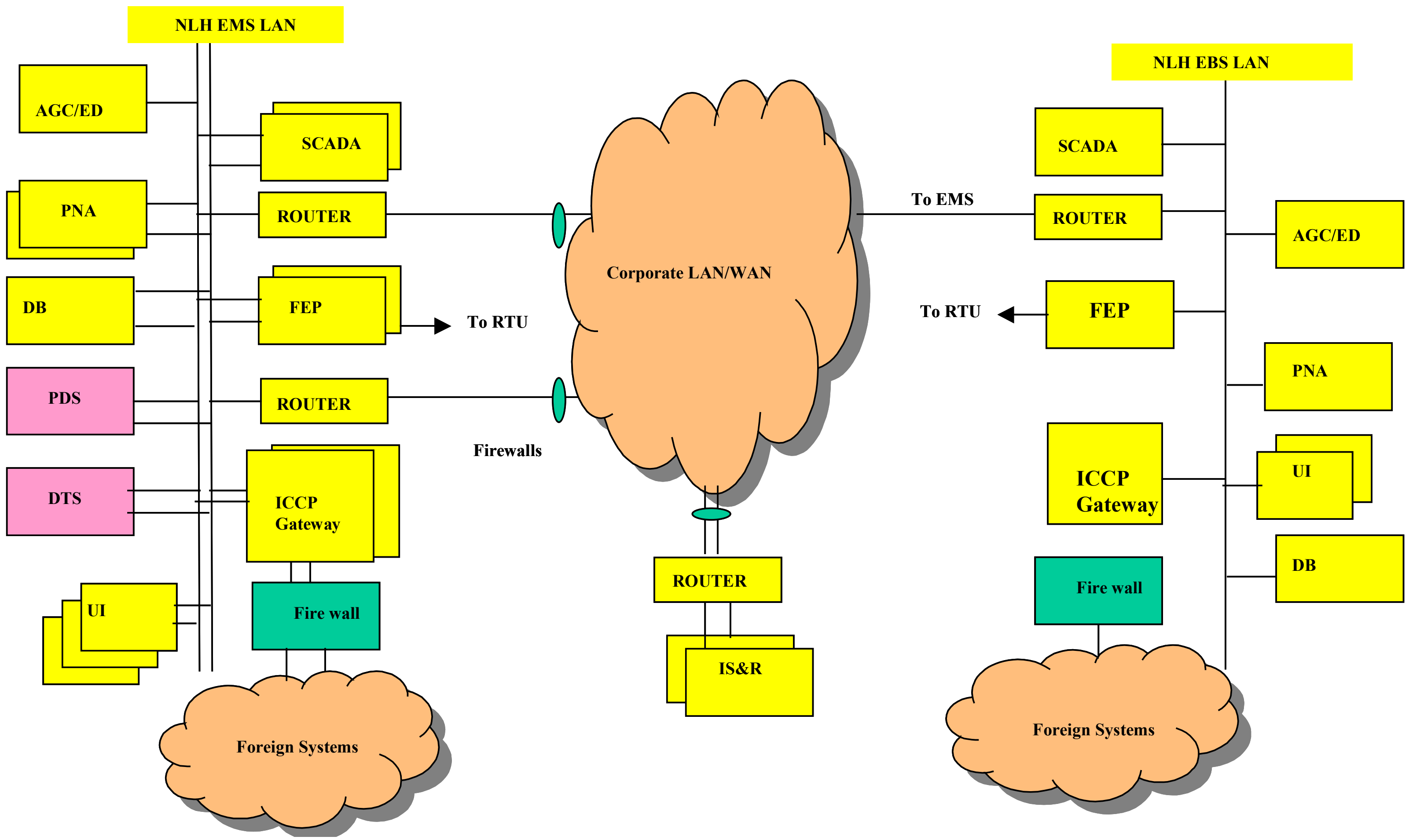
- Disaster Recovery – As reliance on automated processes and real-time data becomes more widespread, the potential for loss of the systems that provide that data to the enterprise becomes less acceptable. The architecture for the new EMS should provide for the continuation of mission critical processes and data should an emergency impact the ability of the existing control facility to function. An optional Emergency Backup System should be specified.

- Improved System Operator Training – A new Operator Training environment, with modern simulation tools and the need for dedicated training personnel should be assessed as an option.

- Advanced Applications – Applications that are not available, outdated, or not used in the existing EMS, should be evaluated for inclusion in the new EMS. These include Unit Commitment, Production Costing, Equipment Outage Scheduling, and Optimal Power Flow.

A conceptual block diagram of the new EMS is provided in Exhibit 7.1-1.

Exhibit 7.1-1 Conceptual System Block Diagram



7.2 SCADA Requirements

7.2.1 Basic Functions

The following requirements are in addition to all of the existing basic functions currently implemented in the SCADA System.

7.2.1.1 Security Considerations

The configuration must be designed to ensure that only authorized users have access to the appropriate data. The system must be designed in accordance with existing NLH security requirements. The use of firewalls between the SCADA/EMS and other LANs is required. All remote access to the EMS must come through a secure interface.

Specific attributes of EMS access security include user login with password protection and activity tracking by user. Access security validation procedure should follow a hierarchy of permissions, including:

- Displays
- Functions
- Database item management
- Enabling and disabling scanning and processing
- Enabling and disabling alarm processing
- Manually entering a value
- Overriding a limit
- Managing alarms

7.2.1.2 User Interface Design Standards

The user interface design for both control room and remote access should implement current graphic standards and be consistent in the use of graphics, commands, menus, colours, item selection procedures, and data entry.

General Features:

- Common display features
- Use of windows
- Display selection and manipulation
- Scaling and translation
- Supervisory control functionality
- Manual data entry
- Multi-user support
- Inactivity timeout
- User guidance
- User help

- Import of "DWG" files for display creation

Trending:

- Support for up to four trends per display
- Support for multiple trend displays on a single monitor.
- Historical Playback

NLH provided displays:

- System Overviews
- Area/Regional Overviews
- Substation and Transmission One-Lines
- Station Tabular Displays (automatic generation)

Contractor-provided displays:

- Access control display
- Menu directory display
- EMS directory display
- EMS configuration monitoring and control display
- Alarm summary
- Event summary
- Off-normal summary
- Alarm inhibit summary
- Tag summary
- Manual replace summary
- Trend control and summary displays

7.2.1.3 Data Acquisition

Data should be collected from the following sources:

1) RTUs, using Harris Protocol with DNP 3.0 protocol as an option.

2) Interconnection with CF(L)Co and NP SCADA Masters to collect and transmit data as defined by the documents "Design Document Newfoundland Power and Newfoundland and Labrador Hydro Data Link", dated 21 January, 2001 and CF(L)Co SNAP tables, using the ICCP protocol.

3) System Frequency and GPS Time

4) Bi-directional interface to the Corporate Network that provides EMS data to the NLH Enterprise and allows Operations staff access to Corporate Email and the Internet.

5) Environmental Data

6) Non-telemetered data entered by the operator

7) Calculated data generated by programs

8) A listen mode to facilitate field commissioning and testing

NLH should also consider requiring the new EMS to support (or be upgradeable to support) the provisions of the Utility Communications Architecture (UCA). UCA is a standards-based approach to utility communications that can facilitate wide-scale communications and data inter-operability. The UCA is designed to apply across the typical functional areas within the electric, gas, and water utilities. These functional areas include customer interface, distribution, transmission power plant, control center, and corporate information systems. UCA Version 2.0 includes a set of communications protocols to meet the requirements of a wide range of utility environments. In addition, the UCA includes detailed object models, which define the format, representation, and meaning of various utility data.

Commercial availability of devices (especially substation IEDs), supporting UCA 2 is growing. If NLH is considering IEDs with this capability, then it should be specified as a requirement for the new EMS.

7.2.1.4 Telemetry Scan Failure

The EMS should notify users of the failure to complete any data collection. Telemetry errors should be collected, reported, and alarmed based upon user-definable parameters. Data should be marked using pre-defined quality codes.

7.2.1.5 Data Processing

The EMS should support the following types of data processing:

Data Type	Processing
Scanned Analog Data	• Data conversion to engineering units (Y=mx+b); unique m and b coefficients for each point • Analog to Digital Converter Accuracy Monitoring • High/Low Limit Checking, including reasonability limits and operational limits • Rate-of-Change Limit Checking • Seasonal and/or Dynamic Limit Replacement (Option)

Scanned Status Data	• Two-state points
	• Three-state points
	• State Calculators
	• Momentary change detected (MCD)
	    o Initially Closed:
	        ▪ Trip (open)
	        ▪ Trip, close
	        ▪ Trip, close, trip

	○ Initially Open: ▪ Close ▪ Close, trip ▪ Close, trip, close • State Change Detection
Scanned Accumulator Data	• Converted into engineering units • Reasonability checking • Accumulator substitution • Limit checking
Calculated Data	• Algebraic Sum/Difference • Multiplication • Linear Approximation • Division • Square Root • MVA • Conditional Calculations (ability to trigger calculations or applications based on system conditions) • Maximum/Minimum • Trigonometric functions • Access to system time within calculation • Digital Integration

All of the existing real-time calculations should be easily re-implemented in the new EMS via these facilities.

7.2.1.6 Remote Control

The following types of devices should be able to be remotely controlled:

- Two- and Three-state Control (Switching Devices)
- Multi-Device Control (Breaker Groups, Tandem Tap Control, Sequential Control)
- Incremental Control (Tap-Changing transformers)
- Setpoint Control (AGC, Generator Control, Voltage Control)

Each control type should be subjected to Control Permissive and Control Completion Checks. The operator should also have the capability to tag control points as follows:

Type of Tag	Description
Control inhibit	No control
Open Inhibit	Prevents the opening of a breaker
Close Inhibit	Prevents the closing of a breaker

Alarm inhibit	Inhibits alarms from occurring on point but continues to be entered in log summary.
Event inhibit	Inhibits both alarming and log summary entries for a point
Information	Allows the system operator to provide additional information related to the point. The entire comment associated with this tag will be displayed when the point is selected.

7.2.1.7 Mimic Diagram

The present SACO tile Mimic Board should be initially retained in its present form and driven from the new EMS. The mimic diagram capability should be enhanced with the capability to add a projector display that, under the operator's control can display any single line diagram or other display available in the EMS. A default display could be a latest copy of the Map displaying the Provincial Transmission and Generation Grid.

