CENTRE FOR MAINTENANCE OPTIMIZATION AND RELIABILITY ENGINEERING

CONSORTIUM MEETING AGENDA

December 7, 2010: 9:00am–4:00pm, Hydro One, Toronto

WELCOME 10 minutes	Jose Costa, Project Manager, OCE-CMM Andrew Jardine, C-MORE Director
EXECUTIVE SUMMARY 20 minutes	Andrew Jardine
OCE/COMPANY COLLABORATIONS 5 minutes	Jose Costa
BATTERY QUARTERLY MAINTENANCE 10 minutes	Ken Sutton, OPG, Neil Montgomery, C-MORE
EXAKT AT HYDRO ONE – update 20 minutes	Bo Ji, Dhruv Patel Adrian Eng, Caitlyn Daly Hydro One
COLLABORATIONS WITH CONSORTIUM MEMBERS 90 minutes	
Ministry of Defence, UK MOD Gearbox CBM – with Tim Jefferis Trans Canada An inspection problem with redundancy - Air Compressors – with Dario Stojanac and Stephane Lefebvre Teck Wheel motor spare parts problem - failures, age replacements, steady state – with David Williams	Neil Montgomery, C-MORE
Manitoba Hydro CBM of power transformers - an update Reliability growth control chart of power generating units	Dragan Banjevic, Sharareh Taghipour, C-MORE Wendelin Schuhmann, Tony Pavlicic, Manitoba Hydro

Barrick Progress report on bay size optimization	William Luff, C-MORE
LUNCH	
ESTABLISHING NSERC INDUSTRIAL CHAIR TO C-MORE 15 minutes	Jennifer Lancaster Senior development officer, Major Gifts, U of T
MAINTENANCE SCHEDULING PROJECT WITH BOMBARDIER 10 minutes	Nima Safaei, C-MORE
DEVELOPING RESEARCH INTERESTS WITH STUDENTS 70 minutes	
Industrial scheduling problems – progress report	Maliheh Aramon, C-MORE
Optimization of inspection schedule for equipment subject to condition monitoring - progress report	Janet Sung, C-MORE
Optimum Inspection Interval for a System Under Periodic and Opportunistic Inspections - progress report	Sharareh Taghipour, C-MORE
Interpreting dissolved gas analysis in maintenance of power transformers	Lorna Wong, C-MORE
NEXT STEPS – NEW OCE PROPOSAL FOR 2010-2012	Jose Costa Andrew Jardine

EXECUTIVE SUMMARY

ANDREW K. S. JARDINE, C-MORE DIRECTOR

INTRODUCTION

The following report summarizes work undertaken between Consortium members and C-MORE since the June 15, 2010 Consortium meeting on the project *MORE (Maintenance Optimization and Reliability Engineering): CBM (Condition-Based Maintenance) and Beyond.*

C-MORE STAFF AND STUDENTS

STUDENTS:

Since our June 15 meeting, PhD student Janet Sung passed her PhD Qualifying exam in October 5, 2010. Presentation title was: "*Non-Periodic Inspection Intervals for Condition-Based Maintenance*."

On November 2, PhD student Maliheh Aramon, supervised by Professor Chris Beck, passed her PhD qualifying exam: presentation title was: "*Studies on Modifying Tactical Maintenance Decisions on an Operational Level"*

Lorna Wong and Corey Kiassat were successful with their doctoral thesis seminars on September 27 and October 5 respectively.

Visiting doctoral student Yuan Yang from the School of Electrical Engineering, Beijing Jiaotong University, returned to China at the end of June after six months with us. Her research topic is: "RAMS Evaluation Theory and Its Application In the Traction Power Supply System of High-speed Railway."

This afternoon we will have four progress reports by graduate students:

- Industrial scheduling problems by Maliheh Aramon
- An inspection model for a system subject to hidden failures by Sharareh Taghipour
- Optimization of inspection schedule for equipment subject to condition monitoring by Janet Sung
- Interpreting dissolved gas analysis in maintenance of power transformers by Lorna Wong

C-MORE LAB STAFF AND POST DOCTORAL FELLOWS (PDFS):

Our Project Director, Dr. Dragan Banjevic, has continued collaboration with Manitoba Hydro on CBM for power transformers with PhD candidate Lorna Wong. He also continued collaboration with Manitoba Hydro on reliability growth of power generating units (with Tony Pavlicic) with active support from PhD candidate Sharareh Taghipour. Current focus is on creating control charts for reliability growth. As always Dr. Banjevic collaborated as appropriate with all members of the C-MORE Lab.

Neil Montgomery continues his involvement in his primary activity of collaboration with supporting companies: he provided support and commentary for the ongoing EXAKT modeling being done by Hydro One staff; he worked on a new spares problem from David Williams at Teck; UK MOD gearbox CBM study is nearing completion; he is working with Dario Stojanac and Stephane Levebvre from TransCanada on the air compressor inspection interval problem. Like Dragan, Neil also provides general support to C-MORE graduate students and undergraduate students working with us on various projects.

