

EXECUTIVE SUMMARY

ANDREW K. S. JARDINE, C-MORE DIRECTOR

INTRODUCTION

The following report summarizes work undertaken between Consortium members and C-MORE since the December 6, 2011, meeting.

NEW POSITION IN RELIABILITY

It is excellent news that the Department of Mechanical and Industrial Engineering is currently inviting applications for a tenure-stream appointment in the area of reliability and maintenance. The appointment will be at the rank of Assistant or Associate Professor, and will begin on July 1, 2013.

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.

NEW RESEARCH FUNDING

AUTO 21

I am pleased to report that in partnership with Professor Francois Bellavance at HEC Montreal, Dr. Pierro Hirsch from Virage Simulation of Montreal, Fleet Challenge Ontario and colleague Professor Birsen Donmez, we have been accepted for funding by AUTO21, a federal funding program for sustainability initiatives in the automotive industry. Doctoral student Corey Kiassat played a key role in setting up the proposal, and Andrew Jardine is Lead Investigator.

Funding is \$86,000 per year for two years and will support a post doctoral 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.

Surface transportation is responsible for a significant portion of Canada’s greenhouse gas emissions. Technological advances in improved fuel consumption are beneficial but still require

correct driver behavior to produce optimal gains. Evidence suggests that eco-driving techniques can reduce fuel consumption by 10% on average, reducing CO₂ emissions and mitigating rising fuel costs for commercial fleets.

RESEARCH GRANT APPLICATION

NSERC ENGAGE

In partnership with General Motors, we have applied for funding of \$25,000 to support an initial six month collaboration titled “Optimal Maintenance Policies for Mobile Assets.”

Mobile assets are powered industrial vehicles requiring a driver or operator and used to lift and transport material across a wide range of business sectors, including automobile manufacturing. General Motors operates a large fleet of mobile assets in its manufacturing and service facilities worldwide, including Canada. The research project seeks to develop a set of sound analytical methods to optimize the repair and replacement decisions for mobile assets in the context of incomplete and truncated data, resulting in a useful decision.

C-MORE STAFF AND STUDENTS

POSTDOCTORAL FELLOWS

I am delighted to inform the Consortium that Dr. Sharareh Taghipour has been offered a position as Assistant Professor at Ryerson University’s Department of Mechanical and Industrial Engineering. At Ryerson she will be working in the area of Reliability. Sharareh’s appointment begins August 1. I am sure you all join me in wishing her the very best.

I am also pleased to report that Dr. Nima Safaei has accepted a position as Senior Systems Engineer with Innovative Scheduling Inc., Florida. Again we all wish Nima great success in his new position

Dr. Gun Ho Jang will arrive at C-MORE on July 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. He joins us from The University of Pennsylvania’s Department of Biostatistics and Epidemiology and will be collaborating with Sharareh.

STUDENTS

I am delighted to report that four of our students have successfully completed their degrees:

- Pedram Sabha will be granted the PhD degree. His thesis was titled “*The Benefit of Capacity Pooling for Repairable Spare Parts.*”
- Tanya Tang will be granted the PhD degree. Her thesis was titled “*Failure Finding Interval Optimization for Periodically Inspected Repairable Systems*”
- Will Luff will be granted the MASc degree. His thesis was titled “*Reliability Models for Linear Assets*”

- Robert Svaluto will be granted the MEng degree. His thesis was titled “*Optimizing Haul Truck Wheel Motor Inventory Levels Using Discrete-Event Simulation*”

Graduate student Andriana Barisic has completed her practicum period with C-MORE, during which time she worked on the breast screening study funded by CHRP. She has now joined Cancer Care Ontario. Presently she is completing a paper based on her time with us titled “*Optimizing Canadian Breast Cancer Screening Strategies: A Perspective for Action.*”

We welcome Jasmik Saini, a graduate student in epidemiology, who has joined C-MORE for his practicum period. He will be working with Sharareh on the CHRP breast screening study. Jasmik is continuing the work of Andriana and will be with us for the summer months.

