Technische Universiteit
Eindhoven
University of Technology

Department of Mechanical Engineering
DCT

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Annual report 2008
DCT 2009.001

Where innovation starts

Technische Universiteit
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1 EMPLOYEES OF THE GROUP (per 31 December 2008)

1.1 Co-workers

Full professors	: Prof.Dr. H. Nijmeijer
	: Prof.Dr.Ir. M. Steinbuch
Part-time professors	: Prof.Ir. O.H. Bosgra (0.2; 0,2 TU/e-EE, 0.2 TUD)
	Prof.Dr.Ir. P. Jonker (0.2; 0.8 TUD)
	Prof.Dr.Ir. N.B. Roozen (0.2; 0.8 Philips CFT)
Senior research staff	: Dr.Ir. J.J.M. Besselink
	Dr.Ir. R.H.B. Fey
	Dr.Ir. W.P.M.H. Heemels
	Dr.Ir. M.F. Heertjes (0.2; 0.8 ASML)
	Dr.Ir. A.G. de Jager
	Ir. L. Kodde
	Dr. D. Kostić
	Dr.Ir. A. de Kraker
	Dr.Ir. I. Lopez
	Dr.Ir. M.J.G. v.d. Molengraft
	Dr.Ir. P.W.J.M. Nuij
	Dr.Ir. W.J.A.E.M. Post
	Dr.Ir. P.C.J.N. Rosielle
	Dr. P.A. Veenhuizen (0.2; 0.8 HAN Arnhem)
	Dr.Ir. F.P.T. Willems (0.2; 0.8 TNO)
	Dr.Ir. N. v.d. Wouw
Supporting staff	: P.R.M. Aspers (0.8)
	Ing. R. v.d. Bogaert
	M.A.P.M. v. Gils
	P.G.A. Hamels
	C.A. Hofkens (0.4)
‘	P.W.C. v. Hoof
	H.C.T. v.d. Loo
	W.J. Loor
	Ing. C.J.M. Meesters
	E. Meinders
	C.M. Neervoort-Sanders (0.8)
	J.G.M. de Vries
Ph.D Students	: Ir. R.M.C. Mestrom
Resource 1	Ir. E. Steur
Resource 2	: Ir. L.J.M. van den Bedem (STW)
(STW/NWO/FOM)	Ir. B. Besselink (NWO)
	Ir. B.A. Hennen (FOM)

	Ir. G.P. Naaijkens (STW)
	Ir. G. Witvoet (FOM)
Resource 3	: M.Sc. S. Adinandra
	M.Sc. A.A. Alvarez Aguirre
	Ir. J.J.T.J. de Best (IOP, SenterNovem)
	Ir. C.H.A. Criens (HTAS, SenterNovem)
	Ir. N.J.M. van Dijk (SenterNovem)
	Ir. M.C.F. Donkers (EU)
	Ir. W.J.E. Evers (CCar)
	Ir. A.J. den Hamer (Philips)
	Ir. R. Hendrix (IOP, SenterNovem)
	Ir. T.A.C. van Keulen (CCar)
	Ir. E.P. v.d. Laan (CCar)
	Ir. H.C.M. Meenink (IOP, SenterNovem)
	Ir. R.J.E. Merry (PointOne, SenterNovem)
	Ir. S.H. v.d. Meulen (VDT)
	Ir. G.J.L. Naus (CCar)
	M.Sc. Dac Viet Ngo (SenterNovem)
	Ir. T.A.E. Oomen (Philips)
	M.Sc J. Pena Ramirez
	Ir. D.W.J. van Raaij (IOP, SenterNovem)
	Ir. S.K. Ravensbergen (PiD, SenterNovem)
	Ir. D.J. Rijlaarsdam (ESI, SenterNovem)
	Ir. R. v.d. Steen (CCar)
	Ir. C. Werner (Nanoned)
Post-docs	Ir. J. Caarls (ESI, SenterNovem)
	Dr. N. El Ghouti (HTAS, SenterNovem)
	Dr. L. Hetèl (01-04-2008 until 31-10-2008)
	Dr.Ir. T. Hofman
	Dr.Ir. S. Lichiardopol (Teleman)
	Dr.Ir. W. Paszke (ESI, SenterNovem)
Visiting Scientists	: Ir. J.D.B.J. v.d. Boom
	Dr.Ir. G. Carbone
	Dr.Ir. R.M. v. Druten
	Ir. R.W. van Gils
	Dr. T. Oguchi
	Dr.Ir. R. Scholte
	Dr.Ir. A.F.A. Serrarens
	Ir. G.E.M. Vael (NWO, Casimir)
	Dr.Ir. B.G. Vroemen

1.2 Personal matters

Appointed in 2008 Control Systems Technology

Name	employment	date
Ir. S.K. Ravensbergen	PhD 3	01-01-2008
L. de Novellis, M.Sc.	Visiting scientist	30-01-2008
Dr.Ir. W. Paszke	Post Doc	01-02-2008
Ir. R. Tilburgs	Visiting Scientist	15-02-2008
Ir. D.W.J. van Raaij	PhD 3	01-04-2008
Dr. L. Hetèl	Post Doc	01-04-2008
Dr. Norddin Elghouti	Post Doc	16-04-2008
Ngo Dac Viet, MSc.	PhD 3	16-05-2008
Dr. A. Cavazos	Visitor	24-06-2008
Ir. G.P. Naaijkens	PhD 2	01-07-2008
Ir. C.H.A. Criens	PhD 3	01-09-2008
Ir. D.J. Rijlaarsdam	PhD 3	01-09-2008
Dr.ir. W.H.T.M. Aangenent	Visiting Scientist	01-09-2008

Leaving office

Name	employment	Date
Dipl.-Ing. J. Richter	Visiting Scientist	01-04-2008
Drs. G.F.IJ. Kramer	Guest	01-06-2008
Ir. R.F.M.M. Hamelinck	PhD 3	01-06-2008
Ir. R. Tilburgs	Visiting Scientist	30-06-2008
Dr. A. Cavazos	Visiting Scientist	08-07-2008
Ir. R. Henselmans	PhD 3	01-09-2008
Dr.Ir. M.L.G. Boerlage	PhD 1	03-09-2008 promotion
Dr. L. Hetèl	Post Doc	31-10-2008
L. de Novellis, M.Sc.	Visiting Scientist	30-10-2008
Dr.Ir. J.J.M. van de Wijdeven	PhD 1	12-11-2008 promotion
Dr. Norddin Elghouti	Post Doc	14-11-2008 to D&C
Dr.Ir. W.H.T.M. Aangenent	PhD	30-11-2008 promotion

Appointed in 2008 Dynamics and Control

Name	employment	date
Dr.ir. I.J.M. Besselink	Assistent Professor (fulltime)	01-01-2008
S. Adinandra MSc.	PhD 3	01-02-2008
Ir. Bart Besselink	PhD 2	01-05-2008
Dr. D. Kostic	Assistant Professor	01-07-2008
Ir. R.W. van Gils	Visiting Scientist	01-09-2008
Dr.ir. A. de Kraker	Associate Professor	01-09-2008
Dr. T. Oguchi	Visiting Scientist	02-10-2008
Ir. J. Pena Ramirez	PhD 3	05-11-2008
Dr. Norddin Elghouti	Post Doc	15-11-2008

Leaving office

Name	employment	Date
Dr.Ir. Marieke Cloosterman-Posthumus	PhD 3	25-06-2008 promotion
Ir. J.D.B.J. v.d. Boom	PhD 2	To Visiting Scientist
Ir. J.C.A. de Bruin	PhD 2	01-08-2008
Dr.Ir. N.J. Mallon	PhD 1	02-10-2008 promotion
Ir. S. Rudinac	PhD 1	30-10-2008
Dr.Ir. R. Scholte	PhD 2	31-12-2008 18-12 promotion

2 COURSES DELIVERD BY THE GROUPS

Control Systems Technology

Code	Course	Lecturers	Year	Obliged Elective	Period From/till
4A250	Signal analysis	René v.d. Molengraft / Pieter Nuij	1	Obliged	S2 D/E
4A320	System Analysis	Maarten Steinbuch	1	Obliged	S2 F
4A550	Control engineering	Maarten Steinbuch	2	Obliged	S1 A
4C620	Design principles	Nick Rosielle	2	Obliged	S2 E/F
4A560	Multivariable control	Bram de Jager	3	Obliged	S2 D/E
4J820	Applied nonlinear control	Bram de Jager	4	Elective	S2 D
4K140	Capita selecta in control	Maarten Steinbuch/ Henk Nijmeijer	4	Elective	S2 F
4K150	Advanced motion control	Maarten Steinbuch	4	Elective	S2 D/E
4K160	Modeling and control of hybrid dynamic systems	Maurice Heemels	4	Elective	S1 B/C
4K410	Digital motion control	Maarten Steinbuch / Gert Witvoet /René v.d. Molengraft	4	Elective	S1 A
4K450	Embedded motion control	René v.d. Molengraft	4	Elective	S2 E/F
4K560	Modelling in systems and control	Okko Bosgra	4	Elective	S1 A/B
4K580	System theory for control	Maurice Heemels	4	Elective	S1 B/C
4N630	Fluid power transmissions and servo systems	Wil Post / Piet Teerhuis	4	Elective	S1 B/C
4N830	Vehicle drive trains	Bram Veenhuizen	4	Elective	S1 B/C
4N840	Hybrid power trains	Theo Hofman	4	Elective	S2 E/F

Dynamics and Control

Code	Course	Lecturers	Year	Obliged Elective	Period From/till
4A240	Dynamics	Henk Nijmeijer / Rob Fey / Ines Lopez	1	Obliged	S2 D/E
4A460	Mechanical vibrations	Ines Lopez	2	Obliged	S1 A/B
4J400	Multibody dynamics	Nathan v.d. Wouw / Ines Lopez	3	Obliged	S2 E/F
4U600	Applications of design principles	Nick Rosielle	3	Obliged	S1 C
4J100	Control of nonlinear mechanical systems	Henk Nijmeijer/ Nathan v.d. Wouw	4	Elective	S2 D/E
4J520	Nonlinear dynamics	Henk Nijmeijer/Nathan v.d. Wouw	4	Elective	S1 B/C
4J530	Eng. Optimization: conc. & appl.	Pascal Etman / Koo Rijpkema	4	Elective	S2 E/F
4J560	Numerical and experimental analysis of linear dyn. systems	Rob Fey	4	Elective	S1 B/C
4J570	Advanced vehicle dynamics	Igo Besselink	4	Elective	S2 E/F
4K140	Capita selecta in control	Okko Bosgra / Maarten Steinbuch / Henk Nijmeijer	4	Elective	S2 F
4K300	Experimental mechanics	Rens Kodde	4	Elective	S1 A/B
4L150	Vehicle dynamics	Igo Besselink	4	Elective	S1 A
4L160	Introduction Robotics	Not given in 2008	4	Elective	S1 A/B
4L810	Fundamentals of systematic low noise	Bert Roozen / Ines Lopez	4	Elective	S2 D/E

2.1 Number of graduated students per professor

Bosgra : 1
Nijmeijer : 23
Steinbuch : 32

2.2 Graduated students

In 2008, 56 students of the DCT Group graduated. For the titles of the engineering theses the reader is referred to Chapter 5 internal reports.

Name	Professor	Date
L.L.F. Merkx R.T. Uil I.B.A. op het Veld	Nijmeijer	28 januari
R.J.T. van Aaken R.A.P.M. van den Bleek K.J.A. van Eersel S.A.K. van Loenhout S.K. Ravensbergen D.A.C. Smolders	Steinbuch	28 januari
M.H.G.W. Hees J.H.H. Huijbers	Nijmeijer	31 maart
M.A. Beenakkers R.J. Jenneskens D.W.J. van Raaij R. Tilburgs	Steinbuch	31 maart
B. Besselink R.R.J.J. van Doorn M.M.E. van Osch	Nijmeijer	2 juni
M.C.F. Donkers	Steinbuch	2 juni 1e diploma 3TU opl. Systems and Control
J.P.A. Bus J.A. van Geenhuizen S.A.J. de Waal	Steinbuch	2 juni
D.S.M. Denie	Bosgra	29 september
R.W. van Gils E.J.P. van de Hoven M.H. Jussen F. Kamalizadeh T. Kniknie W. Lamers D.J. Rijlaarsdam X.G.P. Schuurbiers	Nijmeijer	29 september

G.R. Siau T.L. Spijkers E.M.P. van de Wiel		
C.H.A. Criens T. ten Dam J.F.P.B. Diepstraten M. van Leeuwen H.J.C. Luijten A.J. van der Meulen G.P. Naaijkens M.J. Nieuwenhuizen R.J.G. Rademakers L.H.J. Römers J.N.M. Schnackers J.J. Slob D. Verhagen B.J.M. de Vries	Steinbuch	29 september
C.S. Kraaij A. Lugungu B.J.M. van Schaik H.W.J.A. Schepens	Nijmeijer	24 november
R.M.R. Bruns J.H. Grasman D.P.E. Leermakers J.A.G. Wouters	Steinbuch	24 november

3 RESEARCH DOCUMENTATION OF THE CONTROL SYSTEMS TECHNOLOGY GROUP

3.1 Full title of the research programme Control systems Technology (CST)

3.2 Subsidiary programmes

3.2.1 Advanced motion systems

3.2.2 Control of nuclear fusion

3.2.3 Automotive technology

3.2.4 Mechanical Design

3.3 Programme members

Tenured research staff CST		
Full Professor	Prof.Dr.Ir. M. Steinbuch	0.4
Associate Professor	Dr.Ir.W.P.M.H. Heemels	0.4
	Dr.Ir. A.G. de Jager	0.4
	Dr.Ir. P.C.J.N. Rosielle	0.2
Assistant Professor	Dr.Ir. P.W.J.M. Nuij	0.4
	Dr.Ir. M.J.G. v.d. Molengraft	0.4
	Dr.Ir. W.J.A.E.M. Post	0.1
Total tenured staff	**CST**	**2.3**

Non-tenured research staff CST		
Part-time Professor	Prof.ir. O.H. Bosgra	0.1
Assistant Professor	Dr.Ir. M.F. Heertjes	0.1
	Dr. P.A. Veenhuizen	0.1
	Dr.Ir. F.P.T. Willems	0.2
Total		**0.5**

Post-doctoral fellows CST		
	Dr. L. Hetèl 1-4-2008-31-10-2008	0.1
	Dr.Ir. T. Hofman	0.4
	Dr.Ir. W. Paszke	0.4
Total		**0.9**