After system commissioning, NLH can decide to retain the SACO tile board or retire it. If the SACO board is retired, it may be necessary to install additional projector type displays.

7.2.1.8 Sequence of Events

The present SOE function will be implemented in the new EMS.

7.2.1.9 Alarm Management

The EMS should be able to manage incoming alarms so that the important alarm conditions are reported in a clear, concise, and timely manner while the lower priority alarms are recorded for later analysis and action. The alarm subsystem should include the following:

- Alarm messages must be meaningful and applicable to NLH system and conditions
- Alarms should be functionally classified by area of responsibility (e.g., generation, transmission, distribution, etc.)
- More serious alarms should be annunciated in a more "forceful" manner than less serious alarms
- A standard alarm message format should be used
- The chronology of the detection of alarm conditions should be retained
- Capability to sort and filter alarm and event summaries and abnormal summaries and order the data by system, substation, priority, area of responsibility, chronology or other categorizations (e.g., system audit messages)
- No detected alarms should ever be "lost"
- Capability to inhibit the reporting of an alarm condition for nuisance alarms
- Capability to display, acknowledge, or delete all alarms either individually or by page
- All alarms should be captured for long-term data storage and only printed out on demand
- Capability to trigger an application based on an alarm or event

- All alarms and events should be stored in a Corporate Information Storage and Retrieval System to make them available for later analysis using the search and sort facilities provided with the Corporate RDBMS tools

Alarms should be processed in the following manner on the EMS:

1) Alarm presentation and management

    - Audible annunciation
    - Display annunciation
    - Alarm summary
    - Alarm message deleted when acknowledged
    - Alarm message deleted when return-to-normal alarm occurs
    - Single line of text
    - User ability to modify text
    - All alarms/events should be stored within a Corporate database

2) Enhanced alarm management

    - Minimization of nuisance alarm messages
    - Combining of related alarm messages
    - Prioritization of alarm messages
    - Highlighting of the most urgent messages
    - Suppression of alarms based on related alarm conditions
    - Evaluation of related alarm conditions to determine true alarm condition
    - Access to an informational database to provide explanatory or instructional data.

7.2.2 NLH Applications

NLH has developed specific custom SCADA applications that assist the operators in their daily work. The function of each of these applications should be implemented on a new EMS, as follows:

- Auto Restoration
- Dam Breach
- Multiple Breaker Operation
- Tandem Tap Control

Each of these applications should be able to be implemented using the standard features of current vendor Energy Management Systems.

The current NLH EMS includes features to implement the control and monitoring of a HVDC link between Labrador and the Island of Newfoundland. At this time, the potential for the implementation of this HVDC link is not on the planning horizon. Therefore, this function should not be required in the new EMS. Ideally, this would already be included in the supplier's baseline; otherwise it should be considered as an option.

All other NLH specific applications have been addressed in other sections of this report.

7.3 Generation Dispatch Requirements

Generation of electric energy in Newfoundland is facing many challenges, due to factors such as government directives, stringent requirements on power security, uncertainty in load variation and growth, fuel prices, increasing public concern and regulation on environmental issues, independent power producers, a trend towards deregulation and competition, and the aging of existing facilities.

The EMS must support the following functions:

- Automatic Generation Control (AGC)
  - AGC Performance Monitor
  - Detection of improper unit response
- Economic Dispatch/Unit Commitment
- Reserve Monitoring
- Production Costing

7.3.1 Automatic Generation Control

The Automatic Generation Control (AGC) program is used to automatically adjust generation to meet system load while maintaining system frequency. The AGC must also support automatic time error correction. Recent advancements in AGC include "look ahead" capability to try and anticipate the varying load to ensure that sufficient responsive generation is available to meet the demand.

The AGC program should have the ability to implement raise/lower or set point control to all generating units. It should also have the capability to record each unit response selectively in accordance with each AGC cycle for off-line analysis. In addition, the AGC program should have the capability to detect improper response of a generation unit to the AGC signal.

AGC signals should be in the form of set point control rather than raise/lower signals. The implementation of this function will depend on the functionality of the generation equipment.

7.3.2 Economic Dispatch

The Automatic Generation Control (AGC) program is used in conjunction with the Economic Dispatch (ED) program to minimize the total production cost for meeting system load while maintaining system frequency.

ED calculates base points for generating plants at Bay d'Espoir, Upper Salmon, Cat Arm and Hinds Lake (11 units in total) and is based strictly on economics. The economics are determined from the polynomial based Incremental Water Rate curves of the hydro units and a calculated cost of water for each plant.

This function should continue to be an integral component of the EMS.

7.3.3 Reserve Monitoring

A reserve monitoring function is required to compute and monitor the spinning reserve, non-spinning reserve, operating reserve, available reserve, and operating margin.

Non-spinning reserve, operating reserve, available reserve, and operating margin are new functions to be implemented.

Total spinning reserves are categorized into regulation reserves and other reserves. Regulation reserves consist of hydraulic units in ECON or BASE. Units in MANUAL are categorized into other reserves. Thermal generation, Paradise River and NUGs are other generation reserves when they are online.

A maximum unit-loading algorithm should continue to be used to warn the operator when units are loaded to the extent that if lost, significant load loss would result.

The effectiveness of the currently provided additional parameters for Mvar reserve monitoring should be further evaluated to determine if it worthwhile to require modifications to the suppliers' proposed baseline, or if these parameters can be calculated and monitored using the expanded data access and calculation capabilities of a new EMS.

7.3.4 Production Costing

A Production Costing function is required to compute and maintain hourly, daily, and monthly production cost totals.

In addition, the system should be modeled to include the start up and shutdown costs for each generating unit.

7.3.5 Hydro-Thermal Coordination

The existing Hydro-Thermal coordination utilizes an off-line, PC-based tool called "*Vista*" that optimally decides the coming week's hydro-thermal generation mix from historical inflow sequences and other operational inputs. A manual process is used by System Operations management to prepare guidelines for the Energy Control Center staff that defines the commitment for NLH's major fossil and hydraulic units using the results of "*Vista*". This guideline normally gives the base loading for Holyrood Plant, the loading and expected daily operational duration for Upper Salmon and Hinds Lake, and the economic low for Cat Arm. Bay d'Espoir is scheduled to meet the balance of the system load. The guideline recommends the order of unit shutdown.

The "*Vista*" program should exchange data (conceptually through its ODBC-compliant data store) with the EMS. A Unit Commitment function hosted on the new EMS (typically included in most vendors' baseline) can then be used to optimally schedule the seven Bay d'Espoir units. The "*Vista*" user interface is Windows based, and should be accessed directly from the Operator's workstations on the new EMS.

As a minimum, the new EMS should exchange data with the existing, off-line Unit Commitment program so that the system inputs that are now manually input by the operator are provided automatically from the EMS.

7.4 Power Network Analysis Requirements

The existing NLH EMS has an integrated set of Power Network Analysis applications. Even though the NLH EMS was commissioned in 1990, the design of these applications dates back to the early 1980's. Similarly, the new EMS should include a complete set of modern Power Network Analysis functions that incorporate recent technology and provide better integration with other EMS functions. As a minimum, these must include the following real-time and study-mode applications:

1) Network Topology Processor

2) State Estimator (including tap estimation and line parameters as state variables and models the external network as an integral part of the entire model)

3) Contingency Analysis

4) Power Flow

5) Penalty Factor Calculation

6) Voltage Scheduling

7) Bus Load Forecast

The reasons for modernizing these Power Network Analysis functions include the following:

- Improved integration and consistent look and feel with other EMS applications
- Database and display maintenance common across all other EMS functions
- Estimates of non-metered quantities
- Identification of metering errors
- More accurate bus load data for studies and planning
- Advanced knowledge of potential system violations
- System var management
- Advisory strategies for alleviating overloads
- Import and export of power system model and data (e.g., State Estimator results) in PSS/E, IEEE Common Format and/or EPRI CIM or XML format for data transfer to external users
- Enhanced study case comparison and contingency management capabilities
- Improved application response times, study case storage management, and access by appropriate NLH enterprise users outside of the traditional control room.

7.4.1 Additional Applications

NLH should consider the following applications for inclusion in the new EMS. These applications are either not currently integrated into the existing EMS, or are not being employed to their fullest capability:

1) Equipment Outage Scheduler. As an optional, integrated EMS application, this function is used to schedule outages for various power system devices, including transmission lines, transformers, loads, switching devices, and generators. It can be used to schedule a temporary change in a selected generating unit's MW rating. These schedules can then be used to automatically initialize the other advanced power analysis functions. For example, the real-time power network applications would consider the scheduled outages for non-telemetered devices in determining system connectivity; likewise, initialization of study cases can automatically consider past, current, or future planned outages. The application should also be able to initialize Power Flow and Unit Commitment cases, providing any real-time or study application the ability to automatically consider scheduled device outages or changes in generator MW ratings.

2) Remedial Action. This function provides recommended corrective actions for a system operator selected contingency case, i.e., the corrective actions the operator should take if the contingency occurs.

3) Optimal Power Flow. This function determines optimum settings of designated control variables (e.g., generating unit MW and/or MVars, transformer tap positions, etc.) to minimize a desired "objective function" (e.g., minimization of MW transmission losses) while respecting prescribed system operational limits. While this function is available on the present EMS, NLH has stated it does not have enough experience in using the application to trust its results. Addition of an up to date package in the new EMS will likely provide more accurate results with a flexible, user-friendly interface, leading to increased usage by system operators (as well as other NLH users outside of the control room).

4) Load Forecasting. The new EMS should include one of several different methods for forecasting the system as well as area loads. Similar Day Load Forecast using historical load and weather data is included in almost every EMS in the market today. In addition, some utilities include a weather adaptive load forecast. Recent development work in the load forecast area has been with neural network-based load forecasting, which would be technically preferred (assuming NLH has sufficient history of weather and associated load data). A load forecast update functions is required, to insure the forecast accurately reflects current system operating conditions. Note that the existing calculations associated with Area Load Calculations should be easily re-implemented in the new EMS (reference Section 7.2.1.5). The new EMS may also include inherent capabilities to associate load values in various combinations for load forecasts updates, historical data analysis and reporting as well as other applications.

