
**CENTRE FOR MAINTENANCE OPTIMIZATION AND RELIABILITY
ENGINEERING SEMIANNUAL CONSORTIUM MEETING**

**MAINTENANCE OPTIMIZATION
AND RELIABILITY ENGINEERING
CONDITION-BASED MAINTENANCE
AND BEYOND**

DIRECTOR
Professor Andrew K. S. Jardine

REPORT

Tuesday April 28, 2008
9:00 a.m.–4:00 p.m.

HILTON GARDEN INN
OAKVILLE, Ontario

DEPARTMENT OF MECHANICAL AND INDUSTRIAL ENGINEERING
UNIVERSITY OF TORONTO
ROOM 206, ROSEBRUGH BUILDING
5 KING'S COLLEGE ROAD
TORONTO, ONTARIO, CANADA M5S 3G8
T: +1 (416) 978-2921 F: +1 (416) 946-5462
www.mie.utoronto.ca/cmore

EXECUTIVE SUMMARY

ANDREW K. S. JARDINE, C-MORE DIRECTOR

INTRODUCTION

The following report summarizes work undertaken between Consortium members and C-MORE since the October 21, 2008 Consortium meeting on the project *MORE (Maintenance Optimization and Reliability Engineering): CBM (Condition-Based Maintenance) and Beyond*.

NEW RESEARCH FUNDING SUBMISSION

In April 2009 the University signed off on our new submission to the Natural Sciences and Research Council (NSERC) that they would fund our proposal titled, “*Advanced models, applications, and software for Condition-Based Maintenance*.”, at the level of \$ 264,816 over a 3 year period (\$ 88,272 per year). Professor Baris Balcioglu is the co-investigator on this project. This would not have been possible without the support of consortium members **Manitoba Hydro, XEROX, Ministry of Defence and Enmax** who confirmed to NSERC their support of the research program.

C-MORE STAFF AND STUDENTS

Students: Since our October 21 meeting MAsc student Kelly Kinahan graduated in November having successfully defended her thesis “*Machine Interference Models: An Investigation into Non-Markovian Failure and Repair Models*.” under the supervision of Professor Balcioglu. Corey Kiassiat was granted fast tracking from the M A Sc program to the PhD program. Pedram Sahba and Lorna Wong both successfully defended their first year PhD proposals at their qualifying exams on February 27, 2009 and March 4, 2009 respectively. Their topics were “*Strategies for a Spare Part Provisioning Problem*” and “*Remaining Useful Life of Repairable Systems Subject to Condition Monitoring*” respectively. Sharareh Taghipour (PhD Candidate) successfully defended her 2nd year research progress report on “*Risk-based inspection and maintenance for medical equipment*” on March 20, 2009.

We are pleased to be hosting Domenico Centroneas a visiting doctoral student for a period of 4 months. Domenico is from the Department of Management, Economics and Industrial Engineering, Politecnico di Milano, Italy. His research interest is “*Condition Improved Reliability Analysis (CIRA)*”

We expect one new student to join us in September, Maliheh Aramon Bajestani, from the University of Tehran who will work 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:

- *Human Reliability* by Corey Kiassiat
- *Risk-based maintenance of medical devices at Toronto General Hospital* by Sharareh Taghipour
- *Repair shop centralization that was motivated by ValeInco* by Pedram Sahba
- *Multi-component repair shop scheduling policies* by Robert Svaluto

C-MORE Lab staff and Post Doctoral Fellows (PDFs): In November 2008 we welcomed Francesco Pirillo, as our new Software Developer and earlier this month we welcomed Elisabeth Thompson as our new Administrative/Research Assistant. Our Project Director, Dr. Dragan Banjevic, has continued the development of procedures for extraction of experts' knowledge, with Ali's support, and new features for SMS. And his work continues on the remaining useful life problem, in collaboration with students. Neil Montgomery continues his involvement in his primary activity of collaboration with supporting companies. Dr. Daming Lin continues research in developing standardized software enabled process and prototype software that adds significant, unique value to physical asset management across all industrial sectors. He is also working with PhD student Tanya Tang on a failure finding interval research paper.

PDF Dr. Ali Zuashkiani's research has continued on improving the knowledge elicitation technique that he developed during his PhD. The new method has been designed and applied to a gas distribution company. In addition he is working on the topic of Maintenance Performance Management and is currently collecting practical and interesting KPIs which exist in the public domain and also from companies who are willing to share theirs. PDF Dr. Nima Safaei continues his research interests in solving complex combinatorial optimization problems and continues an 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. PDF Dr. Behzad Ghodrati continues to pursue his research interests in the field of spare parts estimation based on the reliability characteristics of a machine and its operating environment

SOFTWARE

I am very pleased that today a version V1.4 of our SMS software used to optimize the stockholding of slow-moving spares according to 4 different criteria will be delivered to Consortium members. There are new options implemented in SMS for cost calculations when dealing with non-repairable spares. The new options allow users to choose between emergency replacement and downtime when faced with the decision to replace a part. This has been implemented for both finite and infinite population cases, however in the finite case the option is implemented for constant arrival rate. The non-constant rate will be implemented in a future version.

C-MORE ACTIVITIES

C-MORE has been busy during the October 2008 – April 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*
- Arcelor Mittal Dofasco: *Workforce dynamic scheduling*
- 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*
- Ministry of Defence: *Spares requirements before the steady state*
- Manitoba Hydro: *CBM of power transformer fleet*

EUROPEAN INITIATIVE ON "M4SM" (Maintenance for Sustainable Manufacturing)

C-MORE has accepted an invitation to be become a partner in this new initiative. Fuller details will be provided in a session this afternoon.

C-MORE RESEARCH NODE IN UNITED ARAB REPUBLIC

Due to the initiative of Mr. Ali AbdulQader, Director of Rail Maintenance, Road and Transport Authority, Dubai, we are exploring the possible establishment of a node of C-MORE in Dubai. An initial meeting with interested organizations will take place in Dubai on May 22.

C-MORE EDUCATIONAL PROGRAMS

I am very please 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. The following have been held:

- Uptime - Strategies for Excellence in Maintenance Management: December 8-9, 2008
- Reliability Centred Maintenance – foundations for improving asset performance: March 16-17, 2009
- Maintenance Parts Excellence program: April 20-21, 2009

Future ones scheduled are:

- Optimizing maintenance decisions to achieve excellence in physical asset management: May 25-26, 2009
- Benchmarking - Analytical approach to achieve world class reliability and maintenance excellence: June 22-23, 2009

The International Maintenance Excellence Conference (IMEC): THE Asset Management Conference. September 9-11, 2009

We are delighted that this year we are partnering with Applied Technology Publications (ATP) to partner on future educational and developmental opportunities. The first event on which the partners will collaborate is IMEC – The Asset Management Conference, (www.IMEC.ca), scheduled for September 9-11, 2009, in Toronto. We believe that this newly announced 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.

ANNUAL REVIEW OF RESEARCH PROGRAM: Year 2.

As required by OCE-CMM we are required to have an annual review. The Year 2 Report submitted is provided in Appendix G. It addresses the following topics:

1. Original Objectives of the project
2. Any changes to the objectives, and why that was necessary
3. Progress against milestones focusing on research results
4. Milestones for the forthcoming 12 months
5. The nature and extent of industrial participation, including a forecast for the coming year
6. The nature and training of HQP
7. Intellectual property aspects
8. Impact of the project/partnership on the industrial partner

THE FUTURE

We continue to have an excellent team of C-MORE staff and students. All are 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
April 21, 2009