PhD students CST		
	Ir. L.J.M. v.d. Bedem	0.8
	Ir. J.J.T.J. de Best	0.8
	Ir. L.A. Cacace	0.8
	Ir. C.H.A. Criens	0.3
	Ir. M.C.F. Donkers	0.8
	Ir. A.J. den Hamer	0.8
	Ir. B.A. Hennen	0.8
	Ir. T.A.C. van Keulen	0.8
	Ir. E.P. v.d. Laan	0.8
	Ir. H.C.M. Meenink	0.8
	Ir. S.H. v.d. Meulen	0.8
	Ir. R.J.E. Merry	0.8
	Ir. G.P. Naaijkens	0.4
	Ir. G.J.L. Naus	0.8
	M.Sc. Dac Viet Ngo	0.6
	Ir. T.A.E. Oomen	0.8
	Ir. D.W.J. van Raaij	0.7
	Ir. S.K. Ravensbergen	0.8
	Ir. D.J. Rijlaarsdam	0.3
	Ir. C. Werner	0.8
	Ir. G. Witvoet	0.8
Total PhDs	**CST**	**14.5**

Non tenured Temp. researchers CST		
	Dr.Ir. R.M. van Druten	0.1
	Dr.Ir. A.F.A. Serrarens	0.1
	Dr.Ir. B. Vroemen	0.1
	Dr.Ir. G. Carbone	0.1
	Ir. R.F.M.M. Hamelinck	pm
	Dr.Ir. J. v. Helvoirt	0.1
	Ir. R. Henselmans	pm
	Ir. R.H.M. Solberg	0.1
	Ir. G.E.M. Vael	0.1
Total non tenured Temp. researchers CST		**0.7**

Summary	
Total tenured staff	2.3
Total non-tenured staff	0.5
Total Post-doc. Fellows	0.9
Total PhD students	14.5
Total non-tenured temp. reseachers	0.7
Total research staff	**18.9**

3.4 PhD-projects per December 2008: name, source of financing and project title

3.4.1 Advanced Motion Systems

Ir. A.J. den Hamer	PhD 3	Frequency response control synthesis
Ir. R.J.E. Merry	PhD 3	Piezo control
Ir. T.A.E. Oomen	PhD 3	Beyond rigid body control
Ir. J.J.T.J. de Best	PhD 3	Fast Focus on Structures
Ir. M.C.F. Donkers	PhD 3	Event driven control
Ir. D.J. Rijlaarsdam	PhD 3	Low velocity scanning
Ir. D.W.J. van Raaij	PhD 3	Haptic control

3.4.2 Control of nuclear fusion

Ir. B.A. Hennen	PhD 2	Plasma Fusion Control
Ir. G. Witvoet	PhD 2	Burn control

3.4.3 Automotive Technology

Ir. T.A.C. van Keulen	PhD 3	Hybrid truck
Ir. E.P. v.d. Laan	PhD 3	Control in passive safety
Ir. S.H. v.d. Meulen	PhD 3	CVT Slip control
Ir. G.J.L. Naus	PhD 3	Autotuning of automotive controllers
Dac Viet Ngo M.Sc.	PhD 3	Hybrid powertrains
Ir. C.H.A. Criens	PhD 3	Diesel engine control

3.4.4 Mechanical Design

Ir. C. Werner	PhD 3	Large stroke AFM
Ir. L.J.M. v.d. Bedem	PhD 2	Medical Robotics
Ir. T. Meenink	PhD 3	Nuducak Robotics
Ir. S.K. Ravensbergen	PhD 3	Adaptive Optics
Ir. G.P. Naaijkens	PhD 2	High speek motion systems
Ir. L.A. Cacace	PhD 3	Opto mechanical sensor

3.5 Postdocs: name, and period of stay

Dr. L. Hetèl, 01-04-08 till 31-10-08
Dr.Ir. T, Hofman since November 7, 2007
Dr. Ir. W. Paszke, since 01-02-08

3.6 Research area and mission

The mission of the Control Systems Technology group is to develop new methods and tools in the area of Systems Theory, Control Engineering and Mechatronics. The research is focused on understanding the fundamental system properties that determine the performance of mechanical engineering systems. The research program concentrates on performance- driven control and plant design, and develops robust and data-driven control theory, hybrid systems theory, optimization and design principles, aimed at high tech systems and energy as application areas.

Affiliations outside the chair
The Control Systems Technology (CST) group is a member of, or has strong formal ties with, the following institutions:

1. 3TU.Centre for Intelligent Mechatronic Systems, one of the 3TU Centres of Excellence, as part of the 3TU Centre of Competence High Tech Systems
2. EM, Engineering Mechanics, national research school
3. DISC, Dutch Institute on Systems and Control, national research school
4. CCAR, Competence Centre for Automotive Research
5. ESI, Embedded Systems Institute

Group meetings and communication
A number of regular group meetings help to exchange information and make decisions. The scientific staff have two-weekly meetings. MSc students and visitors give lectures in the weekly colloquia. In addition, we hold monthly laboratory staff meetings with the technical staff. Once a year we hold a two-day meeting of all members of the group, together with the Dynamics and Control (D&C) group to discuss strategy and processes. We also hold an annual social event for all CST and D&C members and their partners. PhD students have monthly meetings with their promotors and co-promotor, and typically also weekly meetings with their co-promotors.

Group laboratories
The responsibilities of the CST group concern the exploitation of the Motion and Robotics laboratory ('DCT lab'[1]) and the Mechanical Design laboratory, both together with the D&C group, as well as the Fluid Power (FP) laboratory and the power trains part of the Automotive (AES[2]) laboratory.

Teaching in the group
The CST group is responsible for five courses in the (ME) BSc program (Signal Analysis, System Analysis, Control Engineering, Design Principles, Multivariable Control), and over 13 elective courses in the MSc program and also for a number of case studies for design-based learning (printer control, pizza robot, generator control). The group participates in the *Dynamical System Design (DSD)* and *Automotive Engineering Science (AES)* Master's tracks and in the *3TU MSc Systems & Control*. The group was actively involved in the definition of the new multi-disciplinary master *Automotive Technology*. In the postgraduate courses, nationally organized by the Engineering Mechanics (EM) and Dutch Institute on Systems and Control (DISC) graduate schools, the members of the CST group make substantial contributions to a number of courses. We are co-responsible for the PhD-level course *Design Methods*

[1] The combination of the CST and D&C group is called Dynamics and Control Technology (DCT)
[2] AES = Automotive Engineering Science

for Control Systems and *Modeling and Control of Hybrid Dynamical Systems*. The CST group is also active in several successful post-academic courses for industry: *Motion Control Tuning*, *Advanced Motion Control* and *Iterative Learning Control*, as well as for the postgraduate two-year Software Technology (*Embedded Motion Control*) design program and the Systems Architecture course program of the Embedded Systems Institute (ESI) (*Motion Control* module).

3.7 Strategy and policy

The CST group focuses on understanding the fundamental system properties that determine the performance of controlled mechanical engineering systems, in particular for high- performance motion systems and vehicle power trains as application areas. Based on these insights, the program develops new models, methods and design principles such that significant performance improvements are realized.
The performance of a controlled system is defined as the extent to which the specific behavior of the system matches the requirements, while subject to disturbances acting on the system and variations in system dynamics. Requirements are for example tracking a set point (motion) or energy optimization (hybrid vehicles). Fundamental properties that determine and possibly limit performance can be found in both external sources (disturbances acting on the system) and internal sources (plant properties, controller properties, quality of sensors and actuators etc.).
The *engineering question* for the design problem of high-performance systems is: how to find the best combination of controller and plant realization such that the performance is within specification for all prescribed situations (disturbances and system variations).
The *scientific question* is how to initiate a paradigm shift in achievable performance by using acquired insights into the fundamental properties of the problem. It is clear that the scientific question has a strong interrelationship with the engineering question, in which the latter has the role of validation and inspiration for new directions of research.

The solution strategy is based on developing performance-relevant models of the controlled system, including modeling of disturbances, plant variations and controller implementation aspects. Within this strategy the use of (experimental) data is instrumental for the quality of the models. New measurement methods have been developed for this purpose. The fundamental knowledge obtained on (non-)linear system behavior (for example thermal behavior, friction or non-smooth switching behavior), is used within three lines of attention: (i) performance-driven control design; (ii) performance-driven plant design; and (iii) performance-driven co-design.
The research in performance-driven control design addresses the problem of modeling errors requiring robust control solutions, and limiting the achievable performance. Here, our data-driven research approach is employed to find new methods of using on-line experimental data to continuously adapt models/control signals to improve the controlled performance. Also, hybrid system theory is developed to obtain methods and tools for the performance improvement of dynamical systems that cannot be captured well by smooth models, such as switching dynamical systems. The performance-driven plant design conducts research on enhancing the overall closed-loop performance by improved synthesis of the plant itself, exploiting innovations in mechanical design principles. Finally, the use of design principles and control theory to simultaneously design plant *and* controller is

addressed in the third research line. More details of the three research lines are provided in the following sections.

1. Performance-driven control design

In motion systems such as robots, pick-and-place machines and disc drives, the fundamental limitations with respect to controlled performance are primarily due to causality (Bode's sensitivity integral theorem). This fundamental limitation is the driving force for several lines of system-theoretic research: (i) further exploration of feedforward, including iterative learning control; (ii) data-based control, i.e. adjusting the controller parameters on the basis of on-line measurements; (iii) non-linear and hybrid control of linear motion systems; and finally, (iv) multivariable control of mechanical systems, including exploration of directionality and disturbance identification. In addition to these research lines, the possible extension of frequency response analysis towards non-linear dynamics is also pursued.

Although often neglected, controller implementation issues also induce performance limitations. The group undertakes research in implementation-aware control by exploring encoder technology, vision-in-the-loop and hybrid system theory, including event-driven control. Performance paradigm shifts are possible by the introduction of control in new areas, such as the vehicle passive safety project. Here we investigate the possible inclusion of active control elements in passive safety components (airbags, belts). Reduced peak decelerations of the head and the chest of the vehicle occupant are realized using feedback control, resulting in a reduction of occupant injuries. Another project is addressing the tuning problem for high- performance component control (DAF) and model-based methods such as MPC in control of clutches, motor management and adaptive cruise control (TNO).

2. Performance-driven plant design

The research activities within the field of mechanical design are focused on exploration and development of novel mechanical engineering design principles such that unprecedented performance of high-precision mechatronics comes within reach. The design of a fast measurement machine with nanometer capability was recently completed, with a working prototype evidencing the potential of this research line. The project on adaptive optics addresses the design trade-offs for complex distributed systems (5000 actuators), and we have built a prototype with uniquely low thermal and at the same time high spatial and temporal characteristics. In the Nanoned design project we are cooperating with NMi[3] to develop a metrological AFM (atomic force microscope) concept. A large research activity was recently started on the design of surgical robotic systems, including haptic feedback in tele-operation (together with the HMI group of the TU/e), mechanical design of a laparoscopic slave robot (STW), a slave robot for eye surgery (together with D&C group and TNO), and a mechanical design for image-guided navigation haptic robotic systems (with Philips AppTech and Philips Medical Systems).

3. Performance-driven co-design

Various projects address the research question of design and optimization of closed-loop systems by simultaneously investigating controller and plant design. Here, the limits of performance are being shifted by exploring synergies between mechanical design and the control design space. As an example the use of lightweight (single-stage) motion systems adopting more actuators (and sensors) than the number of (rigid body) degrees of freedom has been explored. Another project focuses on tensegrity structures, including I/O selection and optimization. The design of a new

[3] Nederlands Meetinstituut (Dutch Measurement Instituut)

accurate print head is under investigation together with the printer company Océ, and the control design of new piezo stages for ultra-accurate and extremely slow-moving precision instruments (STM/TEM) is being addressed together with FEI company.
An interesting field in which co-design is addressed is the automotive power train. Design rules for power train components are being derived such that the performance can be guaranteed under all relevant conditions. Slip control of Continuously Variable Transmissions (CVT) is a new and very promising line of research. A first prototype car with a new electromechanical actuation and slip control has been built (in cooperation with Bosch/VDT).
The overall optimization of hybrid power trains poses both numerical and design trade-off issues, which are computationally difficult. Research is being performed on energy management of the complete power train (together with Ford and the Control Systems group of the department of Electrical Engineering). An NWO project addresses the design tradeoffs, reduced complexity modeling and optimization of sizing and choice of components, in particular for hybrid vehicles including trucks (DAF/Paccar, TNO). Advanced model-based optimization methods are used for the offline generation of optimal trajectories for the variables that dictate the energy supply from the combustion engine and/or the electric motor (the spin-off company DTI).

3.8 Processes in research, internal and external collaboration

Research quality

Monitoring of the quality of the research activities is organized at different levels: (i) at the project level through monthly meetings, in addition to the daily coaching of PhDs by the scientific staff; (ii) at the international level by communicating and discussing research results at various international conferences and meetings; (iii) at the output level, by working towards papers in highly rated journals in systems and control, and finally (iv) through the PhD approval and defense system. At all stages we have a thorough process of coaching, for example by try-outs for presentations at conferences (we actually succeed in getting a far-above-average number of best presentation awards at international conferences, see award list), by detailed assessments and by internal review procedures of writing material, i.e. conference proceedings and journal manuscripts. Also, as an educational method, we actively involve our PhD students in peer reviewing try-outs as well as external reviewing tasks of publications. The staff are active in various editorial activities for leading conferences and journals, which leads to awareness and co-determination of international standards.

Collaborations

Within the Mechanical Engineering department, the CST group collaborates intensively with the D&C group, sharing laboratories and computer infrastructures. Research cooperation also exists with various TU/e groups and with the Embedded Systems Institute (ESI). The research within the CST group is organized under the banner of the DISC and EM national research schools, which enables cooperation,

both locally and nationally, with other groups in the fields of interest. The common interest in systems and control theory is the central theme within DISC. At TU/e, the DISC groups are organized within 'Eindhoven Control'. The group is also part of the Graduate School for Biomedical Engineering.

National research institutes and other national universities
As far as national research institutes are concerned, cooperation exists with TNO Science and Industry in the field of motion systems, control and optimization of power trains, opto-mechanics (also with NMi), medical robotics and haptics, control of compressor surge and fusion plasmas. We collaborate with FOM and TNO on the subject of control of plasma burning for fusion (ITER). We have various joint projects with the Embedded Systems Institute (ESI); Dr.ir. W. Heemels is also part-time ESI research fellow). We also have substantial collaborations with TU Delft (Delft Center for Systems and Control, Advanced Mechatronics, BioMechatronics), and the University of Twente (Control Engineering). Our participation within the new 3TU Centre of Excellence: 3TU.Centre for Intelligent Mechatronic Systems provides various new options for cooperation.

Industrial collaborations
The leading role of the Eindhoven region as technological center of Europe with the main emphasis in high-tech systems and automotive technology provides us with intensive and fruitful collaborations with industry. Examples are the cooperations with Océ, Philips Medical, Research, Applied Technologies, ITEC and Optical Storage (Eindhoven, Singapore), CCM, Bosch-Rexroth/Control, Bosch-Rexroth/Hydraudyne, Bosch-VDT, DAF/Paccar, JPE, Innas, DTI, Siemens, ADSE, ASML, FEI, Govers, GCI. In addition there are intensive cooperations with Ford (Germany), BMW (Germany) and Jatco Ltd. (Japan). A number of PhD students and lab equipment are funded by these industries.

