

# EXECUTIVE SUMMARY

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## INTRODUCTION

The following report summarizes work undertaken between Consortium members and C-MORE since the April 28, 2009 Consortium meeting on the project *MORE (Maintenance Optimization and Reliability Engineering): CBM (Condition-Based Maintenance) and Beyond*.

## WELCOME TO NEW MEMBER

It is a pleasure to welcome to this Consortium meeting our newest member: Ontario Clean Water Agency (OCWA).

Those who attended our April Consortium meeting will remember meeting our guest George Terry, the VP of Asset Management at OCWA.

Here is some brief information about OCWA:

The Ontario Clean Water Agency (OCWA) is a Crown Agency of the Province of Ontario in the business of providing safe and reliable clean water services. In fact, OCWA provides clean water management services to more communities than any other water and wastewater service organization in Ontario.

OCWA is the service partner of choice in Ontario, serving some 180 Ontario clients of all sizes, commercial, industrial and institutional water and wastewater system owners, as well as cross-jurisdictional boards where water and wastewater services are shared. OCWA is proud to provide clean water to more people than any other water and wastewater service organization in Ontario.

Full details of OCWA are at [www.ocwa.com](http://www.ocwa.com).

## C-MORE STAFF AND STUDENTS

**STUDENTS:** Since our April 28 meeting PhD student Tanya Tang was successful on September 14 with her PhD Thesis Seminar on “*Failure finding interval optimization for periodically inspected repairable systems*”. Corey Kiassat successfully defended his first year Ph.D. proposal at his qualifying exam on November 18, 2009. His topic was “*Influence of Human-Related Factors on Reliability and Maintenance Optimization*”.

Visiting doctoral student Domenico Centrone from the Department of Management, Economics and Industrial Engineering, Politecnico di Milano, Italy, returned to Italy at

the end of July after 4 months with us. His research interest is “*Condition Improved Reliability Analysis (CIRA)*.”

We were delighted to welcome a new Ph.D. student in September, Maliheh Aramon, from the University of Tehran, who is working under the supervision of Professor Chris Beck in the general area of scheduling in the context of asset management.

This afternoon we will have 4 presentations by graduate students:

- *Industrial scheduling problems* by Maliheh Aramon
- *CBM for linear assets* by Will Luff
- *Recent results on human reliability research* by Corey Kiassat
- Optimization of inspection schedule for equipment subject to condition monitoring by Janet Sung

**C-MORE LAB STAFF AND POST DOCTORAL FELLOWS (PDF):** Our Project Director, Dr. Dragan Banjevic, has continued the development of procedures for the extraction of experts’ knowledge with Dr. Zuashkiani’s support; continued working on the remaining useful life problem; collaboration continued with Manitoba Hydro on CBM for power transformers with PhD candidate Lorna Wong; collaborated with Dr. Safaei on scheduling problems and Neil Montgomery on case studies; working on development of new procedures for SMS software and collaborating in its implementation. Neil Montgomery continues his involvement in his primary activity of collaboration with supporting companies, especially Teck Resources, TransCanada, and UK Ministry of Defence. Dr. Daming Lin continues his support of PhD student Tanya Tang on her failure finding interval research. Our software developer Frank Pirillo has been working on our Spares Management Software (SMS) to enable it to have the ability to import external data to SMS, along with batch calculation and reporting

PDF Dr. Ali Zuashkiani’s research has continued on the topic of Maintenance Performance Management. He was deeply involved during most of the summer in organizing IMEC 2009 jointly run by C-MORE and Maintenance Technology Magazine. He is also busy managing C-MORE’s educational programs including visits to Rail Transit Authority of Dubai and Dubai Airport and establishing a training program for Newmont Gold’s Yanacocha mine in Peru. PDF Dr. Nima Safaei continues his extensive collaboration with ArcelorMittal Dofasco on their maintenance workforce dynamic scheduling problem; and also with Hydro One Networks and the Ministry of Defence on maintenance scheduling problems. Resulting from his Arcelor Mittal Dofasco work he has developed software for handling the Dofasco’s workforce dynamic scheduling problem that will be presented at this meeting. PDF Dr. Behzad Ghodrati continues his work to merge the both internal and external influencing factors (covariates) on machine reliability characteristics to estimate the actual hazard (failure) rate. This helps to more realistically calculate the optimal number of required spare parts. He also supervised a final year undergraduate engineering thesis, “Optimizing Unilever’s Capital/Emergency Spare Stock Sizes.”