7.5 Data Exchange with External Systems

The new EMS must support the exchange of real-time data to both CF(L)Co and Newfoundland Power (NP). These are currently implemented via proprietary protocols or awkward "Mailbox" (i.e., "back-to-back") RTU data exchanges. These links are problematic. For example, since quality information is not transmitted over the link, data must often be validated with the other company prior to any actions being taken. These issues would be resolved by employing a standard communication protocol as described in Section 7.5.1.

The current download of environmental (hydro-meteorological) data must also be supported by the new EMS (reference Section 7.5.2).

7.5.1 Inter-control Center Communication Protocol (ICCP)

The creation of new transmission paths and the redefinition of the NLH role in the delivery of energy to the Province are both potentialities currently being discussed. Either will likely require data exchange with additional external entities. The new EMS must be able to easily and efficiently manage these new requirements as they arise. It is therefore strongly recommended that the new EMS include the capability for data exchange using the IEC 870-6-503 Telecontrol Application Service Element.2 (TASE.2) communication protocol (i.e., ICCP).

The TASE.2 protocol will facilitate data exchange between the new EMS and other utilities' control centers, non-utility generators and future power pools or other regional control centers. Data exchange information may consist of real-time and historical power system monitoring and control data, including measured values, scheduling data, energy accounting data, and operator messages. The standard also provides for various data quality indications to be applied to the values as well as remote device control and remote program control.

The TASE.2 protocol is divided into "Conformance Blocks", which define the required behavior and information (objects) that can be exchanged. As a minimum, the following conformance blocks should be supported by the new EMS:

- Blocks 1 and 2 – SCADA Data. Conformance Blocks 1 and 2 are employed for the acquisition of telemetered data from selected data sources external to the new EMS, and for the transmission of SCADA data to the same external entities.

- Block 4 – Information Messages. Block 4 provides the new EMS with the capability to perform bi-directional exchange of information messages between the EMS and other computer systems. This typically includes special system operator application initiated messages. Note that the participating control centers must agree on the format of each information message transferred using this block. As a result, this block is often offered only as an option, or implemented through some other mechanism (e.g., Email).

- Block 5 – Device Control. This Conformance Block provides the mechanism to support requests for remote device control, e.g., controlling a breaker. The cooperating utilities must define if this block is active, and what devices are authorized for such control actions. Results of the control actions are typically seen through the transfers associated with Blocks 1 and 2.

- Block 7 – System Events. Block 7 defines how system events are transferred between the control centers. As with Block 4, the participating control centers must agree on the types of events and the format to be transferred. As a result, this block is often offered only as an option, or implemented through some other mechanism (e.g., Email).

Note that the implementation of ICCP must be closely coordinated with NP, to avoid the procurement cost of a custom data link in the new EMS. The existing "Mailbox" RTU data exchange could be maintained with CF(L)Co (although it is currently ineffective and not recommended), but this is not an alternative for the exchange of data with NP.

7.5.2 Environmental Download

A facility to access the Department of Lands and Environment, hydro-meteorological data (via an electronic bulletin-board) must be provided on the new EMS. The current system downloads the information to the OIS Sybase database, and is scheduled to execute several times each day to determine if new data needs to be downloaded. From the Sybase database the data can be retrieved for use in MS-Access reports.

Since the new EMS should be specified to include an RDBMS-based Information Storage and Retrieval subsystem, the environmental download can be easily accommodated. In keeping with the goal of minimizing vendor-supplied customs, NLH should consider adapting this feature to the new EMS themselves.

7.6 Information Storage and Retrieval (IS&R)

The IS&R system is the portion of the new EMS that is responsible for the long-term storage and retrieval of operational information. Typically, the IS&R is the first-level repository of the EMS's historical information for access by other departments within the utility. The IS&R is based on a commercially available RDBMS and all tools that are available with the RDBMS can be used to sort, search, and report information stored in the IS&R.

The following types of information should be stored in the IS&R:

1) Real-time and applications database snapshots of scanned, non-scanned, and calculated status, analog and accumulated values

2) Time-tagged alarm and event messages

3) Sequence of Events (SOE) event messages

4) Scheduling and energy accounting information

5) Disturbance data

6) Production and hydrological data

7) Communications statistics and errors

Many of the present EMS suppliers satisfy some of the above functionality through the use of a continuous data recorder application (such as OSIsoft's "PI System"). This type of facility obviates the need for specialized disturbance data collection and reporting (as all system data is continuously collected and stored for a pre-determined period of time). The data can also be combined with Alarm/Event information to effectively replay system conditions (ideally using the same system displays used for operations, but in a "replay" mode).

The IS&R function should also include basic reporting capabilities. The report software should be a commercially available package capable of generating different types of reports. The reporting software should have full access to the IS&R database and should support arithmetic functions such as spreadsheet calculations to allow for creation of reports without procedural programming.

With these capabilities, the new EMS would provide an integrated, reliable replacement for both the present facilities (i.e., the M9200 RGS and the non-redundant OIS). All of the reports and related database functions that these current facilities provide would be easily recreated on the new EMS (without expensive customization of the supplier's baseline). Considering the expanded storage, ad hoc query and reporting capabilities, NLH should survey their internal customers to determine which of these current formal reports would still be required.

The new EMS should also use the IS&R system's RDBMS for other functions, as it can serve as the data store (at least for results and stored cases) for various supplier or NLH developed applications. This should also be the facility through which the new EMS source database management is performed. Its inherent capabilities should minimize or eliminate NLH custom applications that currently manage various aspects of database referential integrity and generate RTU wire lists.

7.7 Communication Requirements

A comprehensive, five phase, Telecommunication Plan was developed in 1997 that defined the process for upgrading Newfoundland & Labrador Hydro Telecommunications facilities on the Island. The implementation of the plan is ongoing, where Phase III should be completed in 2002.

The overall plan calls for extensive use of microwave on the East Coast, Central and part of the West Coast, with the remainder of the West Coast operating primarily with Power Line Carrier and commercially available leased lines.

These telecommunications facilities are used for operational voice communications, data (RTU) communications and power system protection devices.

7.7.1 SCADA Communication

The new EMS should support the current RTU communication scan rates and data speeds. The new EMS should also be capable of evolving to higher data speeds and protocols that support IP addressing on the NLH WAN.

7.7.2 Voice Communication

Customer interaction with the control room during periods of major disturbance needs to be minimized. A system is required that will, on the one hand, provide sufficient information to the control room to ascertain the location and severity of a disturbance and, on the other hand, provide information to the public on the progress of restoration without continual interruption to the control room.

7.7.3 Data Exchange

Communications required for the data exchange between NP and CF(L)Co should ideally be implemented using ICCP protocol (see Section 7.5.1, ICCP).

7.8 Enterprise Integration

Within the new EMS, the integration of different components should be achieved by passing information among subsystems using well-defined interfaces to provide seamless data integration across platforms and application environments. The system should provide a robust set of Application Programming Interfaces (APIs) that support the communications with other NLH components. These APIs will facilitate the integration of other Applications into the EMS environment. Ideally, a message bus technology based capability would be available to further enhance the ability of the new EMS to interface with the rest of the NLH enterprise.

The new EMS would include one or more of the following data transport mechanisms:

1) File transfer via secure ftp

2) TCP/IP messaging and Remote Procedure Calls (RPC)

3) TASE.2

4) Middleware

The future integration architecture at NLH could be based on a federated Enterprise Application Integration/Business Process Automation (EAI/BPA) message bus architecture. The new EMS would not impose any restrictions limiting NLH's ability to evolve to its future EAI architecture. NLH should be able to freely define workflow paths, after which rules for moving data between systems can be established, thereby improving the relationship between business processes and systems. This flexibility is especially important as the NLH role could potentially change during the expected life of the new EMS.

In particular, the new EMS should reflect the current electric utility industry standards for information exchange. These include the EPRI Control Center Application Programming Interface (CCAPI) project and its core Common Information Model (CIM) along with the International Electro-technical Commission (IEC) Technical Committee (TC) 57 Working Group 13 on EMS APIs.

The following sections describe a few of the areas where NLH would be able to take advantage of the enhanced integration capabilities of a new EMS.

7.8.1 Electronic Point Commissioning, Point Status and Repair History

This application should be able to be migrated to the new EMS. The existing data (from the OIS) should be exportable from Sybase to the IS&R environment of the new EMS (reference Section 7.6). The existing Microsoft Access reports can then be modified to use the RDBMS of the new facility. An approach such as this would minimize the migration time and costs, while migrating the data storage and information access capability to the newer, redundant environment, with the added expected benefits of improved user response, and better integration with other relevant EMS data.

Further, the new EMS should be required to provide the capability to access additional point-specific information from an external source, directly on the EMS User Interface. Upon selecting the desired point, a menu should be available such that the user can pick various additional relevant information to be displayed, including point's maintenance history, operating instructions, photographs of related equipment, or other pre-defined external file, database, or Intra/Internet links.

7.8.2 Substation Automation, Metering and Relays

As a long-term strategy, the NLH is moving towards implementing an IP-based WAN to many of its remote sites. This added communications bandwidth and accompanying inter-operability would enable the new EMS to interface with various substation monitoring and control equipment currently being studied and considered for implementation.

For example, the additional WAN capability, together with ongoing substation automation projects and a new EMS, NLH can provide system operators with real-time information regarding fault location and type. This will reduce restoration times and increase repair crew efficiency. Fault data can also be more easily analyzed in conjunction with other EMS data, with the potential for remotely adjusting protection relay settings and identifying troublesome devices for replacement or tracking device operations for preventive/predictive maintenance.

At a minimum, the increased communications bandwidth from the substation can be leveraged to allow for additional real-time telemetry to be provided to the new EMS. Gas pressure and temperature information can then be displayed to the system operator and the generic "breaker alarm" currently provided can be more readily differentiated (with a corresponding increase in efficiency of coordinating repair operations).

7.8.3 Isolated Diesel Monitoring Systems

Remote diesel operating data is currently retrieved daily and fault information is retrieved on demand to a central database in Bishop's Falls, the hub of NLH's Transmission and Rural Operations. The information is used for disturbance analysis, power quality assessment, trending, problem resolution and planning. This data could be acquired by the new EMS and managed within its IS&R subsystem. This would allow for a single, reliable data store, eliminating the need to maintain the data in a separate facility. This should simplify Enterprise data management, broaden the analysis capabilities (as it can be more easily compared to other EMS data) and improves integration with the Transmission and Rural Operations and the overall accessibility of the data to the entire Enterprise.

