

# EXECUTIVE SUMMARY

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## INTRODUCTION

The following report summarizes work undertaken by C-MORE, including collaborations with Consortium members, since the June 5, 2012, meeting.

## CONSORTIUM MEMBER COLLABORATIONS WITH C-MORE

Since June 2012, there have been active collaborations on the following projects:

**Greater Toronto Airports Authority (GTAA):** Collaboration on two projects: optimizing low visibility lighting inspection policies and life cycle costing associated with Vammas snow removal equipment. The low visibility lighting study has resulted in significant economic benefits to GTAA through the increase of inspection intervals, while complying with Transport Canada regulations.

**Iron Ore Canada (IOC):** Addressing a critical spares provisioning question using our software SMS for IOC's pan filter spares.

**Manitoba Hydro:** Collaboration has continued on CBM of their power transformers.

**Ontario Clear Water Agency (OCWA):** Centrifuge maintenance analysis, including CBM.

**Ministry of Defence, UK, (MOD):** Tentative collaboration related to evaluating the design and maintenance of capital equipment through real options related to the comparison of the Unmanned Combat Air System and Joint Strike Fighters.

These collaborations will be discussed in detail during the meeting.

## CONSORTIUM MEMBER SUPPORT FOR RESEARCH TOPICS

**ABB, Barrick Gold, and Hydro One Networks** wrote letters of support to the Natural Sciences and Engineering Research Council of Canada (NSERC) in support of our application for three-year funding for the project "Advanced Critical Spare Parts Provisioning Models." Funding of \$88,084 per year was awarded by NSERC effective April 1, 2012.

**ENMAX Corporation, Manitoba Hydro, MOD, and Teck Resources Ltd** wrote letters of support to the Natural Sciences and Engineering Research Council of Canada (NSERC) in support of our application for three-year funding for the project "Condition-based Maintenance Optimization: Models and Software." Funding of \$88,272 per year was awarded by NSERC effective June 17, 2010.

## **KNOWLEDGE SHARING AMONGST CONSORTIUM MEMBERS**

As stated in our flyer and on our webpage, one of the benefits of Consortium membership is “networking with companies at leading edge of maintenance practice.” It is therefore pleasing to report the following two recent collaborations between Consortium members:

**Barrick Gold and Teck:** Development of an asset management manual.

**OPG and Teck:** Detailed review of OPG’s Work Management process.

## **ADDITIONAL FINANCIAL SUPPORT TO C-MORE**

### **AUTO 21**

In partnership with Professor Francois Bellavance at HEC Montreal, Dr. Pierro Hirsch from Virage Simulation of Montreal, and colleague Professor Birsen Donmez at the University of Toronto, we have funding from AUTO21, a federal funding program for sustainability initiatives in the automotive industry. Funding is \$86,000 per year for two years and will support a postdoctoral fellow and two graduate students. The project title is “The Driving Simulator-Based Eco-Driving Training Program.” The project involves measuring the effectiveness of simulator-based training of commercial drivers in eco-driving techniques.

### **NSERC ENGAGE**

In partnership with General Motors Canada, we received funding of \$25,000 to support an initial six month collaboration titled “Optimal Maintenance Policies for Mobile Assets.” The research project seeks to develop a set of sound analytical methods to optimize repair and replacement decisions for mobile assets.

### **COLLABORATIVE HEALTH RESEARCH PROJECTS (CHRP)**

The three-year CHRP-funded project on breast cancer screening commenced May 2011 is in collaboration with physicians at the Dalla Lana School of Public Health. The goal of the research is to assist clinicians identify women at high risk of breast cancer and provide them an opportunity for screening intervention. Funding is \$411,638 over 3 years

### **BOMBARDIER COMMERCIAL AIRCRAFT**

Bombardier has confirmed its intention to continue collaboration with C-MORE, in partnership with MITACS, on the project “Resource Planning to Schedule the Maintenance Tasks in Bombardier.”

## **NEW POSITION IN RELIABILITY**

This position at the University of Toronto was announced at the June 2012 meeting by Professor Jean Zu, Chair of the Mechanical and Industrial Engineering Department. The closing date for applications is November 30 and an update on the status of the search will be provided at the Consortium meeting.

The successful candidate should have a background in stochastic operations research with substantial exposure to statistics. Applicants must have a doctoral degree in engineering (or related discipline), an outstanding academic and research record including refereed publications, and effective teaching ability. The candidate should have an undergraduate degree in engineering and be eligible for registration as a Professional Engineer. The Department expects to nominate the successful candidate to hold an NSERC Associate Industrial Research Chair (IRC). Associate IRC candidates should be researchers in the early stages of their careers who have demonstrated exceptional promise relative to their peers in their field of research. An IRC is also required to have the ability to interact with industry and nurture partnerships.

## **C-MORE STAFF AND STUDENTS**

### **POSTDOCTORAL FELLOWS**

Dr. Sharareh Taghipour accepted a position as Assistant Professor at Ryerson University's Department of Mechanical and Industrial Engineering, effective August 1, 2012.

Dr. Hossein Mohammadian joined Toronto Transit Commission for a nine-month contract to work on inspection policies for tracks, effective November 12, 2012.

Dr. Yasin Gocgun was welcomed on September 1, 2012. He will be with us for two years and will be working on Statistical/Mathematical Modeling for Breast Cancer Screening, continuing the work undertaken by Dr. Taghipour. Yasin joins us from The University of British Columbia's Sauder School of Business.