International academic co-operation
The CST group has external cooperations with the following groups, as shown by joint publications:

Norwegian Univ. of Science and Technology (Prof. J.Gravdahl) compressor surge control
École Catholique des Arts et Métiers, Lyon (Prof. C. Changenet) transmission efficiency
Bari University (Dr. G. Carbone),CVT modelling
ETH Zürich (Prof. M. Morari), model predictive control
University of Bochum (Prof. J. Lunze), reconfiguration control
University of California at Santa Barbara (Prof. A. Teel), hybrid systems
University of California at San Diego (Prof. R. Skelton), tensegrity structures
University of Siena (Prof. A. Bemporad), model predictive control
University of Milan (Prof. G. Ferrari-Trecate), hybrid identification
University of Seville (Prof. T. Alamo, Prof. D. de la Pena), model predictive control
INRIA Grenoble (Prof. B. Brogliato), non-smooth mechanics
University of Illinois (Prof. A. Alleyne), iterative learning control
University of Zielona Gora (Prof. Galkowski, Dr. Paszke), 2D systems and iterative learning control
Hamilton Institute (Prof. R. Middleton), multivariable control

In the past years, staff members and PhD students from our group have spent periods at these groups for joint work. Several of the researchers listed above or their PhD students have also been working in our group for some period. Each year a substantial number of MSc students conduct their 3-month traineeships with colleagues in Australia, Canada, the USA, Denmark, California, Mexico, Japan etc. These traineeships often take place in groups with which cooperations already exist.

3.9 Academic reputation

The CST group is internationally known for its Motion Design and Control and Power Trains activities, and for its work on non-smooth, hybrid/embedded systems. The group's members have various roles in committees and organizations (see below). We expect further growth in participation in European projects. A summary of the reputation of the group's faculty members is given below.

Dr.Ir. M.P.M.H. Heemels
- Member Journal Editorial Board of the new Elsevier journal "Nonlinear Analysis: Hybrid systems'
- Member IPC ACC08, CDC08 Hybrid systems:Computation and Control
- Member IFAC technical committee on Discrete Event and Hybrid Systems

Dr.Ir. M.J.G. v.d. Molengraft
- Associate Editor IFAC Mechatronics

Dr.Ir A.G. de Jager
- Associate Editor IEEE Trans. On Control Systems Technology

Prof.Dr.Ir. M. Steinbuch:
- Editor-in-Chief IFAC Mechatronics
- Various IPCs

3.10 External Validation

The CST group is involved in two TU/e focal areas: Science and Engineering of Embedded Systems, and Mechanics and Control. The CST group is a member of the 3TU.Centre for Intelligent Mechatronic Systems, as part of the 3TU Centre of Competence High Tech Systems, of which prof. Steinbuch is the 3TU Scientific Director. Within the field of hybrid system theory the CST group is active in the European Union project SICONOS and the HYCON Network of Excellence. The research field of the CST group is within the core of the region ('Brainport') with its focus on high-tech systems and automotive. Many (multinational) industries located in our region have strong global market positions, and concentrate their R&D activities here. The CST group actively benefits from these developments, and makes a strong contribution to initiatives for public/private co-operation between knowledge institutes and industry (for example High Tech Automotive Systems HTAS, Programme for High Tech Systems PfHTS, Point-One). The group is also an important supplier of MSc and

PhD-level employees to these industries. The 'Brainport' environment provides a perfect match for our research activities which are described below.

Knowledge transfer. We have put significant effort into revitalizing education in control engineering, including intensive (unique and published) use of experimentation in our courses. We believe that by now, our graduate students have new and up-to-date knowledge matching the top schools around the globe. Secondly, we have set up a course on Motion Control Tuning, by which we show that a new type of post-academic course can have a high yield: it has already for 8 years been the most successful course (as can be seen in the evaluation forms) of the Dutch PATO foundation. This course has enabled us to provide more than 130 participants from industry with up-to-date knowledge, using a well-balanced mix of theory, simulation and experimentation. We have also designed and developed a new course on advanced motion control, which has already been given successfully twice. We have successfully given similar courses with very good evaluations for the post-graduate two-year Software Technology design program (*Embedded Motion Control*), and for the Systems Architecture course program of the Embedded Systems Institute (ESI) (*Motion Control*).

Entrepreneurship. The successful EcoDrive project ('ZeroInertia') encouraged the three participating PhD students to start up their own company after graduation. The Drive Train Innovations (DTI) company is now growing steadily, and also has links to our group through common MSc and PhD projects. A project with Govers E.T. b.v. (Chaam) resulted in a successful new business on CVTs for auxiliary equipment on distribution trucks. In the field of medical robotics, in particular the plasma needle, a company start-up is being initiated together with students and with Dr. E. Stoffels-Adamowicz (BME department). An STW valorization grant has been obtained for this project. We also are active in converting our new ideas into patents (see Table 7). As a successor to the Zeiss F25, a commercial startup has been made with our NanoCMM prototype. A German institute intends to buy a second prototype of the Nanomefos machine. A new initiative is the CST Innovations company, which has started with a past PhD and an MSc student from our group. CST Innovations will be a 100% TU/e-owned company, with the primary task of providing short-term research solutions based on our recent research results. It will act as a medium between our fundamental research and short-term questions raised by industry. Prof. Steinbuch is cofounder and CTO of a new mechatronics company MI-Partners B.V.

Industrial cooperation. Our expertise in the design and control of advanced motion systems and automotive power trains has had several successful implications for industry. Examples include iterative learning and repetitive control as a technology to achieve high-performance motion systems (CCM, ITEC, ASML, Philips), auto tuning cruise control of passenger cars and trucks (DAF, TNO), a novel idea for active control of passive vehicle safety systems (BMW, TNO), new technology for slip control of CVTs (VDT, Jatco Ltd.), and new results on playability and shock-sensitivity of optical storage drives (Philips). A new algorithm for piezo control is being used by FEI company. Most importantly, we see an even further increase of industrial interest in cooperation with our group, which also contributes to the development of research issues we would like to address with our research. CST is a group with an above-average number of PhD students with direct industry funding. Former PhD students are now working at: Philips (1), ASML (4), Océ (1), Takata (Berlin, 1), TNO (2); with the smaller companies: GCI (2) and VD (1); with their own start-up companies: (3); and as post-docs (2).

3.11 Resources, Funding and facilities

Facilities

The Dynamics and Control Technology groups shares the following laboratory facilities in the Mechanical Engineering Department:

The Motion and Robotics laboratory, also called DCT laboratory
The Motion and Robotics laboratory is a joint laboratory of the Systems Technology and Dynamics and Control groups. It provides an educational and research facility for motion- related MSc and PhD student projects. Laboratory facilities are regularly replaced by newer set-ups to keep the laboratory up-to-date. In the past few years a drill-string set-up, an H-drive pick-and-place system, an RRR robot manipulator, an inverted pendulum, and a one-sided impact flexible beam have been actively used as research test beds. Research is also carried out using a FAMM direct-drive robot, four mechanical pick-and-place units, several small-scale mobile robots, a 1-DOF medical manipulator with force feedback, and an accurate dynamic buckling test facility and a mechanical set-up for slip detection. A real-time Linux-based data-acquisition system has been set up for rapid control prototyping. In addition, we built an experimental set-up for a printer paper path control problem in 2006, and a new environment has also been built for a new course on Embedded Motion Control. Finally, we have been active with set-ups for the TechUnited RoboCup soccer robots.
The Fluid Power (FP) laboratory is the place for all hydraulic activities, and it also supports the automotive power train research.
The technical staff (mechanical and electrical) provide support and create a stimulating environment for PhD and MSc students to carry out experiments in the DCT lab. The real-time hardware, data acquisition and measurement equipment includes more than 10 dSpace systems, 5 SigLab measurement systems and over 30 TU/e DACS systems which enable students to use their own notebook computers as real-time control processors.

The AES lab

The department has growing activities in automotive systems. Each division participates in the Automotive Engineering Science Master's track within the Mechanical Engineering department. The automotive research activities now have also grouped almost all their experimental facilities in the renovated Automotive Engineering Science laboratory in the W-laag building. The renovated AES lab facility was opened in September 2003. In 2003, the flatplank tire tester was obtained from TU Delft – where the vehicle dynamics activities were stopped – and forms a valuable set-up for tire and vehicle dynamics research. Another tire testing facility, the measuring tower to be installed on a controlled drum, will also become operational in the near future. With support from Paccar and TU/e, a substantial step forward has been made in 2006 by completely renewing the drum facility in the AES lab, which now makes it an up-to-date test facility for a range of driving and tire tests.

The Constructions and Mechanisms laboratory

The Constructions and Mechanisms laboratory is led by dr.ir. Nick Rosielle, who is himself supervised by both the Control Systems Technology and the Dynamics and Control chairs. In this laboratory about 6-8 PhDs and 10 MSc students are specializing in the design and construction of machines, instruments and consumer products, with a focus on positioning and manipulation using design principles.

3.12 Keynot & general lectures; seminars (duration ~ 40 or more)

3.13 Awards and Patents

Awards:

Price of the best performance on the Systems and Control Benelux meeting; Ir. Gert Witvoet

Best paper award of IFAC Mechatronics period 2005-2008 for the paper:
"A.W. Notenboom, D.J.H. Bruijnen, F.G.A. Homburg, M.J.G. van de Molengraft, L.J.M. van den Bedem, M. Steinbuch, *Mechatronic design of an active printhead alignment mechanism for wide format printing systems*, Mechatronics, **17**(2-3), 109-120, (2007)"

KIvI Spijkerprijs 2008 (best Automotive MSc Thesis) for:
"M.A. Beenakkers, Coaches: M. Steinbuch, *Drive off control to prevent clutch judder* DCT 2007.138, Internal Report (2007)

Patents:

M.F. Heertjes, *Variable gain observer with improved broad-band fading properties*, Patent: P3318.000 (2008)

M.F. Heertjes, D. Houben, J. Goossens, W. Simons, *Nonlinear frequency-weighted filtering for improved overlay and fading*, Patent: P2953.000 (2008)

M.F. Heertjes, T. Tso, R. Kamidi, M.C.J. Baggen, M.F. Heertjes, M.J.G. van de Molengraft, *learning-based feedforward control using FIR filtering*, Patent: US 2008/0200998 A1 (2008)

A. Kharin, M. Steinbuch, T. de Boer, *Needle for mechanically assisted or automated insertion into object e.g. living body has cutting portion with at least one protrusion or recess type surface irregularity causing peak of insertion resistance force of needle into object* , Patent: WO2008132660-A1 (2008)

3.14 PhD theses

W.H.T.M. Aangenent, *Nonlinear control for linear motions systems, an exploratory study*, PhD. Thesis, 2008, TU/e
Advisors: M. Steinbuch,
Co-advisors: M.J.G. van de Molengraft, W.P.M.H. Heemels

M.L.G. Boerlage, *Rejection of disturbances in multivariable motion systems*, PhD. Thesis, 2008, TU/e
Advisors: M. Steinbuch, A.G. de Jager

J.J.M.van de Wijdeven, *Iterative Learning Control design for uncertain and time-windowed systems*, PhD. Thesis, 2008, TU/e
Advisors: O.H. Bosgra, M. Steinbuch

3.15 Academic publications

3.15.1 Article (refereed)

O. Bachelier, W. Paszke, D. Mehdi, *On the Kalman–Yakubovich–Popov lemma and the multidimensional models*, Multidimensional Systems and Sigal Processing, **19**(3-4), 425-447, (2008)

J.J.T.H. de Best, B.H.M. Bukkems, M.J.G. van de Molengraft, W.P.M.H. Heemels, M. Steinbuch, *Robust control of piecewise linear systems: a case study in sheet flow control*, Control Engineering Practice, **16**(8), 991-1003, (2008)

M.K. Camlibel, W.P.M.H. Heemels, J.M. Schumacher, *Algebraic necessary and sufficient conditions for the controllability of conewise linear systems*, IEEE Trans. on Aut. Control, **53**(3), 762-774, (2008)

M.K. Camlibel, W.P.M.H. Heemels, J.M. Schumacher, *A full characterization of stabilizability of bimodal piecewise linear systems with scalar inputs*, Automatica, **44**(5), 1261-1267, (2008)

G. Carbone, L. Mangialardi, *Analysis of adhesive contact of confined layers by using a Green's function approach*, J. Mech. Phys. Solids, **56**(2), 684-706, (2008)

A. Doris, A.L. Juloski, N. Mihajlovic, W.P.M.H. Heemels, N. van de Wouw, H. Nijmeijer, *Observer designs for experimental non-smooth and discontinuous systems*, IEEE Trans. on Control Systems Techn., **16**(6), 1323 - 1332, (2008)

W.P.M.H. Heemels, J.H. Sandee, P.P.J. van den Bosch, *Analysis of event-driven controllers for linear systems*, Int. J. of Control, **81**(4), 571 - 590, (2008)

W.P.M.H. Heemels, S. Weiland, *Input-to-state stability and interconnections of discontinuous dynamical systems*, Automatica, **4**(12), 3079-3086, (2008)

M.F. Heertjes, X.G.P. Schuurbiers, H. Nijmeijer, *Performance-Improved Design of N-PID Controlled Motion Systems with Applications to Wafer Stages*, , **IEEE**(-), 9, (2008)

J.J.M. van Helvoort, A.G. de Jager, M. Steinbuch, *Data-driven Controller Unfalsification with Analytic Update applied to a Motion System*, IEEE Trans. on Control Systems Techn., **16**(6), 1207--1217, (2008)

J.J.M. van Helvoort, A.G. de Jager, M. Steinbuch, *Data-driven multivariable controller design using Ellipsoidal Unfalsified Control*, Systems & Control Letters, **57**(9), 759-762, (2008)

T. Hofman, M. Steinbuch, R.M. van Druten, A.F.A. Serrarens, *Hybrid component specification optimization for a medium-duty hybrid electric truck*, Int. J. of Heavy Vehicle Systems (IJHVS), **15**(2/3/4), 356-392, (2008)

T.W.G.L. Klaassen, B. Bonsen, K.G.O. van de Meerakker, B.G. Vroemen, P.A. Veenhuizen, F.E. Veldpaus, M. Steinbuch, *The Empact CVT: Modeling, simulation and experiments*, Int. J. of Modelling, Identification and Control, **3**(3), 286-296, (2008)

M. Lazar, W.P.M.H. Heemels, *Global input-to-state stability and stabilization of discrete-time piecewise affine systems*, nonlinear analysis: Hybrid Systems, **2**(3), 721-734, (2008)

M. Lazar, D. Munoz de la Pena, W.P.M.H. Heemels, T. Alamo, *On the Stability of Min-max Nonlinear Model Predictive Control*, Systems & Control Letters, **57**(1), 39-48, (2008)

M. Lazar, W.P.M.H. Heemels, B.J.P. Roset, H. Nijmeijer, P.P.J. v.d. Bosch, *Input-to-state stabilizing sub-optimal NMPC with an application to DC-DC converters*, Int. J. of Robust and Nonlinear Control, **18**(8), 890-904, (2008)

R.J.E. Merry, M.J.G. van de Molengraft, M. Steinbuch, *Iterative learning control with wavelet filtering*, Int. J. of Robust and Nonlinear Control, **18**(10), 1052-1071, (2008)