We have a summer student with us this year. Tian Luan has completed his 2nd year of Industrial Engineering at the University of Toronto and is working on the VAMMAS fleet (ground support equipment) PM and renewal program with consortium member Greater Toronto Airports Authority.

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 “*OCWA centrifuge maintenance analysis project.*”
- Soroush Sharifi will speak on “*Evaluation of design and maintenance of capital equipment through real options*” This topic has been motivated by consortium member UK Ministry of Defence.
- William Luff will talk about his recent four month internship with Covaris, an engineering consulting company, based in Sydney, Australia, with expertise in maintenance engineering and asset management.

In September 2012, we look forward to welcoming four new graduate students:

- Laurent Caudrelier. Laurent joins us from McGill University where he recently completed his degree in Mechanical Engineering
- 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.
- Erik Tryggvi Striz Bjarnason joins us from Alcan Iceland. Erik is a graduate of The University of Iceland with degrees in Industrial Engineering and Mathematics
- Stephen Trusevych joins us from Hatch Limited where he is a site engineer. Stephen is a graduate of Queen’s University in Mathematics and Engineering.

RESEARCH BY C-MORE LAB STAFF AND POST DOCTORAL FELLOWS (PDF)

Our Project Director, Dr. Dragan Banjevic, has continued to collaborate with consortium partners. Dragan continued collaboration with Manitoba Hydro on CBM for power transformers. Additional information has been obtained from MH, such as on maintenance type of different classes of TRs. In this period, the focus was on calculating failure rates for these classes of transformers. He also collaborated with all members of the C-MORE Lab, in particular with Sharareh on CHRP, Janet on inspection intervals, Nima and Maliheh on scheduling problems, Tanya on FFI, and Neil on case studies. Dragan is collaborating with Hossein on the low-visibility lights project with GTAA. During the winter, he collaborated with Ximbo Qian, a visiting PhD student from China. Finally, he has collaborated with Professors Jardine and Balcioglu in supervising graduate students.

Neil Montgomery has continued to be essential to ongoing collaborations with Consortium members. He has provided support and commentary on projects with GTAA being done primarily by students and postdoctoral fellows. He has commenced the analysis of the VAMMAS snow clearing equipment dataset from GTAA. In addition, Neil has provided background support on the CHRP project work being done primarily by Sharareh Taghipour. He continued data gathering work with Tim Jefferis, from the UK's Ministry of Defence, on the ongoing Project Health Prediction project. Finally, Neil continues to provide general support to C-MORE graduate students working on their research projects.

Dr. Daming Lin has been working on the NSERC Engage program, collaborating with Maintenance Assistant (MA) in the project "A Framework to Transform a Web-Based Computerized Maintenance Management System into an Evidence-Based Asset Management Decision Tool." He has been studying the MA system to find the mappings between the MA data structure and the data format required by EXAKT, identifying issues in transforming the MA system into an evidence-based asset management decision tool. Daming also continues to work on the SMS software. He has worked to debug and update SMS v.1.4 and started working on implementation of SMS v. 2.0, which includes more advanced data entry (from external files in the form of a spread sheet) that can be applied to groups of units.

Dr. Ali Zuashkiani has been primarily involved in educational programs. Ali has been working on organizing the International Maintenance Excellence Conference jointly run by C-MORE and Plant Engineering and Maintenance Association of Canada (PEMAC). He has also been busy planning and leading courses in Tehran and Dubai.

PDF Dr. Nima Safaei has completed the first phase of the collaborative project entitled "Aircraft Maintenance Routing and Maintenance Tasks Scheduling" with Bombardier Aerospace Inc. The project was supposed to be a two-year project funded by Bombardier and MITACS Inc. and starting in January 2011. Nima left C-MORE on May 1 to join an U.S. consulting company, but the project's goals are practically completed.