## **SOFTWARE**

I am very pleased that Version 2.0 of our SMS software used to optimize the stockholding of slow-moving spares according to 4 different criteria will be delivered to Consortium members today. The main features of Version 2.0 are its ability to import external data to SMS and undertake batch calculation and reporting.

## **C-MORE ACTIVITIES**

C-MORE has been busy during the April-November 2009 period, participating in conferences and meeting with consortium members. C-MORE is currently involved in the following projects with our industry partners:

- Ministry of Defence: *Gearbox CBM*
- ArcelorMittal Dofasco: *Workforce dynamic scheduling & investigating the effectiveness of the preventive maintenance of thickness gauges*
- Teck Cominco: *Spares provisioning for a 7-out-of-8 system of thickener rake drives in which the drives are not interchangeable*
- Hydro One Networks: *Maintenance crew scheduling*
- Manitoba Hydro: *CBM of power transformer fleet*
- TransCanada Pipelines: *Applications of SMS and optimizing inspection intervals.*

## **C-MORE RESEARCH NODE IN UNITED ARAB REPUBLIC**

Discussions are continuing with Road and Transport Authority, Dubai, and Dubai Airports regarding the establishment of a node of C-MORE in Dubai. An initial meeting with interested organizations took place in Dubai on May 22.

## **C-MORE EDUCATIONAL PROGRAMS**

I am very pleased that Dr. Ali Zuashkiani has continued in his role as Director of Educational Programs with responsibility for developing various knowledge transfer activities through both new Master Classes 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.

## **MASTER CLASSES**

The Master Classes are designed to provide practitioners with first-hand knowledge to make them more effective in their workplaces in a short period of time through an intensive, interactive training environment.

April 12-16, 2010: Mini-PAM (a 5-day course on Physical Asset Management being held at the University of Toronto)

**THE INTERNATIONAL MAINTENANCE EXCELLENCE CONFERENCE (IMEC): THE ASSET MANAGEMENT CONFERENCE. SEPTEMBER 22-24, 2010**

We are delighted that this year we are again working with Applied Technology Publications (ATP) as our media partner for IMEC-The Asset Management Conference, ([www.IMEC.ca](http://www.IMEC.ca))

We believe that this agreement formalizes a mutually beneficial partnership that connects C-MORE's leading research and training in the area of asset management with the vast marketing and industry reach of ATP, a respected publisher of high-quality information for asset management practitioners in North America.

**NEW RESEARCH FUNDING SUBMISSION**

The Collaborative Research and Development (CRD) Grant application on, “*Advanced models, applications, and software for Condition-Based Maintenance,*” at the level of \$264,816 over a 3 year period (\$88,272 per year) was submitted to the Natural Sciences and Research Council (NSERC) on November 11, 2009. Professor Baris Balcioglu is the co-investigator on this project. This submission would not have been possible without the support of consortium members **ENMAX, Manitoba Hydro, Ministry of Defence** and **Teck Resources** who confirmed to NSERC their support of the research program.

**NEW RESEARCH FUNDING PROPOSAL**

Our Ontario Centres of Excellence – Centre for Materials and Manufacturing 3-year grant will end on March 31, 2010. A new proposal for continuing support from OCE-CMM is presently being developed. The overall thrust of the submission will be Evidence Based Asset Management Decision-making. This will be achieved through collaboration with colleagues in the following areas:

Condition based Maintenance: Dragan Banjevic and Neil Montgomery

Failure finding intervals for protective devices: Dragan Banjevic and Daming Lin

Critical spares provisioning: Prof Baris Balcioglu

Maintenance scheduling: Prof Chris Beck

Human reliability: Andrew Jardine

**THE FUTURE**

We continue to have an excellent team of C-MORE staff and students. All continue to be excited about the future development of our research activities. As is always stressed, to continue such activities requires continuing close collaboration and contact with consortium members. We value what has been achieved and are confident that we can maintain the support of members through the excellent staff and students committed to the research program funded by members, OCE, and NSERC.

Andrew K S Jardine

November 23, 2009