S.H. van der Meulen, R.L. Tousain, O.H. Bosgra, *Fixed Structure Feedforward Controller Design Exploiting Iterative Trials: Application to a Wafer Stage and a Desktop Printer*, J. Dynamic Systems, Measurement and Control, **130**(5), 051006, (2008)

P.W.J.M. Nuij, M. Steinbuch, O.H. Bosgra, *Measuring the Higher Order Sinusoidal Input Describing Functions of a non-linear plant operating in feedback*, Control Engineering Practice, **16**(1), 101-113, (2008)

P.W.J.M. Nuij, M. Steinbuch, O.H. Bosgra, *Experimental characterization of the stick/sliding transition in a precision mechanical system using the Third Order Sinusoidal Input Describing Function*, Mechatronics, **18**(2), pp 100-110, (2008)

J.W. Oosterbeek, A. Buerger, E. Westerhof, M.R. de Baar, M. van den Berg, W.A. Bongers, M. Graswinckel, B.A. Hennen, O. Kruijt, D. Thoen, R. Heidinger, S. Korsholm, F. Leipold, S.K. Nielsen, *A line-of-sight electron cyclotron emission receiver for electron cyclotron resonance heating feedback control of tearing modes*, Rev. Sci. Instr., **79**(9), 093503, (2008)

W. Paszke, K. Galkowski, E. Rogers, J. Lam, *H2 and mixed H2/Hinf Stabilization and disturbance Attenuation for differential linear repetitive processes*, IEEE Transactions on Circuits and Systems I, **55**(9), 2813-2826, (2008)

N.B. Roozen, A.H. Koevoets, A.J. den Hamer, *Active Vibration Control of Gradient Coils to Reduce*

Acoustic Noise of MRI Systems, IEEE/ASME Trans. on Mechatronics, **13**(3), 325-334, (2008)

B.J.P. Roset, W.P.M.H. Heemels, M. Lazar, H. Nijmeijer, *On robustness of constrained discrete-time systems to state measurement errors*, Automatica, **44**(4), 1161-1165, (2008)

I. Rotariu, M. Steinbuch, R.M.L. Ellenbroek, *Adaptive Iterative Learning Control for high precision motion systems*, IEEE Trans. on Control Systems Techn., **16**(5), 1075-1082, (2008)

D.Y. Wang, S. Yao, M. Shost, J.H. Yoo, D. Cabush, D. Racine, R. Cloudt, F.P.T. Willems, *Ammonia Sensor for Closed-Loop SCR Control*, SAE Int. J. Passeng.Cars - Electron Electr. Syst., **1**(1), 323-333, (2008)

J.J.M. van de Wijdeven, O.H. Bosgra, *Residual vibration suppression using Hankel Iterative Learning Control*, Int. J. of Robust and Nonlinear Control, **18**(10), 1034-1051, (2008)

N. van de Wouw, H.A. Pastink, M.F. Heertjes, A.V. Pavlov, H. Nijmeijer, *Performance of convergence-based variable-gain control of optical storage drives* , Automatica, **44**, 15-27, (2008)

L. Wu, J. Lam, W. Paszke, K. Galkowski, E. Rogers, A. Kummert, *Control and filtering for discrete linear repetitive processes with H_inf and l_2– l_inf performance*, Multidimensional Systems and Sigal Processing, **-**(-), -, (2008)

G.M. van der Zalm, R. Huisman, M. Steinbuch, F.E. Veldpaus, *Frequency domain approach for the design of heavy-duty vehicle speed controllers*, Int. J. of Heavy Vehicle Systems (IJHVS), **15**(1), 107-123, (2008)

3.15.2 Refereed proceedings

W.H.T.M. Aangenent, G. Witvoet, W.P.M.H. Heemels, M.J.G. van de Molengraft, M. Steinbuch, *An LMI-based L2 gain performance analysis for reset control systems*, in American Control Conference 2008; Editors: IEEE, Seattle, WA, United States, 2248-2253, (2008)

M.C.J. Baggen, M.F. Heertjes, *Data-Based Feedforward Control for MIMO Motion Systems*, in IEEE American Control Conference; Seattle, United States, 3010-3016, (2008)

K.L. Barton, J.J.M. van de Wijdeven, A.G. Alleyne, O.H. Bosgra, M. Steinbuch, *Norm Optimal Cross-Coupled Iterative Learning Control*, in Conference on Decision and Control; Cancun, Mexico, 3020-3025, (2008)

J.J.T.H. de Best, M.J.G. van de Molengraft, *An Active Ball Handling Mechanism for Robocup*, in IEEE International Conference on Control, Automation, Robotics and Vision; Editors: -, Hanoi, Viet Nam, -, (2008)

M.L.G. Boerlage, R. Middleton, M. Steinbuch, A.G. de Jager, *Rejection of fixed direction disturbances in multivariable electromechanical motion systems*, in IFAC World congress, 17th; Seoul, Korea, Republic of, 1-6, (2008)

M.L.G. Boerlage, R. Middleton, M. Steinbuch, A.G. de Jager, *Rejection of fixed direction disturbances in multivariable electromechanical motion systems*, in IFAC World congress, 17th; Seoul, Korea, Republic of, 1-6, (2008)

B.H.M. Bukkems, W.P.M.H. Heemels, M.J.G. van de Molengraft, M. Steinbuch, *Tracking control for piecewise linear systems using an error space approach: A case-study in sheet control*, in Proceedings American Control Conference; Editors: IEEE, Seattle, United States, 3343 - 3349, (2008)

F. Castaños, B. Jayawardhana, R. Ortega, E. Garcia Canseco, *A class of nonlinear RLC circuits globally stabilizable by proportional plus integral controllers*, in 17th IFAC World Congress; Seoul, South Korea, -, (2008)

M.B.G. Cloosterman, N. van de Wouw, W.P.M.H. Heemels, H. Nijmeijer, *Stabilization of Networked Control Systems with Large Delays and Packet Dropouts*, in roceedings of the 2008 ACC Conference; Editors: --, Seattle, United States, 4991-4996, (2008)

M.C.F. Donkers, J.J.M. van de Wijdeven, O.H. Bosgra, *Robustness against Model Uncertainties of Norm Optimal Iterative Learning Control*, in American Control Conference; Seattle, WA, United States, 4561-4566, (2008)

M.C.F. Donkers, J.J.M. van de Wijdeven, O.H. Bosgra, *A Design Approach for Noncausal Robust Iterative Learning Control using Worst Case Disturbance Optimisation*,
in American Control Conference; Seattle, WA, United States, 4567-4572, (2008)

D. Foster, R. Cloudt, F.P.T. Willems, *Towards Integrated Powertrain Control: exploiting synergybetween a diesel hybrid and aftertreatement system in a distribution truck*, in IEEE Intelligent Vehicle Symposium (IV '08); Eindhoven, 1021-1026, (2008)

K. Galkowski, W. Paszke, E. Rogers, *Repetitive Process Approach to the Control of Self-servowriting in Disk Drives*, in CDC; Editors: -, Cancun, Mexico, -, (2008)

E. Garcia Canseco, R. Ortega, J.M.A. Scherpen, D. Jeltsema, *Power-based control of physical systems: two case studies*, in 17th IFAC World Congress; Seoul, Korea, 2556-2562, (2008)

R.F.M.M. Hamelinck, P.C.J.N. Rosielle, M. Steinbuch, R.M.L. Ellenbroek, M. Verhaegen, N. Doelman, *Test results of an adaptive deformable mirror for future*, in Proceedings of the euspen International Conference; Zurich, Switzerland, 4, (2008)

A.J. den Hamer, M. Steinbuch, S. Weiland, G.Z. Angelis, *Non-parametric H_∞ control synthesis with suboptimal controller sets*, in Proceedings of the 17th IFAC World Congress; Seoul, Korea, Republic of, -, (2008)

A.J. den Hamer, S. Weiland, M. Steinbuch, G.Z. Angelis, *Stability and causality constraints on frequency response coefficients applied for non-parametric H_2 and H_∞ control synthesis*, in Proceedings of the 47th IEEE Conference on Decision and Control; Cancun, Mexico, 3670-3675, (2008)

W.P.M.H. Heemels, M. Lazar, N. van de Wouw, A.V. Pavlov, *Observer-based Control of Discrete-time Piecewise Affine Systems: Exploiting Continuity Twice*, in Proceedings of the 47th IEEE Conference on Decision and Control (CDC2008); Cancun, Mexico, 4675-4680, (2008)

M.F. Heertjes, M. Steinbuch, *The Circle Criterion in Linear Control Design*, in IEEE American Control Conference; Seattle, United States, 3176-3181, (2008)

M.F. Heertjes, H. Nijmeijer, *Hybrid control for motion systems with improved disturbance rejection*, in ENOC08; Saint-Petersburg, Russian Federation, 1-6, (2008)

M.F. Heertjes, N. van de Wouw, W.P.M.H. Heemels, *Switching Control in Active Vibration Isolation*, in ENOC 2008; Saint-Petersburg, United States, 1-6, (2008)

D.W.T. Hennekens, D. Constantinescu, M. Steinbuch, *Continuous Impulsive Force Controller for Forbidden-Region Virtual Fixtures*, in 2008 IEEE International Conference on Robotics and Automation; Editors: IEEE, Pasadena, United States, accepted, (2008)

B.A. Hennen, E. Westerhof, J.W. Oosterbeek, P.W.J.M. Nuij, D. De Lazzari, G.W. Spakman, M.R. de Baar, M. Steinbuch, *A closed loop control system for stabilization of MHD events on TEXTOR*, in 25th Symposium on Fusion Technology (SOFT) ; Rostock, Germany, --, (2008)

R. Henselmans, L.A. Cacace, P.C.J.N. Rosielle, M. Steinbuch, *Design, realization and testing of the NANOMEFOS non-contact measurement machine for freeform optics*, in ASPE Annual meeting 2008; Portland, Oregon, United States, -, (2008)

T. Hofman, M. Steinbuch, A.F.A. Serrarens, R.M. van Druten, *Rule-based equivalent consumption minimization strategies for hybrid vehicles*, in 17th IFAC World Congress; Editors: IFAC, Seoul, Korea, Democratic People's Republic of, 6, (2008)

T. Hofman, *Parametric modeling of CVT-based hybrid drive trains*, in Advances in Hybrid powertrains international conference; Editors: IFP, F. Badin, A. Sciarretta, Paris, France, 1-10, accepted, (2008)

T.A.C. van Keulen, A.G. de Jager, M. Steinbuch, *An Adaptive Sub-Optimal Energy Management Strategy for Hybrid Drivetrains*, in Proceedings of the 17th World Congress; Editors: Myung Jin Chung, Pradeep Misra, Hyungbo Shim, Seoul, Korea, Democratic People's Republic of, 102-107, (2008)

T.A.C. van Keulen, A.G. de Jager, M. Steinbuch, *An Adaptive Sub-Optimal Energy Management Strategy for Hybrid Drive Trains*, in 27th Benelux Meeting on Systems and Control; Editors: Gjerrit Meinsma and Hans Stigter, Heeze, Netherlands, 110, (2008)

T.A.C. van Keulen, A.G. de Jager, M. Steinbuch, *Influence of Driver, Route and Vehicle Mass on Hybrid Electric Truck Fuel Economy*, in 9th International Symposium on Advanced Vehicle Control; Kobe, Japan, 911-916, (2008)

T.A.C. van Keulen, A.G. de Jager, A.F.A. Serrarens, M. Steinbuch, *Optimal Energy Management in Hybrid Electric Trucks Using Route Information*, in International Conference on Advances in Hybrid Powertrains; Editors: Francois Badin and Antonio Sciarretta, Rueil Malmaison, France, session 2, (2008)

E.P. van der Laan, F.E. Veldpaus, M. Steinbuch, *LPV Modeling of Occupants*, in 9th International Symposium on Advanced Vehicle Control (AVEC); Kobe, Japan, 620-625, (2008)

E.P. van der Laan, H.J.C. Luijten, F.E. Veldpaus, W.P.M.H. Heemels, M. Steinbuch, *Reference Governors for Controlled Belt Restraint Systems*, in International Conference on Vehicular Electronics and Safety (ICVES) ; Columbus, Ohio, United States, 114-119, (2008)

M. Lazar, W.P.M.H. Heemels, *Optimized input-to-state stabilization of discrete-time nonlinear systems with bounded inputs*, in Proceedings of the American Control Conference; Editors: IEEE, Seattle, United States, 2310 - 2315, (2008)

M. Lazar, W.P.M.H. Heemels, D. Munoz de la Pena, T. Alamo, *Further results on "Robust MPC using Linear Matrix Inequalities*, in Proceedings of 3rd International Workshop on Assessment and Future Directions of Nonlinear Model Predictive Control; Editors: -, Pavia, Italy, -, (2008)

M. Lazar, W.P.M.H. Heemels, *Predictive control of hybrid systems: Stability results for sub-optimal solutions*, in Proc. 17th IFAC World Congress; Editors: IFAC, Seoul, Korea, Republic of, -, (2008)

R.J.E. Merry, M.J.G. van de Molengraft, M. Steinbuch, *Velocity and Acceleration Estimation for Optical Incremental Encoders*, in 17th IFAC World Congress; Seoul, Korea, Republic of, 7570-7575, (2008)

R.J.E. Merry, M. Uyanik, K.R. Koops, M.J.G. van de Molengraft, M.G.A. van Veghel, M. Steinbuch, *Modeling, identification and control of a metrological Atomic Force Microscope with a 3DOF stage*, in American Control Conference; Seattle, United States, 2716-2721, (2008)

D. Munoz de la Pena, T. Alamo, M. Lazar, W.P.M.H. Heemels, *Design of ISS-Lyapunov functions for discrete-time linear uncertain systems*, in Proc. 17th IFAC World Congress; Editors: IFAC, Seoul, Korea, Republic of, -, (2008)

G.J.L. Naus, R.A.P.M. van den Bleek, J. Ploeg, B.T.M. Scheepers, M.J.G. van de Molengraft, M. Steinbuch, *Explicit MPC design and performance evaluation of an ACC Stop-&-Go*, in American Control Conference, 2008; Seattle, WA, United States, 224-229, (2008)

G.J.L. Naus, J. Ploeg, M.J.G. van de Molengraft, M. Steinbuch, *Explicit MPC design and performance-based tuning of an Adaptive Cruise Control Stop-&-Go*, in 2008 IEEE Intelligent Vehicles Symposium; Eindhoven University of Technology, Eindhoven, Netherlands, 51, (2008)

P.W.J.M. Nuij, M. Steinbuch, O.H. Bosgra, *Non-parametric identification of Higher Order Sinusoidal Output Describing Functions*, in Proceedings of ISMA2008; Editors: P. Sas, B. Bergen, Leuven, Belgium, 2361-2371, (2008)

P.W.J.M. Nuij, M. Steinbuch, O.H. Bosgra, *Bias Removal in Higher Order Sinusoidal Input Describing Functions*, in 2008 IEEE Instrumentation and Measurement Technology Conference IMTC08; Victoria, Canada, 1653-1658, (2008)