7.8.4 Customer Service

The new EMS can provide enhanced integration with NLH customer service activities, particularly relating to outage management and associated service restoration. Through modern data integration capabilities, the new EMS would have the ability to share relevant supervisory control information (work-in progress, tags, etc.), selected real-time analog measurements and telemetered and manually updated switch status information to the outage management system, facilitating association of trouble calls with known system problems. Likewise, outage management can provide information to the EMS regarding predicted status of non-telemetered equipment that may be causing customer outages. This bi-directional exchange could easily be accomplished via the recommended TASE.2 facility or through a more generic data messaging facility such as XML.

In addition to data integration, the new EMS would provide the opportunity for enhanced user interface integration. Since the new EMS would likely include a Windows or browser-based UI, EMS operators would have the capability to access the same application that customer-service personnel use during regular business hours. Likewise, selected or specially built EMS displays and alarm/event information can be shared with customer-service personnel. Information regarding the progress of restoration efforts can also be seamlessly shared across the two facilities (ideally, entered directly by the restoration crew from the work site via wireless networking).

The resulting increased levels of data and user interface integration can lead to improving the accuracy of information to the Customer regarding the restoration of their service as well as lead to shorter restoration times through more accurate trouble identification and associated information dissemination.

7.8.5 Equipment Reliability

The inherent capabilities of the advanced applications associated with the new EMS can have a positive effect on the reliability of NLH equipment. For example, the system can help operators plan for and insure in real-time that:

- Loading of equipment respects continuous thermal limits
- Voltage on equipment respects corresponding voltage limits.
- Loading of equipment following credible contingencies is within time-limited thermal limits.
- Voltage on equipment following credible contingencies is within specified limits.

A new OTS environment would also help operations practice operational activities and restoration methods that would be designed to minimize stress to the NLH power system.

The Windows or browser-based UI of the new EMS would also provide an integrated environment for presentation of weather (e.g., lightning) data to system operators, on the same screens as the EMS uses. This reduces the number of different UI devices that the operator must deal with, providing immediate access to relevant information.

The IS&R subsystem of the new EMS would also be the repository for reliability-related data. The IS&R can be used as the central point for bulk electric system reliability reporting, as well as individual component reliability. Applications such as reliability-centered maintenance can therefore be realistically hosted in the new EMS while maintaining enterprise accessibility. The data gathered can also include EMS facilities (e.g., RTU and EMS LAN/WAN communications components), leading to identifying troublesome components.

7.8.6 Corporate ERP

The new EMS should be able to facilitate integration with the J.D. Edwards suite of ERP/CRM software through the inherent data-sharing capabilities supported by previously described IS&R. All the previously described integration applications can be opportunities for integration with the NLH corporate ERP environment. As additional requirements for a more direct method of inter-application data exchange and messaging arise, the new system would provide the required APIs. Most EMS suppliers currently provide a robust set of "proprietary" APIs through which their applications can exchange data with external applications, initiate external functions, or allow external functions to invoke EMS various applications. Next generation EMS baselines are expected to provide more robust data-messaging approaches, supporting message-bus concepts such as dynamic registration and message-brokering for applications distributed across the corporate network. Alternatively, third-party packages can be used to provide this level of integration, although configuration activities may have to be performed by the EMS supplier (or NLH), but this would likely increase the overall costs and limit long-term flexibility.

7.9 Physical User Requirements (Control Room Layout)

The NLH Control Room is occupied on a 24/7 basis by two on-shift staff, the System Operator and the Shift Supervisor. Each position is equipped with a console workstation and a PC. A mapboard depicting a static one-line overview of the NLH system with integral meters and status indicators dominates the room.

The operator is required to enter and re-enter data using multiple entry devices. Data entry should be automated as much as possible and the operator should only have to enter data once using one set of equipment. The operator console workstation should be modified or replaced to provide the display and interaction with all power system data through the use of a single set of entry devices (e.g. integrate the functionality of the EMS console display/data entry with the functionality and applications of the PC).

The mapboard is used to interact with field crews to discuss maintenance and restoration work. The present mapboard provides limited information and does not provide the flexibility to focus on a particular work or restoration area. The mapboard should be modified to provide the following additional features:

1) Dynamic display of status lines and devices by changing the colour of the complete set of affected facilities.

2) Operator control of a portion of the mapboard to allow the detailed display of a portion of the power system that is of specific current interest.

3) Provide the display of the power system in a mapped geographic orientation.

As presently implemented, the mapboard is too close to the working consoles. Modifications should occur that provide a better relationship between the consoles and the mapboard. An ideal solution to these issues would be the implementation of a dynamic projection type mapboard, either as an add-on to the present mapboard or as a replacement for the existing facility.

Periodically, management and planning staff use the third console to access EMS applications, as these applications are not accessible outside the control room. There are a limited number of personnel that are authorized to use this function. Remote consoles, with limited access, should be implemented outside the control room for this function.

There may be periods of time when additional staff may be called in to assist with a particular disturbance situation, primarily to answer telephone calls from residential customers after normal business hours. As these additional personnel may need to interact directly with the facilities in the control room or the on-shift personnel, an area in the control room should be set aside and equipped with telephones for this purpose.

A specific layout of the control room would have to be implemented through proper architectural design and specific selection of equipment components and a detailed transition plan developed that are beyond the scope of this study.

7.10 Backup Control Center Requirements

In conjunction with the new EMS, NLH should plan to implement an Emergency Backup System (EBS) and a Backup Control Center (BCC) at a location off-site from the primary EMS facility. This facility would guarantee continuity of critical operations in the event that the primary facility was either temporarily uninhabitable or suffered catastrophic loss. While complete redundancy is not required, the EBS would include sufficient equipment such that all critical EMS functions can be performed from the off-site location. This should include basic software, database, display and report maintenance (since the length of time the primary facility is out of service is not predictable), but non-essential functions (e.g., OTS) could be eliminated. The EBS hardware and software technology should be identical to the primary EMS such that incremental maintenance costs (e.g., spare parts, training, etc.) are minimized.

Selection of the site is an important consideration for NLH. It must be close enough such that critical operations and system management personnel can be transported to its location in a timely manner. But it must be far enough away such that a single event does not impact the ability of both centers to perform their mission. The re-routing of RTU and critical external system communications is also a consideration. The currently used backup location may be appropriate, however other sites with perhaps better communications access should be considered.

Several alternatives exist as to the architecture of the EBS. The EBS could be an offline or “cold” backup, updated periodically with updates to the database, displays and reports. Only highly “trusted” updates to software should be performed. This reduces the likelihood that a virus or “Trojan horse” impacts the ability of the EBS to perform its mission. But it requires periodic, manual intervention to bring the database and displays up to date. An “online” backup is also feasible, with periodic or continual database updates to the EMS. While usually easier to manage, test and maintain, this configuration typically requires a reliable, high-bandwidth, low-latency connection to the primary EMS equipment. The EBS configuration may also be able to leverage development system or OTS hardware, depending on the location of those activities. A dedicated EBS is recommended as the most effective alternative, and the inconvenience of sharing the platform for these other purposes is avoided. The final EBS implementation philosophy, and resulting architecture should also be driven by the selected vendor’s baseline capabilities. No matter what architecture is chosen, implementation plans must provide for the complete testing of the EBS. Periodic testing of the EBS, and associated emergency operations plans, must be a regular component of the new EMS life-cycle activities.

7.11 Life Cycle Management

Because of the movement of these systems away from proprietary hardware to open systems, the opportunity exists to manage the life-cycle of the new EMS in a manner similar to other modern “evergreen” type IS&T projects. NLH will make a substantial investment in vendor selection, training and installation. It is therefore wise to engage the vendor in a long-term relationship that keeps the system up to date with new hardware and software. Otherwise, the system will become obsolete in a shorter timeframe than the existing EMS.

The first step in this new philosophy actually begins during the system specification and vendor selection process. A strategy critical to achieving a rapid implementation, and the system’s long-term ability to migrate to new versions of the supplier’s baseline, is to manage the number of features that require special programming effort, accepting a solution that uses the supplier’s standard approach. This is accomplished by a two-phase effort. The system specification must be carefully managed (i.e., insuring unnecessary features are not specified). Then the baseline offerings of the competing suppliers should be carefully evaluated. The evaluation should center on picking the baseline that most closely matches NLH needs without customization. The ability of the baseline to adapt to various options (e.g., through configuration parameters, etc.) and the robustness of its APIs (permitting creation of applications external to the vendor’s baseline) are associated key evaluation factors.

The second step also occurs during the vendor selection process. NLH should look for a vendor that can provide an EMS product with a history of a continuously evolving baseline (incorporating functional improvements as well as adapting to new technologies, platforms, operating systems, etc.) combined with a proven track record of performing field upgrades with little to no disruption to ongoing operations. The supplier's hardware and software warranty, as well as their long-term maintenance agreements should also be evaluated.

The third step is the management of NLH staff. This is essential not only to achieving the implementation schedules shown in this report, but to ensure that the correct personnel are involved with vendor selection and installation of the new EMS, as well as receiving the correct training. All these tasks are dependent on the availability of the required NLH staff. Improper management of these activities during the initial phases of the project can lead to reduced acceptability of the new EMS and reduced effectiveness of NLH to maintain the new EMS after the initial installation and warranty phases.

The last step, after the new EMS has completed final acceptance, is the commencement of the long-term life cycle management activities. Facilities must be in place to help manage software, database and display version control (i.e., a software configuration management toolset that manages incidents, associated changes and version control). As a safeguard against personnel attrition and skills obsolescence, continual training (internal and vendor-supplied) must be planned and scheduled covering all aspects of the system's operations and maintenance. The backup control center should be periodically exercised.

Changes will be needed as NLH is faced with the difficult challenge of operating in a dynamic environment. NLH will need to continuously and carefully review and analyze changes that will be needed after final system acceptance. By prioritizing its additional needs in terms of benefits versus the impact on cost and schedule, timing and scope can be managed effectively.