PDF Dr. Ali Zuashkiani's completed his PDF position, and we welcomed him to his new position as a Research Associate effective September 2010. Ali has been continuing his research endeavors in Maintenance Performance Management in addition to being deeply involved during most of the summer in organizing IMEC 2010, jointly run by C-MORE and Maintenance Technology Magazine. He was also busy managing C-MORE's educational programs including a 12 day program at Newmont Gold's Yanacocha mine in Peru and finalizing an Agreement with Keyano College in Fort McMurray to offer several workshops on the topic of Evidenced Based Asset Management.

PDF Dr. Nima Safaei worked extensively on a collaborative project proposal "Resource Planning to Schedule the Maintenance Tasks in Bombardier." We were delighted on November 25 when it was officially announced he had received funding for two years from the MITACS Postdoctoral Research Projects program to enable a collaboration to commence with Bombardier Commercial Aircraft. The important cash contribution from Bombardier was a requirement in the assessment process by MITACS.

PDF Dr. Behzad Ghodrati completed his two-year tenure with us and returned in July 2010 to Sweden to his position at Lulea University's Division of Operation and Maintenance Engineering. During his time with us, Behzad worked on the analyzing of the effects of operating environment (covariates) on system reliability characteristics and on product support requirements and spare parts need.

SOFTWARE

I am very pleased that Zheng Wang a fourth year Statistics specialist student is being supervised by Dragan and Neil for a full year 2010-2011 supervised reading course. The plans are to have him implement in the R programming language much of the mathematical modelling now in EXAKT, to be used for testing EXAKT. The plan is also to develop software for simulating failure data with covariates, again to be used for testing.

C-MORE ACTIVITIES

C-MORE has been busy during the June – December 2010 period participating in conferences and meeting with consortium members. C-MORE is currently involved in the following projects with our industry partners:

- UK Ministry of Defence: *Gearbox CBM*
- Teck: *Wheel motor spare parts problem - failures, age replacements, steady state*
- Teck: *A reliability estimation problem for pipelines*

- Hydro One Networks: *EXAKT at Hydro One*
- Manitoba Hydro: *CBM of power transformer fleet*
- Manitoba Hydro: *Reliability growth control chart of power generating units*
- Barrick: *Progress report on bay size optimization*
- TransCanada Pipelines: *An inspection problem with redundancy - Air Compressors*
- Ontario Power Generation: *Battery Quarterly Maintenance*

In terms of our knowledge transfer activities, we have been very successful with the acceptance of research papers during the past year, with ten published or accepted for publication. Additionally we have seven submitted to journals, and four appeared in conference proceedings. There have been 23 conference presentations during the past 12 months, and already we have four conference abstracts/ papers submitted for 2011.

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. In 2011 we have one Master Class scheduled:

> March 7 – 11, 2011: Mini-PAM (a 5-day course on Physical Asset Management being held at the University of Toronto)

INTERNATIONAL MAINTENANCE EXCELLENCE CONFERENCE (IMEC): THE ASSET MANAGEMENT CONFERENCE, OCTOBER 5-7, 2011:

We are delighted that in 2011, we are again working with Applied Technology Publications (ATP) as our media partner for IMEC-The Asset Management Conference (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.

INTERNATIONAL MAINTENANCE EXCELLENCE CONFERENCE (IMEC) 2010:

The Centre for Maintenance Optimization and Reliability Engineering (C-MORE) and Applied Technology Publications co-organized this year's International Maintenance Excellence Conference (IMEC) held in Toronto, from September 21 to 24. This marked the sixth edition of the annual event which hosted approximately 100 participants from South Africa, USA, Canada, Sweden, UK, the Netherlands, Peru, and Chile.

As always, there was a good blend of academics and asset management professionals. At this international conference, top industry and academic experts present conference themes from two perspectives: professional maintenance practice and maintenance science research. IMEC is structured to encourage dialogue and collaboration between these two communities, enhancing the performance of both.

Canadian companies attending included: AVEOS (formerly Air Canada Technical Services); Ontario Clean Water Agency; IBM; Cetaris; Lanxess; Nova Steel; Hydro One Networks; Barrick Gold; Teck; ValeInco. Academics were from: Chalmers University of Technology, Sweden; Catholic University of Chile; VPI and State University, USA; University of Pretoria, South Africa; University of Tennessee; University of Toronto. C-MORE students, post-doctoral fellows, and researchers did a great deal of work, both behind the scenes and presenting work at the conference.

NEW RESEARCH FUNDING SUBMISSION

A Collaborative Research and Development (CRD) Grant application to NSERC on "*Developing theories as the base and software applications as tools to find optimal spare parts provisioning strategies for systems requiring certain levels of reliability and/or availability*" is at the final stages of submission. Professor Baris Balcioglu is the co-investigator on this project. We look forward to four Consortium members writing to NSERC to support this submission. (Note: Our 2010-awarded CRD related to CBM was supported by consortium members **Enmax, Manitoba Hydro, Ministry of Defence** and **Teck Resources.**

A submission to OCE is also close to being finalized. The title is: "*Development of novel models for critical spare parts procurement decision-making to extend the prototype Spares Management Software*." This submission requires support from Consortium members

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 30, 2010