T.A.E. Oomen, O.H. Bosgra, *Robust-Control-Relevant Coprime Factor Identification: A Numerically Reliable Frequency Domain Approach*, in Proceedings of the 2008 American Control Conference; Seattle, WA, United States, 625-631, (2008)

T.A.E. Oomen, J.J.M. van de Wijdeven, O.H. Bosgra, *Suppressing Intersample Behavior in Iterative Learning Control*, in Proceedings of the 47th Conference on Decision and Control; Cancún, Mexico, 2391-2397, (2008)

T.A.E. Oomen, O.H. Bosgra, *Estimating Disturbances and Model Uncertainty in Model Validation for Robust Control*, in Proceedings of the 47th Conference on Decision and Control; Cancún, Mexico, 5513-5518, (2008)

J.H. Richter, W.P.M.H. Heemels, N. van de Wouw, J. Lunze, *Reconfigurable control of PWA systems with actuator and sensor faults: stability*, in Proceedings of the 47th IEEE Conference on Decision and Control (CDC2008); Cancun, Mexico, 1060-1065, (2008)

D.J. Rijlaarsdam, A.Y. Pogromski, H. Nijmeijer, *Synchronization between coupled oscillators: a uniform experimental approach*, in 6th EUROMECH Nonlinear Dynamics Conference; St. Petersburg, Russian Federation, accepted, (2008)

D.Y. Wang, S. Yao, M. Shost, J.H. Yoo, D. Cabush, D. Racine, R. Cloudt, F.P.T. Willems, *Ammonia Sensor for Closed-Loop SCR Control*, in SAE World Congres, SAE 2008-01-0919; Detroit, United States, (2008)

C. Werner, P.C.J.N. Rosielle, M. Steinbuch, *Design and realization of a long-stroke translation stage for*

SPM, in Nanoscale 2008; Turin, Italy, 1, (2008)

N. van de Wouw, J. de Bruijn, A. Doris, W.P.M.H. Heemels, H. Nijmeijer, *Output-feedback Control of Lur'e-type Systems with Set-valued Nonlinearities: a Popov-criterion Approach*, in Proceedings of the 2008 ACC Conference; Editors: -, Seattle, United States, 2316-2321, (2008)

B.P. Zuurendonk, J. de Boeij, E. Lomonova, M. Steinbuch, *Modeling of disturbance forces of a x-y manipulator on a floating platform* , in Proc. 6th International Symposium on Linear Drives for Industry Applications; Editors: ., Lille, France, 6p., (2008)

3.15.3 Book chapter

S. Di Cairano, M. Lazar, A. Bemporad, W.P.M.H. Heemels, *A Control Lyapunov Approach to Predictive Control of Hybrid Systems*, in Lecture Notes in Computer Science. 11th International Workshop on Hybrid Systems: Computation and Control, St. Louis, MO, USA; Editors: M. Egerstedt and B. Mishra, 130-143, Springer, Book Chapter ISBN (2008)

W.P.M.H. Heemels, M.K. Camlibel, B. Brogliato, J.M. Schumacher, *Observer-based control of linear complementarity systems*, in Lecture Notes in Computer Science. 11th International Workshop on Hybrid Systems: Computation and Control 2008, St. Louis, USA; Editors: M. Egerstedt and B. Mishra, 259-272, Springer, Book Chapter ISBN (2008)

L.J.M. van den Bedem, P.C.J.N. Rosielle, M. Steinbuch, *Design of a slave robot for laparoscopic, thoracoscopic surgery*, -, **17**(4), 211, (2008)

3.16 Overview of research input and output

Research input

	Sources of financing[1]			Total	
	1	2	3	number	fte
Senior academic staff	11			11	2.8
Supporting staff	7			7	
PhD	1	3	17	21	14.5
Postdocs	2		1	3	0.9
Total	21	3	18	42	18.2

[1] Sources of financing: 1: University
2: STW, SON, NWO, FOM, EM
3: Industry, TNO, Brite-Euram, Nuffic, Min. Econ. Affairs, etc.

[2] No research input involved for supporting staff.

[3] Research input per PhD per year: 0.8 fte

Research output

	Total
Scientific publications: refereed journals and Books	33
Scientific publications: refereed proceedings	51
PhD theses	3

3.17 Special Activities

The 6 day PATO course 'Motion Control Tuning' was again organized twice this year, the interest from industry is encouraging, we continue to give this course every year.

The 5 day PATO course 'Advanced Motion Control' was organized once. Its main focus in on multivariable motion control.

Both the Control Systems Technology group and the Dynamics and Control group were rated at the QANU research assessment of Mechanical Engineering as excellent regarding quality, productivity, relevance and viability.

4 RESEARCH DOCUMENTATION OF THE DYNAMICS AND CONTROL GROUP

4.1 Full title of the research programme Dynamics and Control (D&C)

4.2 Subsidiary programmes

4.2.1 Non-linear dynamics of mechanical systems

4.2.2 (Structural) acoustics and noise control. Optimization

4.2.3 Non-linear control of motion systems, robotics

4.2.4 Vehicle dynamics, tire dynamics and control

4.2.5 Mechanical design[4]

4.3 Programme members

Tenured research staff D&C		
Full Professor	Prof.Dr. H. Nijmeijer	0.4
Associate Professor	Dr.Ir. A. de Kraker	PM
	Dr.Ir. P.C.J.N. Rosielle	0.2
	Dr.Ir. N. v.d. Wouw	0.4
Assistant Professor	Dr.Ir. J.J.M. Besselink	0.4
	Dr.Ir. R.H.B. Fey	0.4
	Dr.Ir. I. Lopez	0.4
	Ir. L. Kodde	-
	Dr. D. Kostiç	0.2
Total tenured staff	**D&C**	**2.2**

Non-Tenured research staff D&C		
Part-time Professor	Prof.Dr.Ir. J.W. Verhey	PM
	Prof.Dr.Ir. N.B. Roozen	0.1

[4] Jointly with Control Systems Technology

	Prof.Dr.Ir. P. Jonker	0.1
	Dr.Ir. M.F. Heertjes	0.1
Total NonTenured staff D&C		**0.3**

Post-doctoral fellows D&C		
	Ir. J. Caarls	0.8
	Dr.ir. S. Lichiardopol	0.8
	Dr. Norddin Elghouti	0.1
Total		**1.7**

PhD students D&C		
	M.Sc. F.X. Debiesme	PM
	Ir. J. D.B.J. v.d. Boom (0.4 Comb. Techn.)	0.1
	Ir. R.M.C. Mestrom	0.8
	Ir. W.J.E. Evers	0.8
	Ir. R. Hendrix	0.8
	Ir. R. v.d. Steen	0.8
	Ir. N.J.M. van Dijk	0.8
	M.Sc. A.A. Alvarez Aguirre	0.7
	M.Sc. S. Adinandra	0.7
	Ir. B. Besselink	0.5
	M.Sc. J. Pena	0.1
	Ir. E. Steur	0.3
Total PhDs	**D&C**	**6.4**

Summary	**2008**
Total tenured staff	2.2
Total non-tenured staff	0.3
Total Post-doc. fellows	1.7
Total PhD students	6.4
Total non-tenured temp. reseachers	
Total research staff	**10.6**

4.4 PhD-projects per December 2008: name, source of financing and project title

4.4.1 Non-linear Dynamics of Mechanical Systems

Ir. R.M.C. Mestrom	PhD 1	Dynamics of multiphysics systems
Ir. A.A. Alvarez	PhD 3	Synchronization under delay
Ir. E. Steur	PhD 1	Network Synchronization

4.4.2 (Structural) Acoustics and Noise Control, Optimization

M.Sc. F.X. Debiesme	PhD 3	Design tools for low noise products with uncertain parameters

Ir. J.D.B.J. v.d. Boom	PhD 2	Dynamic stabilization of combustion

4.4.3 Non-linear control of motion systems, robotics

M.Sc. S. Adinandra	PhD 2	Coordination of a Autonomous Mobile Robotics
Ir. B. Besselink	PhD 3	Model reduction for controlled nonlinear systems
Ir. N.J.M. van Dijk	PhD 3	Active Chatter Control
M.Sc. J. Pena	PhD 3	Huygens Synchronization

4.4.4 Vehicle-Dynamics, Tire Dynamics and Control

Ir. W.J.E. Evers	PhD3	Active cabin suspension control
Ir. R. v.d. Steen	PhD 3	FEM Tire Modelling

4.4.5 Mechanical Design

Ir. R. Hendrix	PhD 3	Eye Rhas

4.5 Postdocs, name, and period of stay

Ir. J. Caarls, from March 2007
Dr.Ir. S. Lichardopol 1-9-07-31-8-09
Dr. Norddin Elghouti 15-11-08-

4.6 Research area and mission

The mission of the program is to conduct high-level research in the broad area of *Dynamics and Control*, with the emphasis on modeling, analysis and control of mechanical and mechatronic systems. Nonlinear dynamics and control, acoustics and robotics are among the focus areas of the group. Where possible, theoretical research is combined with numerical tools and supported by dedicated laboratory experiments. Teaching at undergraduate and graduate level is part of the mission of the program, to provide students with an up-to-date knowledge of dynamics and control.

Affiliations outside the chair

The Dynamics and Control group is a member of, or has strong formal ties with, the following institutes and organizations:
1. **EM**, Engineering Mechanics, national research school
2. **DISC**, Dutch Institute on Systems and Control, national research school

3. **ESI**, Embedded Systems Institute, a joint research institute of TU/e, TU Delft and the University of Twente, with industrial participants including Philips and Océ
4. **HYCON**, Hybrid Control Network, an EU Network of Excellence
5. **TU/e;** at TU/e the group has a strong cooperation with the Control Systems Technology group of prof. Maarten Steinbuch. This cooperation is structured as the Dynamics and Control Technology (DCT) group. The group also participates in two TU/e research areas: **SEES**, Science and Engineering of Embedded Systems, involving in particular the departments of Mathematics and Computer Science, Electrical Engineering and Mechanical Engineering; and **EMC**, Eindhoven Mechanics and Control, involving in particular the departments of Mathematics and Computer Science, Applied Physics and Mechanical Engineering;

The group

The Dynamics and Control group, headed by Henk Nijmeijer, is structured around the senior scientists, Igo Besselink, Rob Fey, Dragan Kostiç, Bram de Kraker, Ines Lopez, Nick Rosielle and Nathan van de Wouw, as well as two part-time professors, Bert Roozen and Pieter Jonker. Additional staff are Jurjen Caarls, Nordin Elghouti, and Stefan Lichiardopol as post-doc. At present, the group has around 10 PhD students, and the number of MSc students graduating in the group is currently around 23 per year. Administrative support is provided by the secretary Lia Neervoort, while the technical staff consists of Rens Kodde, Peter Hamels, Pieter van Hoof and Erwin Meinders.

Group communication and motivation

The scientific staff of the Dynamics and Control group have informal weekly meetings to exchange information and discuss upcoming events. Meetings with technicians of both the Control Systems Technology and Dynamics and Control groups are held monthly. Both regular and *ad hoc* meetings of staff members take place as and when necessary.

Student presentations on projects and traineeships and MSc colloquia are organized in collaboration with the Control Systems Technology group. The presentations are mostly held in English, as are the reports.

The staff and PhD students of the Dynamics and Control Technology group (prof. M. Steinbuch and Prof. H. Nijmeijer) and the Systems Engineering group (prof. J.E. Rooda), meet irregularly at the *Academisch Genootschap* (Academic Society) for the exchange of information and scientific presentations. This allows closer interaction between the groups on topics of mutual interest. As part of the common Master's track in Dynamical Systems Design, meetings of the group leaders Rooda, Steinbuch and Nijmeijer are held regularly.

Once a year the Dynamics and Control Technology group organizes a 24-hour off-campus DCT day (*'heidag'*) for all staff, PhDs and technicians, during which intensive discussions about the development and future of the group are held in a highly motivating environment. As well as the technical discussions for all participants and a poster competition, social activities are also an important part of this 24-hour meeting.

In view of the relatively short history of the group, there is strong motivation to build up a strong and highly motivated research team. This ambition is fostered by the regular project meetings between PhD and MSc students, supervisors and group leaders, in which clear objectives are formulated and discussed.

Teaching in the group
In teaching BSc and MSc courses, the Dynamics and Control group is responsible for:
1. Dynamics (BSc, year 1)
2. Mechanical Vibrations (BSc, year 2)
3. Multibody Dynamics (BSc, year 3)
4. College Application of Design Principles (BSc, year 3)
5. Nonlinear Dynamics (MSc, year 4)
6. Experimental Mechanics (MSc, year 4)
7. Control of Nonlinear Mechanical Systems (MSc, year 4)
8. Engineering Optimization: Concepts and Applications (MSc, year 4), with the SE group
9. Engineering Optimization: Advanced topics (MSc, year 4), with the SE group
10. Fundamentals of Systematic low noise design (MSc, year 4)
11. Vehicle Dynamics (MSc, year 4)
12. Advanced Vehicle Dynamics (MSc, year 4)
13. Numerical and Experimental Analysis of Linear Dynamical Systems (MSc, year 4)
14. Introduction Robotics (MSc, year 4)
15. Perfomance of Nonlinear systems MSc, year 4…….
16. Hunamoid Robotics (MSc 4)

The group actively participates in the post-graduate (PhD) courses of the national research schools Engineering Mechanics (EM) and the Dutch Institute on Systems and Control (DISC):
- System and Control of Nonlinear Systems (DISC, yearly, H. Nijmeijer)
- Multi-body Dynamics (EM, tri-annual, N. van de Wouw)
- Modal Analysis (EM, tri-annual, R.H.B. Fey)
- Nonlinear Dynamics (EM, tri-annual, H. Nijmeijer, N. van de Wouw)

4.7 Strategy and policy

The inherent dynamic properties of mechanical systems involve physical and geometrical nonlinearities, possibly a large number of degrees of freedom with interactions between them, and often also a relatively high speed of operation. The combination of these properties easily leads to difficulties in modeling and analysis, and thereby also in successfully implementing a model-based controller design in practice. This is the basic challenge throughout the research in the Dynamics and Control group. Clearly, the ambition of the group is to work at the forefront of today's technology, and to aim at a highly recognizable research stature not only within the department, but also in the Netherlands and internationally.

The Dynamics and Control group focuses on the following research themes:

1. Non-linear dynamics of mechanical systems
2. (Structural) acoustics and noise control, optimization
3. Non-linear control of motion systems, robotics
4. Vehicle dynamics, tire dynamics and control
5. Mechanical design[5]

1. Non-linear dynamics of mechanical systems

The numerical and experimental study of non-linear and in particular non-smooth mechanical systems, such as systems with friction, impacts or other constraints are

[5] Jointly with Control Systems Technology

key activities in this sub-theme, and play an essential role in the modeling and analysis of advanced mechanical systems. The research on these phenomena is highly relevant in many engineering applications (friction in high-performance/high-precision systems, drill strings, high-speed milling, hybrid control systems etc.). Numerical aspects are notably difficult, but are becoming more and more feasible with increasing computer power.