An essential component of the life cycle management is a plan for periodic replacement/upgrading of the system's hardware and software components. From an "open systems" perspective, the general rule of thumb is that the hardware is obsolete in 3 to at most 5 years. From that basis, it is prudent to budget 20% to 33% of the base hardware costs (excluding traditional RTU communications equipment, which typically has limited upgrade potential) to be expended per year. This would include the periodic replacement of worn-out (printers, monitors, disks, etc.) and obsolete equipment (e.g., workstations, servers, LAN, and other communications interfaces). This does not include consumables, expansion (other than that which could be expected to be handled by higher performing processors, etc.), 24x7 emergency service plans, or implementation of drastically new requirements or technology. In summary, the hardware life-cycle costs over a ten-year period might be projected to be as follows:

Year 1 ......…. $0 (hardware warranty in effect)

Year 2 ......….CDN $50K (minor replacements due to normal wear & tear)

Year 3-10.....… CDN $225 - $375K per year

Note that "Year 2" after system installation actually reflects hardware that is three to four years old (dependant on when the system's hardware was purchased by the supplier). Subsequent year's costs can vary based on the general equipment obsolescence policy adopted by NLH and other equipment purchase agreements or volume discounts that might be leveraged.

Life-cycle software activities and costs are much harder to predict. Factors include how often a new release is made available from the supplier, how often NLH actually implements a new release, how much effort is required to re-integrate customs, migrate database & displays, how much testing is expected, impacts to third party SW licenses, etc.

A reasonable assumption is that three EMS software upgrades are performed over a 10-year life cycle. Each would cost approximately 10% of base SW (CDN $150K) each, and three corresponding integrations of customs at 20% of original custom cost (CDN $100K) each, there are payouts at years 3, 6 & 9 of about CDN $250K each (or about $85K per year banked for the quantum payouts).

"Big ticket" third party SW licenses, such as the RDBMS, are not normally included in software upgrade costs. These prices will vary greatly, based on which brands are employed, and if the utility has an umbrella licensing agreement in place. This could easily be CDN $50K-$250K or more per replacement. So using the same EMS software upgrade assumptions (i.e., three upgrades over 10 years), an additional CDN $75K would be reasonable to budget annually. This brings the total annualized budget for new EMS hardware and software maintenance and upgrades to be approximately CDN $420K. Exhibit 7.11-1 provides an illustration of these typical external life cycle costs.

YEAR #	HW (CDN $K)	Vendor SW (CDN $K)	3rd Party SW (CDN $K)	
1	0			
2	50			
3	350	250	200	
4	350			
5	350			
6	350	250	200	
7	350			
8	350			
9	350	250	200	
10	350			
Category Totals	2850	750	600	
Grand Total				4200
Per Year				420

Exhibit 7.11-1 Typical life cycle costs

7.12 Operational And Support Training Requirements

The selected supplier of the new EMS will be required to provide comprehensive training for NLH personnel. This training should be to the extent that NLH will be comfortable in all aspects of the operation, maintenance, and expansion of the system and its functions. The training would include formal classes at both the supplier's site and in St. John's. Each class should include both classroom and individual "hands-on" training. Additionally, NLH should seek opportunities for "on-the-job" training (OJT), with selected NLH personnel working closely with the supplier performing appropriate assignments (i.e., jointly agreed to tasks) associated with implementing the new EMS.

7.12.1 SCADA/EMS User Training

A comprehensive System Operations Manual should be provided and context sensitive, on-line help should be available to every user of the new EMS.

A formal training course, conducted on-site at NLH, is recommended for all operations personnel. This would cover all aspects of system operations, from the system operators' perspective. Ideally, the course would be conducted on NLH equipment, using actual NLH database, displays and applications. The course may be needed to be held several times in order to accommodate all shift personnel and other scheduled (and unscheduled) activities.

User training should also be provided to personnel that might use the system for non-operations type functions, including system planning, customer service and general management. Special, highly focused classes should be provided to these users. Internal NLH trainers that are fully trained in all aspects of operating the new EMS would probably be best suited to perform this training.

Assuming OTS (reference Section 4.8.1) is included in the new EMS, a separate class on its operation should be provided. This would be targeted at trainers and OTS maintenance staff, specifically focusing on the capabilities and management of the OTS. Scenario creation and maintenance, along with a discussion of effective training techniques, are essential elements of this course.

After final system acceptance, the OTS should become an integral component of operator training. It can be used to help familiarize new operators with the capabilities of the new EMS, as well as maintain the expertise of experienced operators dealing with system conditions that are rarely encountered.

7.12.2 SCADA/EMS Hardware Support Training

The new EMS will be mainly comprised of standard third party components. As such, the need for specialized hardware training from the EMS supplier will be greatly reduced (probably limited to specialized communications interfaces and equipment). Standard Original Equipment Manufacturer (OEM) documentation and diagnostic tools should accompany all third party hardware. NLH should still take advantage of the EMS vendor's suite of hardware oriented classes, which should provide an overview of the system's hardware components, and familiarize NLH maintenance technicians with the tools and procedures needed to perform basic system diagnostic actions and take effective corrective measures.

7.12.3 SCADA/EMS Software Support

This is the largest and most complex category of documentation and training. The Software documentation and training courses from the new EMS supplier must provide the background necessary for NLH software support staff to do the following:

- Add/maintain/delete RTUs, data links, and associated points
- Create and maintain all displays
- Create and maintain all reports
- Build and maintain the Generation Dispatch and advanced power network applications models (including OTS generator and relay models) and provide an overview understanding of the CIM model
- Change the master station configuration, such as, add/upgrade workstations, add/upgrade servers, add/upgrade loggers, etc.
- Add applications functions that access real-time databases and store back into the real-time databases or the data warehouse
- Interface with NLH corporate LANs and WAN
- Upgrade software, including the Operating System Software, to future releases

The supplier's standard course offering should include at a minimum, the following types of software courses:

1) Support Software including:
   a) Operating System Software
   b) System Initialization, Failure Recovery, and Network Management
   c) Software Configuration Management
   d) Performance Assessment
   e) Software Upgrades
2) Communications Software including router and network configuration
3) System Maintenance and Expansion
4) User Interface Design
5) Basic System Software
6) Applications Software
7) Application Programming Interfaces (API)

Where third party components are involved, OEM provided documentation should be forwarded to NLH. Additional detailed training from the OEM may also be recommended.

7.13 Organizational Structure and Staffing

This section provides the staffing recommendations for support of the new NLH EMS. It provides a detailed analysis of the staffing requirements needed for the EMS project implementation, as well as the permanent EMS support staff required to maintain the EMS after its acceptance. Please note that the overall project schedule is anticipated to be approximately 36 months (reference Exhibit 8.1-1).

7.13.1 Project Implementation Staffing Requirements

7.13.1.1 Personnel Tasks

The project implementation phase of the EMS replacement project is estimated to take approximately 20-24 calendar months to complete including the project implementation at the EMS supplier's factory[1] plus approximately three months for the startup and commissioning of the new EMS at the NLH site. To facilitate

[1] Note that NLH staff participation would begin well in advance to the contractual start of the implementation phase. Prior to contract signing, a period of up to one year will be required for supplier pre-qualification, specification preparation, bid evaluation and statement of work. It is strongly recommended that key members of this team continue with the project to form the core of NLH's project implementation team.

transition and operations of the new system, this team should then become the core of the new system's permanent support staff. This optimizes the return on the NLH investment in training and cross training of this team during the early phases of the replacement project.

The following staffing positions are needed to support the project implementation effort:

1) Project Manager

   The Project Manager has overall responsibility for all aspects of the project, with emphasis on the management of project contractual and administrative issues. Specific responsibilities would include:

   a) Coordinating the efforts of the NLH project team

   b) Insuring all project specific documentation (e.g., project schedules, progress reports, overview documents, software documents for custom designs, hardware documents, and test plans and procedures) is delivered per contract and meets NLH standards for content and format.

   c) Directing the project contractual meetings

   d) Authorizing/certifying the project deliveries per contract

   e) Managing all site installation and acceptance testing activities

   f) Working closely with the EMS consultants to ensure that the EMS supplier satisfies all of NLH needs

   g) Working closely with other NLH departments

2) Project Technical Lead

   The Project Technical Lead will report to the Project Manager, and will be responsible for the overall technical implementation of the new EMS. Specific responsibilities would include:

   a) Directing the project technical meetings

   b) Reviewing all project specific documentation (e.g., project schedules, progress reports, overview documents, software documents for custom designs, hardware documents, and test plans and procedures) for technical accuracy

   c) Supervising and reviewing the design of the new full graphics displays

d) Attending training courses

e) Coordinating and leading the factory acceptance test activities and determining when testing must be repeated and if the system is acceptable for shipment

f) Supervising and coordinating all site installation technical activities and acceptance testing

g) Working closely with the EMS consultants to ensure that the EMS supplier satisfies all of NLH technical requirements

3) Software Engineers / Software Specialists

The Software Engineers/Specialists will report to the Project Technical Lead. Their responsibilities will include the following:

a) Being trained in programming, system administration, and database administration

b) Developing the standards used by the database staff when building the database, displays, and reports

c) Maintaining the Program Development System used by the database staff

d) Reviewing all software documentation for custom designs

e) Assisting with the design of the database and full graphics displays

f) Migrating the NLH-specific applications to the new system

g) Participating in project and technical meetings

h) Reviewing factory test plans and procedures

i) Attending training courses

j) Performing factory tests

k) Assisting the advanced applications engineers in developing the network model.

l) Assisting the EMS supplier with the installation and commissioning of the new EMS once it arrives at NLH

4) Technology Architect

The Technology Architect will report to the Project Technical Lead. The Technology Architect's responsibilities will include the following:

a) Reviewing hardware documentation (e.g., hardware manuals, drawings, user manuals, etc.)

b) Reviewing EMS communication requirements to ensure that the equipment interfaces correctly with the existing NLH communications system including management of the network equipment (routers, hubs, front end processor equipment, etc.)

c) Reviewing the hardware integration test plan and procedures

d) Attending and contributing to project and technical meetings

e) Reviewing all hardware model updates

f) Performing the hardware integration test and factory acceptance test at the supplier's factory

g) Attending hardware and basic system training

h) Supporting the EMS supplier with the system installation at NLH

i) Insure that the new EMS properly interfaces to the existing communications infrastructure

j) Reviewing the spare parts list to ensure that NLH receives the required amount of spare parts

5) Power System Applications Engineers

The Power System Applications Engineers will report to the Project Technical Lead. The Power Applications Engineers' responsibilities will include the following:

a) Reviewing all advanced applications documentation for custom designs (Automatic Generation Control, Network Model Builder, State Estimator, Contingency Analysis, Power Flow, Optimal Power Flow and the Operator Training Simulator)

b) Being trained in programming, system administration, and database administration

c) Developing the standards used by the database staff when building the database, displays, and reports

d) Migrating the NLH-specific applications to the new system

e) Reviewing the factory test plans and procedures for all advanced applications

f) Attending and contributing to project and technical meetings

g) Defining the power system network model for the advanced applications as well as the models required to execute the Operator Training Simulator

h) Performing factory tests

i) Attending training

j) Assisting with the commissioning all the advanced applications and Operator Training Simulator in the field.