PDF Dr. Hossein Mohammadian continues to work with GTAA on the low-visibility lighting system at the airport. He has created software to organize and analyze the fault data of the lights. He has also calculated and optimized inspection intervals that conform to regulations and reduce the cost of inspection.

PDF Dr. Sharareh Taghipour has been working on the CHRP-funded project on breast cancer screening. Using data from the Canadian National Breast Screening Study (CNBSS), she has created a model for breast cancer progression using a partially observable Markov process. The results of this study can be used by clinicians to identify women at high risk of breast cancer and provide them an opportunity for screening intervention. Moreover, a personalized intervention plan, for example, in terms of starting and ending age of screening and screening frequency can be recommended to each woman according to her anticipated risk of breast cancer.

Professor Baris Balcioglu remains on research leave at Sabanci and Bogazici Universities in Turkey working on spare part problems and repair shop scheduling. He supervised C-MORE PhD student Pedram Sahba.

C-MORE ACTIVITIES

Since December 2011, C-MORE lab members have been working on research, participating in conferences, and meeting with consortium members. C-MORE is currently involved in the following projects with industry partners.

- **Barrick Gold:** Barrick is a supporting company in the renewed NSERC CRD on Spare Parts Provisioning.
- **Hydro One Networks:** Hydro One is a supporting company in the renewed NSERC CRD on Spare Parts Provisioning.
- **Teck:** Teck and C-MORE are working on further refinements on the simulation software to calculate the optimal number of spares to minimize cost and/or availability (also of general interest to other consortium members). Rob Kalwarowsky worked with Robert Svaluto, in collaboration with Neil Montgomery.
- **MOD UK:** A health prediction modeling study is ongoing. Neil Montgomery continued to compile data for this project.
- **Manitoba Hydro:** C-MORE and Manitoba Hydro are continuing to work on power transformers. Data analysis of MH's power transformers has continued, mainly on updated maintenance and failure data sent by Wendelin Schuhmann. Transformers are now classified by their maintenance program (TRF001 and TRF002), which differentiate them mainly by size. Failure rates per year for TRF001 and TRF002 classes have been calculated. Detailed analysis of measurement data (DGA and STD) continues.
- **ENMAX:** ENMAX continues to support the current CRD on condition-based maintenance models.

- **Iron Ore Canada:** Iron Ore Canada, as C-MORE's newest member, will give a presentation on its asset management activities at the June 2012 Consortium Meeting. We look forward to establishing collaborations with IOC.
- **OCWA:** OCWA has continued its collaboration on maintenance of centrifuges with C-MORE's Janet Sung. The vibration records have been obtained and the analysis is ongoing. Data on failures, repairs and maintenance actions have been received and analyzed. Other possibilities for collaboration are being explored.
- **Ontario Power Generation:** Ken Sutton will give a presentation at the June 2012 Consortium Meeting. I am happy to report that OPG won the PEM maintenance excellence award for 2011 and is featured in the January/February 2012 issue of PEM magazine: <http://pem.clbmedia.dgtpub.com/2012/2012-02-29/home.php>.
- **GTAA:** PDF Hossein Mohammadian has been working on the low-visibility lighting system at the airport. He created software to organize and analyze the fault data of the lights. He calculated and optimized inspection intervals that conform to regulations and reduce the cost of inspection. GTAA and C-MORE are also working on the VAMMAS project, with the help of summer student Tiam Luan and Senior Research Associate Neil Montgomery.

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 five-day Certificate program in Physical Asset Management program held last week (May 28-June 1) was a success, with 18 participants coming from across Canada, as well as South Africa and Thailand. A number of our Consortium members sent participants: IOC, GTAA, Hydro One, and OCWA. In addition, we had one participant from Maintenance Assistant with whom we had a recent NSERC ENGAGE collaboration.

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

IMEC will take place on November 19-22, 2012, and will be the eighth edition of this annual event. Along with the shift in dates, this year, IMEC will be 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.

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.

A handwritten signature in black ink, appearing to be 'A. J. H.', written in a cursive style.

May 29, 2012