2. (Structural) acoustics and noise control, optimization
This sub-theme deals with various structural vibrations and the associated sound radiation. The focus is on the one hand on numerical/computational tools for acoustic models, and on the other hand on the experimental validation of those tools. Subsequently, both passive and active means for acoustic noise suppression are investigated. Several mechanical applications are used as benchmark examples, particularly tire–road noise. The development of tools for optimization is essential in the dynamic behavior of mechanical constructions.

3. Non-linear control of motion systems, robotics
In the non-linear control area, the emphasis is placed on (i) stability, stabilization and performance of non-linear/non-smooth systems; (ii) synchronization/coordination of mechanical systems; and (iii) embedded control of mechanical systems. Particular interest lies in applications in robotic systems. In this theme too, the theoretical developments are combined with and supported by experimental validation in the lab.

4. Vehicle dynamics, tire dynamics and control
Since 2002, the group has been responsible for the research and teaching in vehicle dynamics. The research focuses on modeling and analysis of articulated vehicles, and modeling and analysis of vehicle tires. For the latter, extensive use is made of the flat plank tire tester. The tire research is linked to the tire–road noise research referred to above.

5. Mechanical design[6]
The Constructions and Mechanisms group focuses on a range of research questions in mechanical design. Design projects on measurement accuracy form a substantial part of the group's work, as does a growing research line which addresses minimally invasive robotic surgery systems.

The research activities of the Dynamics and Control group take place partly in cooperation with the Control Systems Technology group. The general research objective of the Dynamics and Control Technology group is the study of all aspects related to the dynamics and control of high-performance mechanical systems. This covers the full range of topics such as design, modeling and analysis of systems, controller synthesis, signal analysis and performance analysis. Where possible, practical and experimental validation also form part of the research.
The above research themes represent a coherent representation of up-to-date research in the field. Each research theme can be viewed as a separate activity, but projects often focus on combinations of several themes. For example, non-linear

[6] Jointly with Control Systems Technology

dynamics is intimately linked to non-linear control, and both are used in the robotics and vehicle dynamics application domains. Likewise, tire–road noise forms an important research topic, and requires expertise in both acoustics and tire dynamics. Mechanical design, a theme shared with the Control Systems Technology group, is in many ways relevant in the other research themes. The selected research themes also make a substantial contribution to the engineering and research training of the mechanical engineering students.

In each of the themes, relevant lab set-ups are available for experimental validation, and in other cases such set-ups are designed and built. In a few of these themes there is closer cooperation with the Control Systems Technology group, but there is a clear distinction from that group regarding the specific non-linear approach towards both dynamics and control.

4.8 Processes in research, internal and external collaboration

Research

The research within the Dynamics and Control group is organized under the banner of the DISC (Dutch Institute of Systems and Control) and EM (Engineering Mechanics) national research schools. This enables cooperation between groups both locally and nationally in the fields of interest. The common interest in systems and control theory is the central theme within DISC. DISC was evaluated and reapproved as a national research school by the KNAW (Royal Netherlands Academy of Arts and Sciences) in 2005. In Eindhoven we have organized the DISC groups within 'Eindhoven Control'. Each year DISC organizes advanced PhD courses on a one-day-per-week basis, in which many of the group's PhD students participate. Prof. Nijmeijer teaches a DISC course on Nonlinear Systems and Control each year. The group is part of the EU's Marie Curie Control Training Site, an initiative to promote short-term visits of PhD students to partner institutes. The Control Training Site has been included in the activities of the EU HYCON Network of Excellence since 2006. The group also takes part in the EM (Engineering Mechanics) national research school. Engineering Mechanics was evaluated and reapproved as a national research school by the KNAW in 2001 and 2007. Engineering Mechanics organizes advanced PhD courses in a slightly different manner, with courses lasting one to two weeks. The Dynamics and Control group members R. Fey, H. Nijmeijer, J. Rijpkema and N. van de Wouw are involved in EM courses. At TU/e the EM research groups are organized in the TU/e research area Eindhoven Mechanics and Control (EMC).

Collaborations

Internal

Within the department, as stated above, the Dynamics and Control group collaborates intensively with the Control Systems Technology group, sharing several of the laboratory facilities. In addition, research cooperations exist with the Systems Engineering group, the Combustion Technology group, the Polymer Technology group and the Energy Technology group within the department. Cooperation has also been established with the Embedded Systems Institute (ESI) at TU/e. There are also collaborations with the groups of prof. GertJan van Heijst (Applied Physics), prof.

Henk Corporaal (Electrical Engineering) and prof. Kees van Hee (Computer Science) through the TU/e SEES and EMC research profiles.

National research institutes

As far as national research institutes are concerned, important co operations exist with the following major TNO institutes:

- TNO Industry in the field of high-speed chattering
- TNO Automotive in the field of vehicle dynamics and control
- TNO Applied Physics in the field of structural acoustics, in the area of opto-mechanics
- TNO Building & Construction Research in the field of non-linear dynamics and multi-phase materials

The Senter-TS-funded 'Boderc' research project with the Embedded Systems Institute (ESI, Eindhoven) ran in the period 2002-2008. We are actively involved in this project on embedded systems, and work together with a number of others universities and industrial partners (Océ, Philips). Since 2006 the group participates in ESI's Falcon project for the development of a future distribution centre.

International cooperation

Within the EU 5th framework program, the Dynamics and Control group participates in a number of European Projects such as SICONOS (non-smooth dynamics and control) and the Marie Curie Control Training Site (CTS). In the 6th framework we are actively involved in the HYCON Network of Excellence in which the emphasis is on (the control of) hybrid systems.

Dynamics and Control of Hybrid Mechanical Systems (DyCoHyMS) is a joint project sponsored by NWO (Netherlands Organisation for Scientific Research) and its Russian counterpart RBFR, in which the Dynamics and Control group cooperates with researchers from St. Petersburg (G. Leonov, A. Fradkov) and Nizhny Novgorod (V.I. Belykh) with the aim of creating novel (experimental) results in the area of synchronization and coordination of multiple mechanical systems.

Each year substantial numbers of students go abroad for their 14-week training period to visit various colleagues in the field (for example in Australia, Detroit, Florida, Singapore, Copenhagen, San Diego, Vancouver, Mexico, Japan etc.). These traineeships take place in groups with which cooperation's already exist. The Dynamics and Control group has extensive external cooperation's with the persons and universities listed below, as shown by joint publications:

- Prof. Zhong Ping Jiang, Polytechnic Univ, New York
- Prof. Kristin Pettersen, Prof. Thor Fossen, prof. Tor-Arne Johanson, MSc Anne-Karin Bondhus, dr. Erik Kyrkeby, dr. A.Pavlov, NTNU Trondheim, Norway
- Prof. W.Respondek, INSA, Rouen, France
- Dr. Fred Mazenc INRIA Montpellier, France
- Dr. A. Rodriguez-Angeles, CINVESTAV, Mexico
- Dr. D. Lizarraga, IPICYT, Mexico
- Dr. N.P.I.Aneke, Ford, Aachen, Germany
- Dr. R.I.Leine, Prof. C. Glocker, ETH, Zürich, Switzerland
- Dr. G. Santoboni, Maryland, USA
- Dr. C. Cruz, CICESE, Mexico
- Prof. B. Brogliato, INRIA Rhones Alpes, Grenoble, France
- Prof. K. Tchon, dr. J.Jakubiak, Techn. Univ. Wroclaw, Poland
- Dr. H.J.C. Huijberts, Queen Mary, University of London
- Dr. A. Loria, dr. E. Panteley, Prof. R. Ortega, Prof. F. Lagarigue-Lamnabhi, LSS, Gif-sur-Yvette, France
- Dr. D. Putra, Technical University Bandung, Indonesia

- Prof. A. Fradkov, Prof. I.I. Blekhman, Russian Academy of Sciences, St. Petersburg, Russia
- Prof. G. Leonov, St. Petersburg University, St. Petersburg, Russia
- Prof. V. Belykh, Nizhny Novgorod University, Nizhny Novgorod, Russia
- Prof. R. Sepulchre, University of Liège, Belgium
- Prof. J. Hespana, University of California, Santa Barbara, USA
- Dr. I. Tyukin, University of Leicester, UK
- Prof. C. van Leeuwen, RIKEN Institute of Brain Science, Tokyo, Japan
- Prof. J. Imura, Tokyo Inst. of Technology, Tokyo, Japan
- Prof. C. Bil, RMIT Univ., Melbourne, Australia
- Dr. T. Oguchi, Tokyo Metropolitan University, Tokyo, Japan
- Prof. A. Shukla, Miami University, Ohio, USA
- Dr. W. Michiels, KULeuven, Leuven, Belgium

Several international researchers have visited the Dynamics and Control group for longer periods. A list of visitors is given below:

- Dr. T. Oguchi, Tokyo Metropolitan University, Tokyo, Japan October 2008 – September 2009

4.9 Academic reputation and memberships

Prof.Dr. H. Nijmeijer:

- Editor in Chief Journal of Applied Mathematics
- Associate editor AUTOMATICA
- Corresponding editor SIAM J Control Optimization
- Subject editor International J. of Robust and Nonlinear Control
- Member Editorial Board J. of Applied Mathematics Computer Science
- Member Editorial Board J. of Dynamical Control Systems
- Member Editorial Board International J. of Control
- Member Editorial Board J. of Stability and Control
- Member Editorial Board European Journal of Control
- Member Editorial Board International Journal of Bifurcation en Chaos
- Board International Physics and Control Society (IPACS)

Prof.Dr.Ir. N.B. Roozen:

- President of the Acoustical Society of the Netherlands (NAG)
- Director of the International Institute of Acoustics and Vibration (IIAV).

4.10 External validation

Industrial contacts and co-operations

The Dynamics and Control group has a growing number of industrial contacts and co-operations with the high-tech industry in the Eindhoven region. Clearly, these are linked to the group's unique expertise in the area of dynamics and nonlinear control.

In many cases the first contacts are developed through MSc projects in which MSc students works on their final-year projects in industry under the supervision of one of the staff members of the group. A number of PhD projects exist with industrial support, for example from Océ, Vredestein, DAF and TNO. A number of current projects are sponsored by Technology Foundation STW; typically these also have substantial financial support from industrial partners. There is also a current co-operation with Philips Research, CFT and Philips Optical Storage on optical drive systems and vibration control. At the level of students' final thesis work, other industrial contacts are maintained with Océ, Philips Electronics, DAF, LMS, ASML, NXP, Bosch Rexroth, Lips and several other industrial partners.

Platforms between universities and industry
The group is involved in various initiatives regarding high-tech industries, such as the Platform for HighTech Systems, HighTech Automotive Systems and Point-One. All these initiatives have in common the fact that industry-driven research questions are formulated and sponsored by government and industry.

Spin-offs
R. Scholte and H. Nijmeijer received an STW Valorisation Grant (25.000 euro) for their proposal ANSITE (Acoustic Imaging)
A prototype of a Mobile Intensive Care Unit (MICU) for pediatric patients has been developed in cooperation with the Construction and Mechanisms laboratory and Maastricht University Hospital (MUH). Plans exist at MUH to develop the prototype into a commercial product.

4.11 Resources, funding and facilities

Facilities
The Dynamics and Control group shares the following laboratory facilities in the Mechanical Engineering Department:

The Motion and Robotics laboratory, also called DCT laboratory
The Motion and Robotics laboratory is a joint laboratory of the Systems Technology and Dynamics and Control groups. It provides an educational and research facility for motion- related MSc and PhD student projects. Laboratory facilities are regularly replaced by newer set-ups to keep the laboratory up-to-date. In the past few years a drill-string set-up, an H-drive pick-and-place system, an RRR robot manipulator, an inverted pendulum, and a one-sided impact flexible beam have been actively used as research test beds. Research is also carried out using a FAMM direct-drive robot, four mechanical pick-and-place units, several small-scale mobile robots, a 1-DOF medical manipulator with force feedback, and an accurate dynamic buckling test facility and a mechanical set-up for slip detection. A real-time Linux-based data-acquisition system has been set up for rapid control prototyping. In addition, we built an experimental set-up for a printer paper path control problem in 2006, and a new environment has also been built for a new course on Embedded Motion Control. Finally, we have been active with set-ups for the TechUnited RoboCup soccer robots.
The Fluid Power (FP) laboratory is the place for all hydraulic activities, and it also supports the automotive power train research.
The technical staff (mechanical and electrical) provide support and create a stimulating environment for PhD and MSc students to carry out experiments in the

DCT lab. The real-time hardware, data acquisition and measurement equipment includes more than 10 dSpace systems, 5 SigLab measurement systems and over 30 TU/e DACS systems which enable students to use their own notebook computers as real-time control processors.

The AES lab

The department has growing activities in automotive systems. Each division participates in the Automotive Engineering Science Master's track within the Mechanical Engineering department. The automotive research activities now have also grouped almost all their experimental facilities in the renovated Automotive Engineering Science laboratory in the W-laag building. The renovated AES lab facility was opened in September 2003. In 2003, the flatplank tire tester was obtained from TU Delft – where the vehicle dynamics activities were stopped – and forms a valuable set-up for tire and vehicle dynamics research. Another tire testing facility, the measuring tower to be installed on a controlled drum, will also become operational in the near future. With support from Paccar and TU/e, a substantial step forward has been made in 2006 by completely renewing the drum facility in the AES lab, which now makes it an up-to-date test facility for a range of driving and tire tests.

The Constructions and Mechanisms laboratory

The Constructions and Mechanisms laboratory is led by dr.ir. Nick Rosielle, who is himself supervised by both the Control Systems Technology and the Dynamics and Control chairs. In this laboratory about 6-8 PhDs and 10 MSc students are specializing in the design and construction of machines, instruments and consumer products, with a focus on positioning and manipulation using design principles.

Details of funding (in k€) of Dynamics and Control

Research projects	**2007**	**2008**
EU-CTS	5	-
STW-5792-Dynamic Buckling	70	-
TS: Boderc	55	-
STW-Scholten	40	65
EU-HYCON	25	40
STW-Active … acoustic instabilities)*	75	45
TNO-Automotive (WJ Evers)	55	55
Senter-IOP EyeRhas	70	70
Stimulus M2 Buddy Buzzer	7	-
CCAR-TNO-Vredestein	52	55
NWO-DyCoHyMS	30	30
Senter-IOP PT Chatter Control	52	60
Senter-IOP PT Fast Focus	52	60
ESI-Falcon	70	100
NWO-Nonsmooth Stability	40	45
TNO Automotive	30	-
Teleman/SEES	25	60
Lips	15	10
Devlab	30	-
STW-Model Reduction	20	40
TNO Automotive flatplank	10	10
STW Valorisationgrand ANSTTE		25
Pro9ject C'mm'n		25
Intelligent Vehicles Symp.		30
Total k€ external funding	902	

4.12 Keynote & general lectures; seminars (duration 40 min. or more

4.13 Awards and patents

Awards:

At the EUROMECH Nonlinear Dynamics Conference, held in St. Petersburg, Russia from June 30 till July 4, Rob Mestrom received the Young's Author's Prize in the category Young Scientists.
He presented his paper *[1]* in the mini-symposium on Micro- and Nano-Electro-Mechanical Systems

Ir. E. Steur won the KIVI NIRIA Regeltechniekprijs 2008 best master thesis on Control Engineering.