6) Operations Personnel

System operations personnel will be needed to support the new EMS, and their responsibilities will include the following:

a) Assisting with and reviewing the design of the new full-graphics substation one-line displays and custom reports

b) Building new displays

c) Performing factory tests, focusing on the user interface (e.g., alarm presentation, tagging, and the display of results)

d) Coordination of implementation and scheduling activities associated with cutover to the new EMS

e) Support the optional OTS (if the option is selected) by participating in associated vendor training, and through the implementation and review of associated generator and relay model definitions, scenarios construction and evaluation, and acceptance testing of the OTS.

This team of NLH personnel working with the EMS consultants will provide NLH with the staff and expertise required to effectively assist the supplier in the successful implementation and installation of the new EMS.

7.13.1.2 Personnel Effort

The following table outlines the number of personnel that will be required by each of the positions identified in Section 7.13.1.1. These numbers are characteristic of the staff needed on similar sized EMS replacement projects currently in progress. Where appropriate, specific areas of responsibility are indicated within each category.

Title	# Of Persons	% Load (each)
Project Manager	1	50
Project Technical Lead	1	75
Software Engineer / Specialists SCADA, UI, System Support Facilities System, Database & Network Administration	 2 3	 75 33
Technology Architect	1	50
Power Systems Applications Engineers Generation Control/Hydro Applications Power Network Applications	 1 1	 75 75
Technical Support (Database, Display & Report Creation)	3	67
Operations Personnel	2	20
TOTAL Full Time Equivalent Personnel	**8.15**	
Plus Operations support for optional OTS	*1*	*50*

Exhibit 7.13-1 EMS Implementation Project Staffing

Several factors will affect these staffing levels, including the project scope and schedule (e.g., fast track vs. phased replacement), the ability to automatically convert databases and translate displays from the present systems, and the familiarity with operating systems and database environments to be employed by the new system. In addition, some vendors have been developing tools that automatically build the one-line displays from a CIM representation of the database.

To minimize the risk of NLH-induced delays on the project, this staff should have the EMS replacement project as its primary assignment (i.e., their work on other projects, including the existing EMS, should be secondary).

7.13.2 Permanent EMS Support Staffing Requirements

7.13.2.1 Need For A Permanent EMS Support Staff

The new state-of-the-art EMS demands continuous and on-going support from a well trained, dedicated support staff. Ideally, this staff would have been highly involved in the EMS procurement and implementation efforts. To maximize the value received by procuring a state-of-the-art EMS, a sufficiently trained support staff must be assigned to perform the following functions:

1) Preventive and corrective system maintenance (e.g., updating displays and databases as new substations are brought on-line, generate new reports that may be requested from other NLH departments and management, configure new RTUs, troubleshoot hardware problems, etc.).

2) Respond to requests from other NLH departments for EMS information (e.g., preparing reports that show peak load data or disturbance data).

3) Perform system enhancements that may be needed to meet the changing needs within NLH as well as to meet the demanding changes that will be required from deregulation.

4) Perform system upgrades to avoid system obsolescence.

5) Respond to requests from system operators for new functionality or displays to improve their visibility of the power system.

6) Perform maintenance of the power system network model and Operator Training Simulator models to maximize the operational effectiveness of the advanced application programs and the OTS.

7) Develop new functionality that is required because of changes in the operating needs of NLH.

8) Provide training to NLH EMS Operations, Operational Support Staff, and other users as appropriate.

7.13.2.2 Personnel Tasks

The following minimum staffing requirements are needed to support the on-going EMS needs:

1) EMS Manager

   The EMS manager should be well trained in the new EMS and have previous experience in working on an EMS. The EMS manager should be familiar with all aspects of EMS operations and come from an engineering background. The EMS manager responsibilities will include the following:

   a) Coordinating the efforts of the EMS support staff

   b) Scheduling and reviewing the progress of all preventive/corrective maintenance procedures

   c) Responding to requests from the system operators as well as other NLH departments

   d) Managing the security of the EMS (e.g., assigning console and user authorities)

   e) Managing all upgrades performed on the system

   f) Working closely with the Manager of Systems Operations to effectively plan and prioritize new enhancements that may be required to keep pace with NLH changing needs

g) Attending user group meetings

h) Insuring that EMS operations and operational support personnel are properly trained

2) Software Engineers / Software Specialists

It is recommend that Software Engineers/Specialists be assigned to the permanent support staff. The Software Engineers/Specialists should have degrees and/or strong backgrounds in either computer science (i.e., programming) or computer engineering. The Software Engineers/Specialists should be well trained in the use of the supplier's programming and maintenance tools, programming languages such as Fortran, C, C++, and the operating system. The Software Engineers/Specialists should be trained so that they can effectively perform all of the tasks below. The Software Engineer/Specialists' responsibilities will include the following:

a) Training and supporting the database technicians in maintaining and updating the database, displays, and reports

b) Working with system operators to ensure that any new operational needs are implemented (e.g., new displays)

c) Designing, implementing and conducting training on any new applications that are required to meet the changing needs of NLH

d) Preparing EMS data in response to a request from other NLH departments

e) Assisting the EMS Manager in updating the EMS with new software releases; attending vendor training pertaining to the new release and conduct related training for NLH personnel

f) Assisting the advanced applications engineers in maintaining the network model for the advanced applications including the OTS

3) Technology Architect / Hardware Technicians

It is recommended that a Technology Architect be assigned to the permanent support staff to look after EMS hardware and communication engineering functionality. The Technology Architect should have an engineering degree or be certified from an accredited institution. The Hardware Technicians should be cross-trained to supervise the troubleshooting of master station hardware failures as well as RTU and related communications problems. The Technology Architect and Hardware Technician's responsibilities will include the following:

a) Troubleshooting all EMS hardware and RTU problems

b) Maintaining an adequate supply of spare parts

c) Reviewing requests and performing all hardware upgrades (e.g., adding new printers, workstations, disks, PCs, etc.)

d) Troubleshooting communication problems with RTUs, communications links, and the EMS network and associated equipment

e) Participate in vendor and relevant third-party training associated with new hardware components, test equipment, etc.

4) Power System Applications Engineers

It is recommended that Power System Applications Engineers be assigned to the permanent support staff. The Power System Applications Engineers should have a degree in electrical engineering with a power system background or previous experience with power network analysis applications such as power flow and state estimator. The Power System Applications Engineers should be well trained in the EMS supplier's specific implementation of these programs. The advanced applications engineer's responsibilities will include the following:

a) Ensuring that all advanced applications (e.g., generation control, state estimator, power flow, contingency analysis, etc.) are working and the results produced are correct

b) Maintain the power system network model used by the advanced applications (e.g., define network model requirements for new substations such as transformer impedance)

c) Work with the Operator Training Instructor to define training scenarios for use in system operator training sessions

d) Maintain the Operator Training Simulator databases and models

e) Work closely with other maintenance personnel to ensure that the field measurements are accurate

f) Work closely with the system operators to ensure that operators are trained and have confidence in the use of applications

g) Design or specify any enhancements that may be required to support new requirements

h) Assist in the system upgrades to the advanced applications; attend vendor training relating to the new releases and conduct associated training for NLH personnel

This team of personnel will allow NLH to effectively maintain and support the on-going needs of the new EMS.

The following table summarizes the recommendations for the permanent EMS support staff:

Title	# Of Persons
EMS Manager	1
Software Engineer / Specialists	2
Database/Display Maintenance Support (Note that this number could increase during periods of new construction, new application development and/or EMS upgrades)	2
Technology Architect / Hardware Technician	2
Power System Applications Engineers	2
Operations Support of Optional OTS	1
Total Staffing Requirements	9-10

Exhibit 7.13-2 EMS Permanent Staffing Requirements

Note that the staffing recommendations presented here represent one organizational model. Other models can be successful. The recommendations are meant to provide a guideline of equivalent staffing levels that need to be allocated to the new EMS. Since mainstream technologies are employed within the new EMS, it has become more feasible to matrix support staff in these technologies (i.e., system, database, and network administration). However, if staff is not completely dedicated to the new EMS, one or designated team members in each category must have EMS Support as their primary mission. Cross training of a broader set of support staff would also be a requirement, as would mission rotation (to insure that unique support aspects of the system are not forgotten).

8. Implementation

8.1 Implementation Plan

This section presents an overall implementation plan for the NLH project for EMS replacement. A Gantt chart representing the overview of the proposed project activities is shown in Exhibit 8.1-1.

