

Optimization of Maintenance Activities—Models, Methods and Applications

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Some GMMC highlights

- **Gene expression:** New detection methods which beat established techniques
- **Processes in cells:** Criteria for checking whether time delay models are determined by available data
- **Robust design:** Introduced a system which helps manufacturing companies improve product reliability
- **Optimization of financial portfolios:** New and innovative methods

Overview

- 1 GMMC
- 2 Maintenance optimization at Mathematical Sciences
- 3 Workshop program
- 4 Proceedings publication
- 5 A final remark

GMMC foundation

- A 22 MSEK grant from SSF (Swedish Foundation for Strategic Research) to Mathematical Sciences, Chalmers, 2006–2010
- Centre leader: Holger Rootzén; deputy centre leader: MP
- GMMC (Gothenburg Mathematical Modelling Centre) is formed primarily by researchers from
 - Chalmers
 - University of Gothenburg
 - FCC (Fraunhofer-Chalmers Centre for Industrial Mathematics)
- Main research areas:
 - Optimization and modelling
 - Biomathematics
 - Risk, reliability and quality



Our own background

- Invitation 2000 from Volvo Aero Corporation (VAC): maintenance of the RM12 jet engine
- Paired PhD project between applied math/optimization and math statistics/material fatigue and reliability
- Optimization student: a model for opportunistic maintenance; superior to simpler policies
- Math statistics student: models for the determination of life distributions
- Continuation projects: VAC; maintenance of components in wind and nuclear power plants—some are presented here!

Early literature on maintenance optimization

- Research since the 1930s, although mostly in isolation
- 1950s: RAND, Santa Monica (Bellman); military applications
- 1960s: Stanford (Wagner); application of scheduling
- Focus: infinite planning horizon, few parts, policies; joint work mathematical statistics & mathematical programming — classic operations research
- Prime example: Morse, Barlow, Hunter (Operations Research Group, US Navy); first OR text book Morse/Kimball; Morse (1958) preventive maintenance model; Barlow/Hunter (1960) policy for this model, focusing on reliability; classic text in 1965

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Inspirations, I

- Campbell (1941): replacement of lamps along a city street. Two policies can be utilized, where the first is to replace each lamp when it breaks, and the other is to replace all lamps as soon as one breaks
- The first opportunistic replacement model: further development at RAND 1960—
- Exceptional also in that the planning horizon is finite

Themes at the workshop

Type	Problem area
Fatigue life & reliability	Road infrastructure
Condition-based Maint.	Electric power generation
Maint. backlog	Electric power distribution
Opportunistic Maint.	Wind power systems
Multi-criteria	Aircraft engines & systems
Stochastic programming	Maint. and production

Inspirations, II

- Our opportunistic model for the finite-horizon case is based on a paper by Dickman, Epstein & Wilamowsky (1981)
- Extended to (a) stochastic programming models in order to cover non-deterministic life lengths, (b) more complex component structures and decisions
- The paper [DEW81] is remarkably absent from reference lists!
- Some of the above-mentioned models will be presented during this workshop
- Also many other paths have been taken; evident from the topics of this workshop

Program summary

- Plenary talks 1 h; regular talks 35 minutes. Includes Q&A
- Five minute break for personal maintenance between each talk
- Lunches: today 11.30–13.00; Friday 11.50–13.00. The session hall will be locked during lunch
- Coffee/refreshment breaks: today 14.55–15.20; Friday 10.00–10.25 & 14.15–14.50
- Photo session: Friday 11.40–11.50 at Math. Sciences
- Closing address: Friday 16.05–16.30

Participants

- Plenary speaker 1: *Andrew Jardine*, Director, Centre for Maintenance Optimization and Reliability Engineering, University of Toronto
- Plenary speaker 2: *Rommert Dekker*, Director, Econometrics study, School of Economics, Erasmus University, Rotterdam
- 12 additional speakers
- 33 participants — 23 academic, 10 from industry

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A final remark

“Hey Ho, Let’s Go!”

Joey Ramone

Publication

- We have agreed with the journal *Annals of Operations Research* to publish the proceedings of this workshop
- Tentative publication date following peer reviews is December 2010
- Instructions for submission will be posted on the workshop website soon
- Deadline for submission: 31 March 2010