Patents:

R. Scholte, I. Lopez Arteaga, N.B. Roozen, H. Nijmeijer, *Acoustic Holography*, Patent: EP08155162.4 (2008) - -

4.14 PhD theses

M.B.G. Cloosterman, *Control over Communication Networks: Modeling, Analysis, and Synthesis,* PhD. Thesis, 2008, TU/e
Advisors: H. Nijmeijer
Co-advisor: N. van de Wouw, W.P.M.H. Heemels

J.A.W.M.van Eekelen, *Modelling and control of discrete event manufacturing flow lines,* PhD. Thesis, 2008, Eindhoven University of Technology
Advisors: J.E. Rooda, H. Nijmeijer
Co-advisor: A.A.J. Lefeber

N.J. Mallon, *Dynamic Stability of Thin-Walled Structures; a semi-analytical and experimental approach*, PhD. Thesis, 2008, Eindhoven University of Technology
Advisors: H. Nijmeijer,
Co-advisor: R.H.B. Fey

R. Scholte, *Fourier based High-resolution Near-field Sound Imaging,* PhD. Thesis, 2008, Eindhoven University of Technology
Advisors: N.B. Roozen, H. Nijmeijer
Co-advisor: I. Lopez Arteaga

4.15 Academic publications

4.15.1 Article (refereed)

J.J.B. Biemond, A.P.S. de Moura, G. Károlyi, C. Grebogi, H. Nijmeijer, *Onset of chaotic advection in open flows*, The American Physical Society, **78**(-), 016317-1016317-5, (2008)

M.K. Camlibel, W.P.M.H. Heemels, J.M. Schumacher, *Algebraic necessary and sufficient conditions for the controllability of conewise linear systems*, IEEE Trans. on Aut. Control, **53**(3), 762-774, (2008)

M.K. Camlibel, W.P.M.H. Heemels, J.M. Schumacher, *A full characterization of stabilizability of bimodal piecewise linear systems with scalar inputs*, Automatica, **44**(5), 1261-1267, (2008)

A. Doris, A.L.. Juloski, N. Mihajlovic, W.P.M.H. Heemels, N. van de Wouw, H. Nijmeijer, *Observer designs for experimental non-smooth and discontinuous systems*, IEEE Trans. on Control Systems Techn., **16**(6), 1323 - 1332, (2008)

W.J.E. Evers, I.J.M. Besselink, A.C.M. Knaap, van der, H. Nijmeijer, *Development and validation of a modular simulation model for commercial vehicles*, Int. J. of Heavy Vehicle Systems (IJHVS), **-**(-), (accepted), (2008)

M.F. Heertjes, X.G.P. Schuurbiers, H. Nijmeijer, *Performance-Improved Design of N-PID Controlled Motion Systems with Applications to Wafer Stages*, , **IEEE**(-), 9, (2008)

H.J.C. Huijberts, H. Nijmeijer, T. Oguchi, *Erratum:* \, Chaos, **18**(1), 019901, (2008)

M. Lazar, W.P.M.H. Heemels, B.J.P. Roset, H. Nijmeijer, P.P.J. v.d. Bosch, *Input-to-state stabilizing sub-*

optimal NMPC with an application to DC-DC converters, Int. J. of Robust and Nonlinear Control, **18**(8), 890-904, (2008)

R.I. Leine, N. van de Wouw, *Stability Properties of Equilibrium Sets of Nonlinear Mechanical Systems with Dry Friction and Impact*, Nonlinear Dynamics, **51**(4), 551--583, (2008)

R.I. Leine, N. van de Wouw, *Uniform convergence of monotone measure differential inclusions: with application to the control of mechanical systems with unilateral constraints*, Int. Jnl. Bifurcation and Chaos, **18**(5), 1435–-1457, (2008)

N.J. Mallon, R.H.B. Fey, H. Nijmeijer, *Dynamic stability of a thin cylindrical shell with top mass subjected to harmonic base-acceleration*, Int. J. Solids Structures, **45**(6), 1587-1613, (2008)

R.M.C. Mestrom, R.H.B. Fey, K.L. Phan, J.T.M. van Beek, H. Nijmeijer, *Modelling the Dynamics of a MEMS Resonator: Simulations and Experiments*, Sensors & Actuators A, **142**(1), 306-315, (2008)

N.B. Roozen, A.H. Koevoets, A.J. den Hamer, *Active Vibration Control of Gradient Coils to Reduce Acoustic Noise of MRI Systems*, IEEE/ASME Trans. on Mechatronics, **13**(3), 325-334, (2008)

B.J.P. Roset, W.P.M.H. Heemels, M. Lazar, H. Nijmeijer, *On robustness of constrained discrete-time systems to state measurement errors*, Automatica, **44**(4), 1161-1165, (2008)

A.J.C. Schmeitz, I.J.M. Besselink, S.T.H. Jansen, *TNO MF-SWIFT*, Vehicle System Dynamics, **45**(Suppl), 121–137, (2008)

R. Scholte, I. Lopez Arteaga, N.B. Roozen, H. Nijmeijer, *Wavenumber domain regularisation for near-field acoustic holography by means of modified filter functions and a cut-off and slope iteration*, Acta Acustica, **94**(3), 339-348, (2008)

R. Scholte, I. Lopez Arteaga, N.B. Roozen, H. Nijmeijer, *Experimental application of high precision k-space filters and stopping rules for fully automated Near-filed Acoustic Holography*, **13**(4), 157-164, (2008)

I. Tyukin, E. Steur, H. Nijmeijer, C. van Leeuwen, *Nonuniform small-gain theorems for systems with unstable invariant sets*, SIAM J Control Optimization, **47**(2), 849-882, (2008)

A.A. van Veggel, D. van den Ende, J. Bogenstahl, S. Rowan, W. Cunningham, G.H.M. Gubbels, H. Nijmeijer, *Hydroxide catalysis bonding of silicon carbide* , Journal of the European Ceramic Society, **28**(28), 303-310, (2008)

A.A. van Veggel, H. Nijmeijer, *Stable mounting of beamsplitters for an interferometer*, Precision Engineering, (33), 7-17, (2008)

N. van de Wouw, A.V. Pavlov, *Tracking and Synchronisation for a Class of PWA Systems*, Automatica, **44**(11), 2909--2915, (2008)

N. van de Wouw, H.A. Pastink, M.F. Heertjes, A.V. Pavlov, H. Nijmeijer, *Performance of convergence-based variable-gain control of optical storage drives* , Automatica, **44**, 15-27, (2008)

4.15.2 Refereed proceedings

M.S. Anayevskiy, A.L. Fradkov, H. Nijmeijer, *Control of mechnical systems with constraints: two pendulums case study*,
in 17th IFAC World Congress; Editors: Myung Jin Chung, Pradeep Misra, Hyungbo Shim, Seoul, Korea, Republic of, 7690-7694, (2008)

M.S. Anayevskiy, A.L. Fradkov, H. Nijmeijer, *Control of two pendulums with energy constraints*,
in ENOC 2008; Editors: ENOC 2008, Saint Petersburg, Russian Federation, 6 pp, (2008)

V. Belykh, E. Pankratova, A.Y. Pogromski, H. Nijmeijer, *Two Van Der Pol--Duffing Oscillators With Huygens Coupling*,
in 6th EUROMECH Nonlinear Dynamics Conference; St. Petersburg, Russian Federation, accepted, (2008)

V. Belykh, B. Ukrainsky, H. Nijmeijer, A.Y. Pogromski, *A Discrete-time Hybrid Lurie Type System With Strange Hyperbolic Nonstationary Attractor*,
in 6th EUROMECH Nonlinear Dynamics Conference; St.Petersburg, Russian Federation, accepted, (2008)

I.J.M. Besselink, T.J. Veldhuizen, H. Nijmeijer, *Improving Yaw Dynamics by Feedforward Rear Wheel Steering*,
in IEEE Intelligent Vehicles Symposium; Eindhoven, Netherlands, 5, (2008)

M.B.G. Cloosterman, N. van de Wouw, W.P.M.H. Heemels, H. Nijmeijer, *Stabilization of Networked Control Systems with Large Delays and Packet Dropouts*,
in roceedings of the 2008 ACC Conference; Editors: --, Seattle, United States, 4991-4996, (2008)

N.J.M. van Dijk, N. van de Wouw, H. Nijmeijer, R.P.H. Faassen, E.J.J. Doppenberg, J.A.J. Oosterling, *Real-Time Detection and Control of Machine Tool Chatter in High-speed Milling*,
in 2nd International Conference ; Cluny, France, on CDROM, (2008)

R.R.J.J. van Doorn, I. Lopez Arteaga, R. van der Steen, N.B. Roozen, H. Nijmeijer, *Frequency loci veering in deformed rotating tyres*,
in Euronoise 2008; Paris, France, (2008)

R.R.J.J. van Doorn, I. Lopez Arteaga, R. van der Steen, N.B. Roozen, H. Nijmeijer, *Transmissibility of a deformed rotating tyre*,
in Euronoise 2008; Paris, France, -, (2008)

W.J.E. Evers, A.C.M. Knaap, van der, I.J.M. Besselink, H. Nijmeijer, *Modeling, Analysis and Control of a Variable Geometry Actuator*,
in Intelligent Vehicles Symposium; Eindhoven, Netherlands, 251-256, (2008)

W.J.E. Evers, A.C.M. Knaap, van der, I.J.M. Besselink, H. Nijmeijer, *Analysis of a Variable Geometry Active Suspension*,
in International Symposium on Advanced Vehicle Control; Kobe, Japan, 350-355, (2008)

R.H.B. Fey, R.M.T. Wouters, H. Nijmeijer, *Steady-state vibration mitigation in a piecewise linear beam system using PD control*,
in 6th EUROMECH Nonlinear Dynamics Conference (ENOC 2008); Editors: A. Fradkov, B. Andrievsky, June 30 - July 4, 2008, Saint Petersburg, Russian Federation, paper c7p40r3968, (2008)

W.P.M.H. Heemels, M. Lazar, N. van de Wouw, A.V. Pavlov, *Observer-based Control of Discrete-time*

Piecewise Affine Systems: Exploiting Continuity Twice,
in Proceedings of the 47th IEEE Conference on Decision and Control (CDC2008); Cancun, Mexico, 4675-4680, (2008)

M.F. Heertjes, H. Nijmeijer, *Hybrid control for motion systems with improved disturbance rejection*,
in ENOC08; Saint-Petersburg, Russian Federation, 1-6, (2008)

M.F. Heertjes, N. van de Wouw, W.P.M.H. Heemels, *Switching Control in Active Vibration Isolation*,
in ENOC 2008; Saint-Petersburg, Russian Federation, 1-6, (2008)

H.J.C. Huijberts, W. Michiels, H. Nijmeijer, *On the characterisation of stability by means of time-delayed feedback control*,
in 47th IEEE Conference on Decision and Control; Editors: IEEE, Cancun, Mexico, 5280-5285, (2008)

S. Lichiardopol, N. van de Wouw, H. Nijmeijer, *Boosting Human Force: A Robotic Enhancement of a Human Operator's Force*,
in Proceedings of the 47th IEEE Conference on Decision and Control (CDC2008); Cancun, Mexico, 4576-4581, (2008)

I. Lopez Arteaga, C.A. Blok, H. Nijmeijer, *Energy dissipation of a friction damper: experimental validation*,
in ISMA 2008; Editors: P. Sas, B. Bergen, Leuven, Belgium, 881-892, (2008)

R.M.C. Mestrom, R.H.B. Fey, H. Nijmeijer, *Theoretical and experimental nonlinear dynamics of a clamped-clamped beam MEMS resonator*,
in 6th EUROMECH Nonlinear Dynamics Conference (ENOC 2008); Editors: A. Fradkov, B. Andrievsky, June 30 - July 4, 2008, Saint Petersburg, Russian Federation, paper c7p185r4415, (2008)

W. Michiels, H. Nijmeijer, *Synchronization in networks of nonlinear oscillators wihth coupling delays*,
in 47th IEEE Conference on Decision and Control ; Editors: IEEE, Cancun, Mexico, 2056-2062, (2008)

T. Oguchi, H. Nijmeijer, *Synchronization of chaotic systems in unidirectional ring networks with delay*,
in 6th Euromech Nonlinear Dynamics Conference; Editors: European Mechanics Society, Saint Petersburg, Russian Federation, CD rom 6 pp, (2008)

T. Oguchi, H. Nijmeijer, T. Yamamoto, T. Kniknie, *Synchronization of Four Identical Nonlinear Systems with Time-delay*,
in 17th IFAC World Congress; Editors: Myung Jin Chung, Pradeep Misra, Hyungbo Shim, Seoul, Korea, Republic of, 12153-12158, (2008)

T. Oguchi, H. Nijmeijer, T. Yamamoto, T. Kniknie, *Synchronization of Four Identical Nonlinear Systems with Time-delay*,
in 17th IFAC World Congress; Editors: Myung Jin Chung, Pradeep Misra, Hyungbo Shim, Seoul, Korea, Republic of, 12153-12158, (2008)

A.V. Pavlov, N. van de Wouw, *Convergent discrete-time nonlinear systems: the case of PWA systems*,
in Proceedings of the 2008 ACC Conference; Editors: -, Seattle, United States, 3452-3457, (2008)

A.V. Pavlov, N. van de Wouw, *Fast computation of frequency response functions for a class of nonlinear systems*,
in Proceedings of the 47th IEEE Conference on Decision and Control (CDC2008); Cancun, Mexico, 1180-1186, (2008)

J.H. Richter, W.P.M.H. Heemels, N. van de Wouw, J. Lunze, *Reconfigurable control of PWA systems with actuator and sensor faults: stability*,
in Proceedings of the 47th IEEE Conference on Decision and Control (CDC2008); Cancun, Mexico, 1060-1065, (2008)

D.J. Rijlaarsdam, A.Y. Pogromski, H. Nijmeijer, *Synchronization between coupled oscillators: a uniform experimental approach*,
in 6th EUROMECH Nonlinear Dynamics Conference; St. Petersburg, Russian Federation, accepted, (2008)

R. Scholte, I. Lopez Arteaga, N.B. Roozen, H. Nijmeijer, *Applications of Near-field Acoustic Holography on Small Apertures*,
in Proceedings of Acoustics 2008; Editors: Paris, France, -, (2008)

R. van der Steen, I. Lopez Arteaga, B. de Bruijn, A.J.C. Schmeitz, H. Nijmeijer, *FE modeling of rubber friction on rough roads*,
in Proceedings of the WCCM8, ECCOMAS; Editors: B.A. Schrefler, U. Perego, Venice, Italy, CD-ROM, (2008)