ID	Task Name	Start	Finish
1	Consultant Selection	Fri 11/1/02	Thu 11/28/02
2	Consultant Under Contract	Mon 12/2/02	Mon 12/2/02
3	Prepare RFI	Mon 12/2/02	Fri 12/20/02
4	Issue RFI	Fri 12/20/02	Fri 12/20/02
5	Construct RFI Evaluation Criteria	Mon 1/6/03	Fri 1/10/03
6	Vendors prepare RFI Response	Mon 12/23/02	Thu 1/23/03
7	Review RFI responses	Fri 1/24/03	Thu 2/13/03
8	Select best-qualified vendors	Fri 2/14/03	Thu 2/20/03
9	Prepare RFP	Fri 1/17/03	Thu 5/8/03
10	Issue RFP	Thu 5/8/03	Thu 5/8/03
11	Construct RFP Evaluation Criteria	Fri 5/9/03	Thu 5/15/03
12	Vendors prepare RFP Response	Fri 5/9/03	Thu 6/12/03
13	Review RFP Responses	Fri 6/13/03	Thu 7/3/03
14	Select Vendor	Fri 7/4/03	Thu 7/10/03
15	Statement of Work	Fri 7/11/03	Thu 10/2/03
16	Contract Signing	Thu 10/2/03	Thu 10/2/03
17	Implementation and Test	Fri 10/3/03	Thu 8/4/05
18	System Shipment	Fri 8/5/05	Thu 8/11/05
19	Field Installation and test	Fri 8/12/05	Thu 11/3/05
20	Final System Acceptance	Thu 11/3/05	Thu 11/3/05

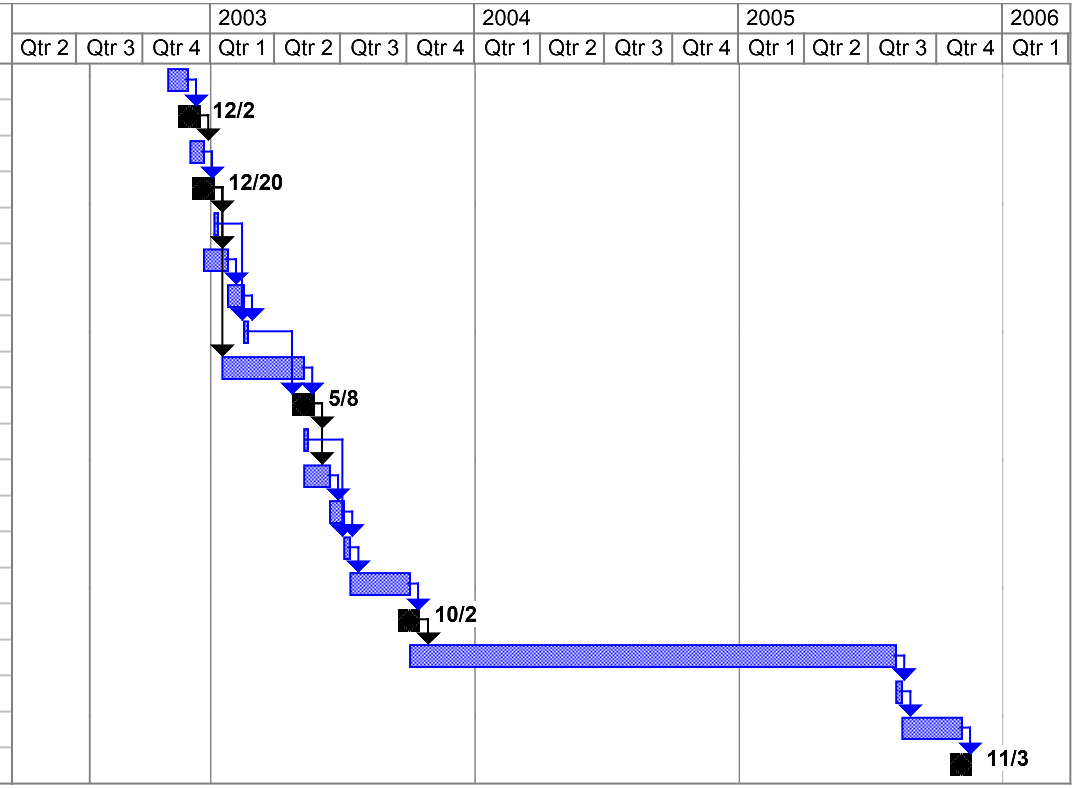


Exhibit 8.1-1 Project Overview Gantt Chart

8.1.1 EMS Procurement

This task includes the procurement of a new EMS. The following activities are included:

8.1.1.1 Specification Preparation

This two-month activity includes the finalization of functional requirements, the preparation of the new EMS specification, and final review and approval of the specifications. At the conclusion of this activity, the EMS specification is released for bidding.

The EMS specification will present firm functional requirements, sizing parameters, and performance and availability criteria. The information presented earlier in this report will be the basis for the detailed specifications. The Supplier will use existing baseline hardware and software, where this hardware and software satisfy the functional requirements, to meet the specification requirements.

During this activity, KEMA Consulting, under NLH direction, will have primary responsibility for producing the specifications for the new EMS. NLH personnel would be responsible for providing information for the specification and for final review and approval of the specification.

8.1.1.2 Supplier Pre-qualification

This two-month activity includes developing Pre-qualification documents and evaluating the potential Supplier's response to develop a best-qualified list of EMS Suppliers. This activity occurs in parallel with the Specification Preparation. The Pre-qualification document will highlight NLH requirements and request information on the EMS Supplier's baseline systems. The team will evaluate the responses against a pre-determined set of criteria to identify those EMS Suppliers that are in the best position to meet NLH functional and business requirements.

8.1.1.3 Bid Evaluation, Supplier Selection, and Contract Negotiation

This four-month activity includes the Bidder's time to prepare proposals, NLH technical and commercial evaluation of the EMS bidder proposals, selection and approval of the selected supplier, and finalization of a contract with that supplier. Achieving this schedule depends on the full availability of NLH staff assigned to this activity.

The bid evaluation will be based on the supplier's proposals and the supplier's responses to the specification and evaluation questionnaires. It is anticipated that NLH procurement rules will allow NLH personnel to conduct and witness demonstrations of the suppliers' systems as part of the evaluation process. The evaluation team will summarize the results of its evaluation of the proposals to NLH management in a bid evaluation report and presentation.

The contract with the successful supplier will consist of the specification as modified by the supplier indicating all agreed-upon deviations to the specification requirements. This contract (i.e., Statement of Work) will be used throughout the project to enforce the implementation of all functional requirements.

KEMA Consulting, under NLH direction, will be responsible for guiding and documenting the bid evaluation and contract negotiations. NLH personnel need to actively participate to ensure that NLH interests are fully addressed. NLH will be responsible for approving the selected bidder and contract documents.

8.1.2 EMS Project Implementation - Factory

This task may take from 20 to 24 months. One of the major factors in achieving the shorter schedule is the availability of NLH staff for database and display building and document review. Another factor is the applications and limited customization chosen for implementation. A third important factor, unfortunately not fully under NLH control, is the quality of the supplier's programming effort. If there are significant deficiencies in the system at the time of the factory test, NLH must require that the supplier fix the problems and retest the system. This situation will add to the length of the project schedule.

This task includes all EMS activities at the supplier's facilities and the program development activities at NLH facilities between the time the contract is signed and the time the EMS is delivered to NLH.

Activities at the supplier's facilities include equipment procurement, software design, training, integrated testing, and factory acceptance tests. Activities performed on the Program Development System at NLH facilities include database, display, and report generation as well as RTU checkout. The supplier will be required to submit functional requirements documents for its baseline software for review as well as custom design documents, detailed drawings, test plans and procedures, and an operator's manual for review and approval.

8.1.3 EMS Project Implementation - Post Delivery

Following delivery, the EMS will be installed at NLH and site acceptance testing of the new EMS will be conducted. This on-site acceptance test repeats portions of the factory acceptance tests with the EMS in its final configuration and processing data retrieved from RTUs; performing supervisory control actions, and exchanging data with other computer systems. The availability test is performed when the EMS has been turned over to the operators for daily use. Successful completion of this test, successful resolution of all variances, and final approval of all SCADA system documentation constitutes final acceptance of the new EMS. A one-year warranty period begins after final acceptance.

Detailed control center facilities planning needs to begin early so the facilities will be ready to accept the new equipment. The results of this planning need to be incorporated into a detailed transition plan document that gets written during the project implementation.

The detailed transition plan outlines the facilities work that needs to be done as a prerequisite to installing the system, plan for co-locating the new EMS with the existing systems, and the detailed plans for cutting over all the RTUs. The development of the transition plan is typically performed with assistance from the selected Supplier during project implementation several months prior to the scheduled shipment date.

8.2 Risk Analysis

This section presents the major risks associated with the new EMS project. The major risks include the following:

1) Potential for schedule delays.

2) Potential for cost overruns.

3) Potential of not purchasing a system that meets NLH needs.

While it is prudent to identify the potential risks for a project of this magnitude, it is equally important to develop risk mitigation strategies.

8.2.1 Mitigation of Schedule Delay and Cost Overrun Risk

The following methods are critical to minimizing the potential for schedule delays and cost overruns:

1) Scope Management – One of the major factors critical to achieving a rapid implementation is to curtail the number of features that require special programming effort, and accepting a solution that uses the supplier's standard approach.

2) Change Management – It is critical to the success of the project to implement a process to manage the scope changes that will occur as the project progresses. Although a detailed specification will be used to capture the requirements identified now, changes will be needed as NLH is faced with the difficult challenge of operating in a dynamic environment. NLH will need to carefully review and analyze scope changes that will be requested after the contract is signed. By prioritizing its additional needs in terms of benefits versus the impact on cost and schedule, scope can be managed effectively.

3) Staff Management – Achieving the schedule shown in this report is dependent on the availability of the NLH staff identified as being required for the work. A commitment is needed to provide this staff. Steps must be taken to ensure that the work normally done by the staff assigned to the project, including work to support the existing EMS, is done by others. The work on the new project should not be interrupted by the need for staff to attend to their current job assignments.

4) Issues Management - Many issues will arise throughout the course of the project. Issues management consists of establishing a practical decision-making process to examine the issues and bring them to successful resolutions. An action item and issues tracking mechanism can be used to monitor the status of all issues. The issues will need to be prioritized based upon the criticality of the resolution of the issue to the schedule and cost of the project.

5) Supplier Management - This consists of two major components: (1) supplier staffing and resource commitment and (2) stability of the baseline system. It is important that NLH understand the commitment of the Supplier to providing a system within NLH schedule and budgetary requirements. NLH should require committed resources that are dedicated to the NLH project. In addition, proper project implementation processes need to be established and used to ensure that NLH is satisfied with the Supplier's performance. The stability of the Supplier's baseline EMS functionality is critical to meeting the NLH schedule needs. If the baseline system is unstable, immature, or requires significant work to be stable, the chances of meeting the schedule are reduced significantly.

6) Communications Management - A project of this scope that crosses interdepartmental boundaries requires effective communications between the participants on the project. For example, the core project team will need to communicate with the communications department to ensure that the communication system interfaces correctly with the new EMS. A process to communicate issues and invoke cooperative participation with other department resources will be required.

7) Rapid Decision Making - In conjunction with issues management, the ability to quickly make decisions that are impeding the schedule is critical to delivering the system on time. Establishing a process to escalate key issues (that cannot be resolved at the project level) to upper management can mitigate this risk.