### **STUDENTS**

In September 2012, we welcomed four new graduate students:

- Laurent Caudrelier. Laurent joins us from McGill University where he recently completed his degree in Mechanical Engineering. Laurent joins our breast cancer screening and risk modeling research group to further contribute to this crucial topic.
- Clayton Van Volkenburg joins us from the Department of National Defence. He is on secondment for two years. Clayton, a graduate of the Royal Military College of Canada, is a Major in the Electrical and Mechanical Engineering Branch with responsibilities for the Tracked Light Armoured Vehicles group. His research interests include modeling the maintainability of combat vehicle systems.
- Erik Tryggvi Striz Bjarnason joins us from Rio Tinto Alcan Iceland. Erik is a graduate of The University of Iceland with degrees in Industrial Engineering and Mathematics. Erik's work will focus on joint optimization of spare parts provisioning and preventive maintenance policies.
- Stephan Trusevych joins us from Hatch Limited where he was a site engineer. He is a graduate of Queen's University in Mathematics and Engineering. Stephan will be studying asset management policies for large electrical transformers. He is working on

methods of incorporating financial risk into transformer spares policy, to hedge against the financial losses faced by industrial sites following critical transformer failure.

Three graduate students will present at today's meeting:

- Janet Sung will speak on her collaboration with Consortium member Ontario Clean Water Agency on the topic of "OCWA Centrifuge Maintenance Analysis Project: An Update."
- Stephan Trusevych will discuss "Manitoba Hydro: CBM of Power Transformers – Classification of Maintenance Records." Stephan will also speak on "My background at Hatch and research interests on spare transformers."
- Laurent Caudrelier will speak on "My background, and research interests in CHRP."

#### **RESEARCH BY C-MORE LAB STAFF**

Our Project Director, Dr. Dragan Banjevic, has continued collaboration with Manitoba Hydro on CBM for power transformers, with help of Stephan Trusevych, our new graduate student. In this period, the focus was on classification of maintenance events (failures, repairs, etc.) into classes by severity, urgency, etc. Dragan was also very active on the CHRP project, as well as the collaborations with OCWA and GTAA, along with giving guidance to doctoral students Maliheh Aramon and visiting student Xinbo Qian.

Neil Montgomery has continued his work collaborating with Consortium members. He worked with Dragan and Hossein on the GTAA low visibility lighting system project and the VAMMAS snow clearing equipment dataset. Neil also worked on the CHRP project. He has begun altering the spares simulation code to allow for dependencies between component failures. Neil continued to provide general support to C-MORE graduate students working on their research projects.

Dr. Daming Lin worked on the recovery of the SMS V1.40 code and developing new features for SMS. He completed an NSERC Engage project collaboration with GM Canada on preventive replacement of mobile equipment. He also prepared an NSERC CRD proposal on a collaborative research program between C-MORE and GM Canada in the areas of preventive maintenance, fleet size determination, and condition-based maintenance implementation. Finally, Dr. Lin submitted an NSERC Engage proposal for collaboration between C-MORE and Oliver Interactive Inc. to develop a potential marketable software product for operations people without sufficient reliability background to perform common reliability analysis and maintenance optimization tasks.

#### **SOFTWARE**

##### **SPARES MANAGEMENT SOFTWARE (SMS)**

We have continued the development of our spares management software SMS and the simulation procedures for computationally intractable spare parts models. Neil Montgomery is working on the incorporation of dependent component failures and preparing on a more user-friendly release version for Consortium members. Daming Lin is continuing the development of

SMS v2.0 with enhanced data entry and reporting features. The old SMS v. 1.40 now works on Windows 7.

#### **AIRPORT AIRFIELD LIGHTING INSPECTION SOFTWARE**

- **Software for GTAA:** Hossein Mohammedian completed comprehensive software for airfield lighting inspection interval optimization for GTAA. The software includes facilities for organizing, mapping, and selecting groups of lights. It estimates light reliability and the probability that the lighting systems meet regulations.
- **Lighting System Builder:** Hossein subsequently worked on software that will allow an airport user to build and customize its own airfield lighting system configuration. This will allow other airports to more easily apply our results to their own situations.

#### **C-MORE EDUCATIONAL PROGRAMS**

Dr. Ali Zuashkiani has continued in his role as Director of Educational Programs with responsibility for developing various knowledge transfer activities through both new Physical Asset Management Certificate programs and our regular International Maintenance Excellence Conference (IMEC). The objective is to combine high quality content delivered by leading instructors with the academic rigour of the University of Toronto.

Notably, the most recent course, the eight-day Certificate program in Physical Asset Management program held November 5-9 and 12-14 was a success, with 16 participants coming from across Canada, and from as far away as Bolivia and Sweden.

#### **THE INTERNATIONAL MAINTENANCE EXCELLENCE CONFERENCE (IMEC): THE ASSET MANAGEMENT CONFERENCE**

IMEC took place on November 20-21, 2012, and was the eighth edition of this annual event. This year, IMEC was jointly run with MainTrain, Canada's largest annual peer-developed maintenance, reliability and asset management conference. MainTrain is developed by PEMAC (Plant Engineering and Maintenance Association of Canada). Details at [www.imec.ca](http://www.imec.ca).

#### **THE C-MORE TEAM**

We continue to have an excellent team of C-MORE staff and students. All are excited about our ongoing and new research activities. We can't say it often enough: the continuation of such activities requires close collaboration and frequent contact with Consortium members. We value what has been achieved and are confident that we can maintain the support of members through the hard work and dedication of our staff and students.



November 26, 2012