

Scientific Computing and Control

Modelling, Analysis, and Computing 2 (MAC2)

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May 13th 2011



Centrum Wiskunde & Informatica

Permanent Staff MAC2, 2005-2010



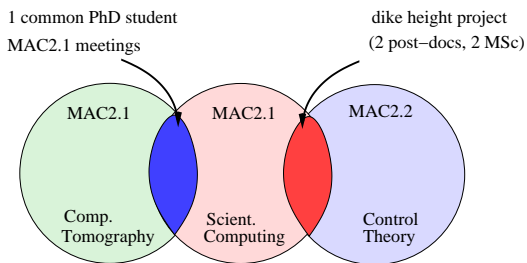
- From left to right:

- ▶ Piet Hemker (CWI fellow, retired 2006; guest in MAC2 since then)
- ▶ Barry Koren (group leader until 2010, now cluster leader)
- ▶ Kees Oosterlee (started 2007; group leader since 2010)
- ▶ Joost Batenburg (started 2010; tenure track)
- ▶ Jan van Schuppen (CWI fellow since 2011)

⇒ Five full professors

Research Embedding MAC2

- "Fundamental applied mathematics research directly related to relevant application areas"; in accordance with CWI's mission.
- **Broad and strong funding**, from (inter-)national agencies to industry.
- **Organization** of several international workshops and conferences (ECCOMAS and EMG).



Research Embedding MAC2

⇒ MAC2.1:

- Development of robust and efficient numerical methods and **scientific computing** for problems arising in modern applications.
- **Examples:** optimization of wind farms and tokamak plasmas; pricing of novel financial derivatives; 3D imaging at atomic resolution.

⇒ MAC2.2:

- Fundamental research on **control and system theory**.
 - Leading an EU project on control of distributed systems.
 - **Applications:** control of autonomous underwater vehicles; control of biochemical reaction networks.
- ⇒ **Common project:** Control of dike levels in the Netherlands; modelling and computing trade off between cost of dike increase and flooding.

Research Interests

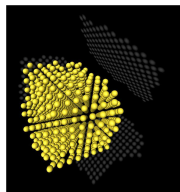
Batenburg: Computerized tomography; inverse problems

Hemker: Electromagnetics; optimization

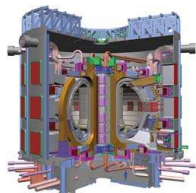
Koren: Computational energy systems; partial differential equations

Oosterlee: Computational finance; solution methods

Van Schuppen: Control and system theory

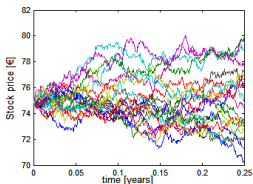


- Leading expert in discrete tomography.
 - Fast and robust solver for large-scale linear inverse problems with discrete value constraints.
 - Full professor at age 29; acquired a **NWO Vidi** grant in 2010.
 - Publication in **Nature** on imaging at atomic resolution.
 - **Internal cooperation** with INS3 (currently SEN1) on 3D visualisation.
 - **External cooperation** with Cambridge, Antwerp and Leiden University, European Synchrotron Radiation Facility, Lawrence Berkeley Laboratory.
- ⇒ **Challenge:** Mathematical understanding of parameter estimation in tomography.



- Efficient multigrid methods for turbulent flow around ship hulls.
 - Stability analysis for magnetohydrodynamics with application to nuclear fusion (ITER).
 - PhD student Wackers, **best PhD thesis** in CFD, ECCOMAS 2008.
 - **Bonus grant** for "computational energy systems".
 - Editorial board member Journal of Computational Physics.
 - **Internal cooperation** with all MAC groups, SEN4 (energy).
 - **External cooperation** with energy research groups and institutes (ITER, CEA, INRIA, ECN, FOM, NRG) and maritime research institutes (NMRI, CNRS/Ecole Centrale de Nantes, MARIN).
- ⇒ **Challenge:** Strengthen energy research within CWI.

Contributions Oosterlee



- Fourier cosine expansions for efficient valuation of financial derivatives.
 - Novel shifted Laplacian preconditioners for the Helmholtz equation.
 - **Direct research funding** from industry (currently nine PhD students). Methods are used at many (financial) institutions **world-wide**.
 - Editorial board member SIAM Journal of Scientific Computing (2003-2009).
 - **Internal cooperation** with MAC1 (computational methods and uncertainty).
 - **External cooperation** with Oxford, Hitotsubashi (Tokyo), Zaragoza, Delft University; Fraunhofer institute SCAI, banks (Rabobank, ING, ABN AMRO) and policy-making research institutes (CPB, NRG).
- ⇒ **Challenge:** Generalization of methods to stochastic control; writing a second book.

Contributions Van Schuppen



- Realization theory for rational systems.
- Coordination control of distributed/decentralized systems.
- **Leading EU project** "Control for coordination of distributed systems" (C4C).
- EU project "Distributed supervisory control" (DISC).
- **CWI fellow** since January 2011.
- Editor-in-chief *Mathematics of Control, Signals and Systems*.
- **Internal cooperation** with MAC4 (biochemical reaction networks).
- **External cooperation** with University of California at Berkeley, Universities of Ghent, Porto, Cyprus, VU Amsterdam, Delft Univ. of Technology, and company Trinité Automation.

Contributions Collins/Hemker



- **Collins:** Computability: efficient rigorous numerical method for nonlinear systems with noise.
- Computation of symbolic dynamics for one-dimensional maps.
- **NWO Vidi grant 2004;** cooperation with SEN2 (co-algebra).
- **Hemker:** Defect-correction techniques applied to optimization (manifold mapping).
- Applications especially in electrical engineering (antennas, magnets).
- **CWI fellow** in evaluation period; Knighted (to Ridder in de Orde van de Nederlandse Leeuw) and elected member Koninklijke Hollandse Maatschappij der Wetenschappen.

Output 2005-2010

⇒ "Applied mathematics research directly related to application areas."

- **Papers in renowned applied mathematics journals:** SIAM J. Scient. Computing, SIAM J. Control and Optimization, SIAM J. Discrete Mathematics, Numerische Mathematik, Inverse Problems, Discrete Applied Mathematics, J. Comput. Appl. Math.
 - **But also in journals in other disciplines:** Journal of Comp. Physics, Journal of Comp. Finance, Journal of Credit Risk, Pattern Recognition, Journal of Mathematical Imaging and Vision, IEEE Transactions Automatic Control.
- ⇒ **High output:** 84 journal papers, 94 conf. procs., 8 book chapters, 13 PhD students graduated with MAC2 supervisors.

SWOT Analysis

- S.** Active group of internationally visible top researchers, dealing with broad research themes, from control theory to scientific computing, with applications from engineering, physics, and economics.
As of May 2011, we supervise 22 PhD students (10 @ CWI) and 2 post-docs.
 - O.** Diverse sources for funding, from NWO, FOM and EU to direct funding from industry. Future funding expected. Energy, imaging and finance are important application areas for the near future.
 - T.** The retirement of Van Schuppen in 2012 requires careful planning for MAC2. Keeping MAC2 together "as it is" is a challenge.
- ⇒ **Ambition:** Batenburg tenure; a new top talent as tenure tracker (energy); application for ERC grant.

MAC2 Products