8.2.2 Mitigation of System Not Meeting NLH Needs

NLH has already undertaken the first important step in mitigating this risk by performing this detailed needs analysis study. The next step in the process will be to develop detailed specifications for those portions of NLH infrastructure that will be replaced. The detailed specifications will allow potential Suppliers to bid systems that meet the majority of NLH fundamental needs. However, no system Supplier can offer a system off-the-shelf that will meet all of NLH needs. Therefore, it is imperative that NLH identify all its needs, allow the potential Suppliers to conduct extensive demonstrations of their baseline systems, and evaluate where the Suppliers' baseline systems will need to be customized to meet NLH unique needs. If NLH is to maintain the project schedule and manage project costs, it is imperative that custom requirements be prioritized and potentially phased-in at the appropriate time. If the Supplier has an alternative method of performing a function that is different than current NLH ways, NLH should evaluate the risk of customizing the system versus accepting a baseline implementation. When performing this analysis, NLH should consider not only the initial implementation cost and risk but also the effect on the annual upgrades of the software.

8.3 Vendor Bid List

There are many vendors that could implement the new EMS for NLH. The primary system suppliers with good experience delivering systems of this nature in North America include:

- Alstom ESCA
- ABB Network Management
- GE Network Solutions
- Siemens
- Open Systems International (OSI)

A second tier of vendors that potentially could deliver an acceptable system to NLH include:

- Advanced Control Systems (ACS)
- Metso Automation
- SNC-Lavalin
- Foxboro (Invensys – currently no OTS)

The actual bid list should be limited to the four best candidates, based on the Pre-qualification evaluation.

Appendix A

ABBREVIATIONS

The following are abbreviations and acronyms used in this document:

ACE	Area Control Error
AGC	Automatic Generation Control
AOR	Area of Responsibility
API	Application Program (or Programming) Interface
APPS	Advanced Power Network Applications
BCC	Backup Control Center
BPA	Business Process Automation
CA	Contingency Analysis
CCAPI	Control Center Application Program Interface
CDN$	Canadian Dollar
CF(L)Co	Churchill Falls (Labrador) Company
CIM	Common Information Model
CME	Complete Model Estimator
CRM	Customer Relationship Management
CRT	Cathode Ray Tube
CS	Contingency Selection
CY	Calendar Year
DAC	Data Acquisition and Control
DDCL	Disturbance Data Collection and Logging
DLF	Dispatcher's Load Flow
DNP	Distributed Network Protocol (for RTUs)
EAI	Enterprise Application Integration
EBS	Emergency Backup System
ECC	Energy Control Center
ED	Economic Dispatch
EMS	Energy Management System
EOS	Equipment Outage Scheduler
EPRI	Electrical Power Research Institute
ERP	Enterprise Resource Planning
FAT	Factory Acceptance Test
ftp	file transfer protocol
GOMSFE	UCA Generic Object Models for Substation and Feeder Equipment
GPS	Global Positioning System
HVDC	High Voltage DC
HW	Hardware
ICCP	Inter-control Center Communication Protocol (TASE.2)

IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
IEEE	Institute of Electrical and Electronic Engineers
IHR	Incremental Heat Rate
IP	Internet Protocol
IS&R	Information Storage and Retrieval
IS&T	Information Systems and Telecommunications
ISO	Independent System Operator
IWR	Incremental Water Rate
kV	Kilovolt
LAN	Local Area Network
Ltrax	Lightning Tracking System
Mb	Megabyte
MCD	Momentary Change Detection
MS	Microsoft
Mvar	Megavar
MW	Megawatt
NC	Network Configurator
NLH	Newfoundland and Labrador Hydro
NP	Newfoundland Power
NUG	Non-Utility Generation
ODBC	Open Database Connectivity
OEM	Original Equipment Manufacturer
OIS	Operations Information System
OPF	Optimal Power Flow
OSI	Open Systems International, Inc.
OTS	Operator Training Simulator (also referred to as Dispatcher Training Simulator)
P&C	Protection and Control
PC	Personal Computer
PFC	Penalty Factor Calculation
PLC	power line carrier
PSS/E	Power System Simulator for Engineering (PTI Application)
PSS/O	Power System Simulator for Operations (PTI Application)
PTI	Power Technologies, Inc.
RDBMS	Relational Database Management System
RFI	request for information (prequalification)
RFP	request for proposal
RGS	Report Generation Subsystem
RPC	Remote Procedure Calls

RTSA	Real-Time Security Analysis
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
SE	State Estimator
SNAP	System Numerical and Action Package (CF(L)Co SCADA System Calculation package)
SOE	Sequence of Events
SW	Software
TASE	Telecontrol Application Service Element
TC	IEC Technical Committee
TCP	Transmission Control Protocol
TVA	Tennessee Valley Authority
UC	Unit Commitment
UCA	Utility Communications Architecture
UI	User Interface
UPS	Uninterruptible Power System
var	Volt-ampere reactive
VHF	Very High Frequency
WAN	Wide Area Network
XML	Extensible Markup Language

Appendix B

List of Transmittals

The following is a list of transmittals from NLH to KEMA Consulting. These transmittals may be referenced in the System Assessment Report and/or the completed questionnaire:

Number	Subject
H-001-2002 03 14	Hydro Organizational Charts
H-002-2002 03 18	Comments on KEMA Project Schedule
H-003-2002 03 20	IS&T Strategy
N-001-2002 03 14	Power System One-Line and Map
N-002-2002 03 14	Control Room Drawings
N-003-2002 03 14	Format and Samples of Station Drawings
N-004-2002 03 14	Telecommunication Plan
N-005-2002 03 14	Existing Communication Topology
N-006-2002 03 15	Data Exchange Descriptions
N-007-2002 03 15	Description of Real-time Calculations
N-008-2002 03 18	Display Information
N-009-2002 03 18	Communications Plan
N-010-2002 03 20	Report Descriptions
N-011-2002 03 20	Alarm Message Intensity during Disturbances
N-012-2002 03 20	Alarm Class Description
N-013-2002 03 20	RTU Summary
N-014-2002 04 12	Alarm & Events Customs ... Questionnaire# 3.8.g
N-015-2002 04 15	Suggested Interviewees
N-016-2002 04 15	APS Overview Description ... Questionnaire# 4.2.1.g
N-017-2002 04 16	Control Validation Definitions ... Questionnaire# 3.8.b
N-018-2002 04 16	Dam Breech Application ... Questionnaire# 3.8.e
N-019-2002 04 16	Disturbance Data Collection & Logging Description ... Questionnaire # 3.8.f
N-020-2002 04 16	Multiple Breaker Control & Tandem Tap Control Description ... Questionnaire # 3.8.c/d
N-021-2002 04 16	Availability and Outage Duration Statistics ... Questionnaire # 4.4.9
N-022-2002 04 16	Auto Restoration Information ... Questionnaire# 3.8.a
N-023-2002 04 18	Communication Error Report and Statistics Custom Documents ... Questionnaire 4.1.1.b
N-024-2002 04 18	System Operating Training Plan ... Questionnaire# 3.23
N-025-2002 04 18	Contingency Plan for Loss of EMS ... Questionnaire# 3.18.a
N-026-2002 04 18	Generation Dispatch (System Operating Instruction T-001) ... Questionnaire # 2.5
N-027-2002 04 18	Unit Commitment (System Operating Instruction T-074) ... Questionnaire # 3.5
N-028-2002 04 18	Generation By Unit Display ... Questionnaire# 3.6.e
N-029-2002 04 18	Load Management - Interruptible 'B' (System Operating Instruction A-013) ... Questionnaire # 3.7.c
N-030-2002 04 18	Shift Supervisor Job Description ... Questionnaire# 3.9.c
N-031-2002 04 18	Power System Maps for Interconnected & Diesel Systems and Service Areas... Questionnaire # 2.2 and 2.4
N-032-2002 04 18	Display Editor Procedures ... Questionnaire# 4.1.1.n
N-033-2002 04 18	Database Procedures ... Questionnaire # 4.1.1.m
N-034-2002 04 19	Sample Displays ... Questionnaire# 4.1.2
N-035-2002 04 19	Console AOR's ... Questionnaire 4.1.6 & 8
N-036-2002 04 19	Questions Completed To-Date
N-037-2002 04 22	LTraX Documentation ... Questionnaire # 4.1.7.a
N-038-2002 04 22	Switching Order Application Documentation ... Questionnaire # 4.1.7.a
N-039-2002 04 22	BDE Efficiency Monitoring Documentation... Questionnaire # 4.1.7.a
N-040-2002 04 22	GES and TEFO Applications ... Questionnaire# 4.1.7.a

Number	Subject
N-041-2002 04 22	Equipment Outage Application ... Questionnaire# 4.1.7.a
N-042-2002 04 23	Sample Reports ... Questionnaire # 4.1.2
N-043-2002 04 25	Mapboard Lamp Assignments Custom ... Questionnaire# 4.1.9.f
N-044-2002 04 25	Commissioning Procedure (Operations Standard Instruction 051) ... Questionnaire # 4.3.1
N-045-2002 04 26	Points Database Description ... Questionnaire# 4.3.1
N-046-2002 04 26	EMS Subsystem Overview Document ... Questionnaire# 4.2.1.a
N-047-2002 04 26	Software Modifications Database Application ... Questionnaire # 4.5.1
N-048-2002 04 26	SOE View Custom ... Questionnaire # 4.2.3
N-049-2002 04 26	SOE and A&E Data Transfer to OIS ... Questionnaire# 4.2.3
N-050-2002 04 26	Utility to maintain Integrity Between EMS Database and Points Database ... Questionnaire # 4.2.3
N-051-2002 04 26	SCADA Customs Implemented by Harris ... Questionnaire4.2.5.a
N-052-2002 04 26	EMS Subsystem Customs Implemented by Harris ... Questionnaire # 4.2.5.a
N-053-2002 04 26	APS Customs Implemented by Harris ... Questionnaire# 4.2.5.a
N-054-2002 04 26	EMS Subsystem Customs Implemented by NLH... Questionnaire # 4.2.5.b
N-055-2002 04 26	APS Subsystem Customs Implemented by NLH... Questionnaire # 4.2.5.b
N-056-2002 04 26	EMS Subsystem Customs In-Progress by NLH... Questionnaire # 4.2.5.b
N-057-2002 04 26	Questionnaire As Completed To-Date
N-058-2002 05 08	System Block Diagrams ... Questionnaire# 4.4.1
N-059-2002 05 08	EMS Performance Statistics ... Questionnaire# 4.4.4.a
N-060-2002 05 09	System Diagrams - EMS Network & Computer Room Layout... Questionnaire # 4.4.1
N-061-2002 05 10	Questionnaire As Completed To-Date