E. Steur, L. Kodde, H. Nijmeijer, *Synchronization of diffusively coupled electronic Hindmarsh-Rose oscillators*,
in 6th Euromech Nonlinear Dynamics Conference; Editors: european mechanics society, Saint Petersburg, Russian Federation, CD rom 6 pp, (2008)

I. Tyukin, H. Nijmeijer, C. van Leeuwen, *Non-uniform Small-gain Theorems for Systems with Critical and Slow Relaxations*,
in 17th IFAC World Congress ; Editors: Myung Jin Chung, Pradeep Misra, Hyungbo Shim, Seoul, Korea, Republic of, 6269-6276, (2008)

I. Tyukin, E. Steur, H. Nijmeijer, C. van Leeuwen, *State and Parameter Estimation for Systems in Non-canonical Adaptive Observer Form*,
in 17th IFAC World Congress; Editors: Myung Jin Chund, Pradeep Misra, Hyungbo Shim, Seoul, Korea, Republic of, 14372-14378, (2008)

I. Tyukin, E. Steur, H. Nijmeijer, C. van Leeuwen, *Non-uniform Small-gain Theorems for Systems with Unstable Invariant Sets*,
in 47th IEEE Conference on Decision and Control; Editors: IEEE, Cancun, Mexico, 5080-5085, (2008)

N. van de Wouw, J. de Bruijn, A. Doris, W.P.M.H. Heemels, H. Nijmeijer, *Output-feedback Control of Lur'e-type Systems with Set-valued Nonlinearities: a Popov-criterion Approach*,
in Proceedings of the 2008 ACC Conference; Editors: -, Seattle, United States, 2316-2321, (2008)

N. van de Wouw, R.I. Leine, *Convergence properties of monotone measure differential inclusions*,
in Proceedings of the 6th EUROMECH Nonlinear Oscillations Conference (ENOC); Editors: A. Fradkov, St. Petersburg, Russian Federation, --, (2008)

N. van de Wouw, R.I. Leine, *Tracking Control for a Class of Measure Differential Inclusions*,
in Proceedings of the 47th IEEE Conference on Decision and Control (CDC2008); Cancun, Mexico, 2526-2532, (2008)

4.15.3 Book

R.I. Leine, N. van de Wouw, *Stability and Convergence of Mechanical Systems with Unilateral Constraints*, Springer Verlag, ISBN 978-3-540-76974-3 (2008)

4.15.4 Book chapter

W.P.M.H. Heemels, M.K. Camlibel, B. Brogliato, J.M. Schumacher, *Observer-based control of linear complementarity systems*, in Lecture Notes in Computer Science. 11th International Workshop on Hybrid Systems: Computation and Control 2008, St. Louis, USA; Editors: M. Egerstedt and B. Mishra, 259-272, Springer, ISBN (2008)

4.16 Overview of research input and output

Research input

	Sources of financing[1]			Total	
	1	2	3	number	fte
Senior academic staff	11			11	2.5
Supporting staff	4			4	
PhD	2	2	8	12	6.4
Postdocs			3	3	1.7
Total	17	2	11	30	10.6

[1] Sources of financing: 1: University
2: STW, SON, NWO, FOM, EU
3: Industry, TNO, Brite-Euram, Nuffic, Min. Econ. Affairs, etc.

[2] No research input involved for supporting staff.

[3] Research input per PhD per year: 0.8 fte

[4] No research input involved for Twaio-students because they perform a designers progamme

Research output

	Total
Scientific publications: refereed journals and Books	24
Scientific publications: refereed proceedings	36
PhD theses	4

4.16 Special Activities

Prof. H. Nijmeijer together with prof. B. Van Arem (UT) acted as co-chair of the very successful IEEE Intelligent Vehicles Symposium IV08 that was held 4-6 June in Eindhoven. The conference attracted over 400 participants and with its demo-day at the Kenedylaan in front of the TU/e reached a large public coverage.

Both the Control Systems Technology group and the Dynamics and Control group were rated at the QANU research assessment of Mechanical Engineering as excellent regarding quality, productivity, relevance and viability.

5 INTERNAL REPORTS

P.G.M. Hoeijmakers, Coaches: O.M. Aamoo, H. Nijmeijer, *Implementation of an extremum seeking controller for vortex shedding attenuation in a 2D*, 37, DCT 2008.009, Internal Report (2008)

C.H.A. Criens, Coaches: W.H.T.M. Aangenent, M.F. Heertjes, M.J.G. van de Molengraft, M. Steinbuch, *LPV Control of an Active Vibration Isolation System*, 47, DCT 2008.082, Internal Report (2008)

O.A. Nguepkap Yamba, Coaches: T. Backx, M. Steinbuch, *Cooling Crystallization PID and MPC Control*, 24, DCT 2008.151, Internal Report (2008)

B.J.S. van Putten, Coaches: M. Baderschneider, A. Pinnel, I.J.M. Besselink, *Design of an Electronic Stability Program for vehicle simulation software*, 24, DCT 2008.138, Internal Report (2008)

J.A.M. Hopmans, Coaches: I.J.M. Besselink, *Analysis of a Dakar rally truck using a multibody model*, 53, DCT 2007. 139, Internal Report (2008)

J.A.M. Hopmans, Coaches: I.J.M. Besselink, *Analysis of Dakar ralley truck using a multibody model*, 65, DCT 2007.139, Internal Report (2008)

W. Lamers en P.W. Fleuren, Coaches: I.J.M. Besselink, H. Nijmeijer, *Voertuidynamica FSRTEo2*, 49, DCT 2008.056, Internal Report (2008)

W Lamers en P.W. Fleuren, Coaches: I.J.M. Besselink, H. Nijmeijer, *Voertuigdynamica FSRTEO2*, 49, DCT 2008.056, Internal Report (2008)

W. Lamers, Coaches: I.J.M. Besselink, H. Nijmeijer, *Development and analysis of a multi-link suspension for racing applications*, 95, DCT 2008.077, Internal Report (2008)

R.G.J. Rijkers, Coaches: I.J.M. Besselink, H. van Benthem, H. Nijmeijer, *Het dynamische gedrag van onregelmatige bandslijtage*, 33, DCT 2008.079, Internal Report (2008)

Ing. G,R, Siau, Coaches: I.J.M. Besselink, I. Lopez Arteaga, H. Nijmeijer, *Equivalent Spring and Damper for Conceptual suspension Modeling*, 91, DCT 2008.091, Internal Report (2008)

Ruud van der Hofstad, Coaches: I.J.M. Besselink, H. Nijmeijer, *Modelling and integration of the Excentre hub in the Regiorailer*, 31, DCT 2008.128, Internal Report (2008)

T.G.M. Vromen, Coaches: I.J.M. Besselink, *Bepaling van de belastingen op een Knapen Trailer met behulp van een voertuigmodel*, 43, DCT 2008.094, Internal Report (2008)

R.P.C. van Dorst, B.J.H. van Laarhoven, R.A.M. Meesters, M.W.F. Mol, Coaches: I.J.M. Besselink, T. Hofman, H. Nijmeijer, *Drive Train Analysis and Vehicle Dynamics for the C,mn,n 2.0*, 39, DCT 2008.142, Internal Report (2008)

R, van Bethraij, Coaches: I.J.M. Besselink, *Simulatie van vermoeiingsbelasting op een oneffen wegdek voor een Knapen trailer*, 30, DCT 2008.093, Internal Report (2008)

I.W.J. Hamersma, Coaches: J.J.T.H. de Best, *Ball Position Estimation on a soccertable*, 38, DCT 2008.084, Internal Report (2008)

G.M. Heldens, Coaches: J.J.T.H. de Best, M. Steinbuch, *Mechanical Design of an Automated Foosball table*, 50, DCT 2008.083, Internal Report (2008)

Erik Grassens, Coaches: F. de Boer, G. Heins, M. Steinbuch, *Transfer function determination for a PM synchronous AC motor*, 25, DCT 2008.146, Internal Report (2008)

T. ten Dam, Coaches: M.L.G. Boerlage, A.G. de Jager, M. Steinbuch, *Disturbance Characterization for MIMO Control*, 133, DCT 2008.090, Internal Report (2008)

ing. M.J.C. Ronde, Coaches: O.H. Bosgra, J.J.M. van de Wijdeven, *Frequency domain based H□‡ Iterative Learning Control*, 54, DCT 2008.033, Internal Report (2008)

T.P. Luiten, Coaches: M.B.G. Cloosterman, N. van de Wouw, *Experimental validation of tracking control for Networked Control Systems with time-varying delays and sampling intervals*, 66, DCT 2008.121, Internal Report (2008)

A.J.P. van Engelen, Coaches: D. Constantinescu, M. Steinbuch, *Virtual coupling with impulses in a haptic simulation*, 35, DCT 2008.034, Internal Report (2008)

K.G.E. van Dijck, Coaches: N.J.M. van Dijk, N. van de Wouw, H. Nijmeijer, *Identification Machine Dynamics in High-Speed Milling*, 62, DCT 2008.021, Internal Report (2008)

M.J.J. van Ballegooijen, Coaches: J.A.W. van Dommelen, H. Nijmeijer, Y. Altintas, *Overview of stability analysis in machining processes*, 48, DCT 2008.134, Internal Report (2008)

D.P.E. Leermakers, Coaches: R.M. van Druten, B.R.A. Janssen, M. Steinbuch, *Transmission design for an electric bicycle*, 95, DCT 2008.117 CONFIDENTIAL, Internal Report (2008)

M.C.W. van de Sanden, Coaches: W.J.E. Evers, I.J.M. Besselink, *Actuatorontwerp voor een actieve ophanging*, 55, DCT 2008.122, Internal Report (2008)

C.P.M. Bunink, Coaches: R.H.B. Fey, *Dynamische stabiliteit van een eenvoudige tenseritystructuur*, 52, DCT 2008.055, Internal Report (2008)

D.J.F. Heck, Coaches: R.H.B. Fey, *Dynamic Vibration Absorber voor een stuksgewijs lineair dynamisch systeem*, 73, DCT 2008.086, Internal Report (2008)

M.J.P. Groenendijk, Coaches: O. Handrick, H. Schneeweiss, I.J.M. Besselink, H. Nijmeijer, *Development and validation of a vehicle ride model*, 39, DCT 2008.057 CONFIDENTIAL, Internal Report (2008)

M.J. Nieuwenhuizen, Coaches: J. van Helvoirt, M. Steinbuch, *Parameter analysis and identification of the Greitzer model by analogy with the Van der Pol equation*, 72, DCT 2008.065, Internal Report (2008)

R. Henselmans, G.F.IJ. Kramer, *NANOMEFOS Software development*, Internal Report (2008)

P.J. Neefs, Coaches: H.J.C. Huijberts, H. Nijmeijer, *On Time-Delayed Coupled Hindmarsh-Rose Neurons: Stability of Equilibria and Synchronisation*, 68, DCT 2008.023, Internal Report (2008)

P.W. Backx, Coaches: R. Huisman, M.J.G. van de Molengraft, G.J.L. Naus, V. van Reeven, *Modeling, identification and control design for engine braking*, 122, DCT 2008.140 CONFIDENTIAL, Internal Report (2008)

R.S. Pieters, Coaches: P.P. Jonker, H. Nijmeijer, *Active Vision: Directing Visual Attention*, 95, DCT 2008.145, Internal Report (2008)

Ivo de Rijk, Coaches: H. Kawakatsu, M. Steinbuch, *Realization of a Liquid Atomic Force Microscope*, 58, DCT 2008.004, Internal Report (2008)

Bas Lemmen, Coaches: T.A.C. van Keulen, R. van den Bogaert, L. Kodde, *Coolant temperature control*, 25, DCT 2008.104, Internal Report (2008)

Bert Maljaars, Coaches: L. Kodde, J.J. Hoogesteger, *Optimalisatie vacumeerproces in Volautomatische Tray Sealmachine*, 50, DCT 2008.031, Internal Report (2008)

I. Dockx, Coaches: L. Kodde, E. Steur, *Experimentele synchronisatie van Hindmarsh-Rose zenuwcellen*, 63, DCT 2008.089, Internal Report (2008)

W,W.J. Aarden, Coaches: D. Laro, M. Steinbuch, *Model and Controller Design of the IU-Module*, 35, DCT 2008.099, Internal Report (2008)

L.W.L. Houben, Coaches: R. Liebregts, I.J.M. Besselink, H. Nijmeijer, *Analysis of truck steering behaviour using a multi-body model*, 102, DCT 2008.139, Internal Report (2008)

B.P.T. van Goch, Coaches: C.J. Liu, I. Mareels, H. Nijmeijer, *Modeling the Simplest Three Dimensional Walker*, 51, DCT 2008.051, Internal Report (2008)

B.G.B. Hunnekens, Coaches: I. Lopez Arteaga, R. van der Steen, *Tire road frictional ainteraction Physical approach*, 35, DCT 2008.088, Internal Report (2008)

J.J. Nieuwenhuijsen, Coaches: I. Lopez Arteaga, R.R.J.J. van Doorn, *Frequency analysis of the flat plank tyre tester for validation of tyre transmissibility*, 43, DCT 2008.072, Internal Report (2008)

S.G.van der Tas, Coaches: P. McAree, A. Reid, M. Steinbuch, *Data acquisition for an electric mining shovel pose estimator*, 41, DCT 2008.025, Internal Report (2008)

M.J.H. Elferink, Coaches: R. McAree, M. Steinbuch, *Hybrid models for MPC of electric mining shovels*, 37, DCT 2008.115, Internal Report (2008)

M.J.C. Ronde, Coaches: R.J.E. Merry, M.J.G. van de Molengraft, K.R. Koops, M. Steinbuch, *MIMO and repetitive control of a calibration AFM*, 87, DCT 2008.137, Internal Report (2008)

Jos Elfring, Coaches: S.H. van der Meulen, A.G. de Jager, M. Steinbuch, *Improving Pushbelt CVT Efficiency Using Detection and Modulation Techniques: A Literature Study*, 65, DCT 2008.109 CONFIDENTIAL, Internal Report (2008)

C.M. Neervoort - Sanders, *DCT Meeting 2007*, 121, DCT 2008.010, Internal Report (2008)

J.J.C. van Schendel, Coaches: D. Nesic, M. Tabbara, W.P.M.H. Heemels, *Networked Control System Simulation & Analysis*, 74, DCT 2008.119, Internal Report (2008)

T.A.C. Verschuren, Coaches: H. Nijmeijer, P. Lammertse, *Friction compensation for a haptic manipulator: the Haptic MASTER*, 53, DCT 2008.003, Internal Report (2008)

J.W.L.H. Maas, Coaches: H. Nijmeijer, I.J.M. Besselink, *Development and validation of a vibration model for a complete vehicle*, 65, DCT 2007.131, Internal Report (2008)

J.H.H. Huibers , Coaches: H. Nijmeijer, *Non-linear Propeller Pitch Control*, 138, DCT 2008.019 CONFIDENTIAL, Internal Report (2008)

F.P.M. Dullens, Coaches: H. Nijmeijer, *MIMO Controller Design for a SCARA Robot*, 93, DCT 2008.024, Internal Report (2008)

Ing. M.H. Jussen, Coaches: H. Nijmeijer, *Surface quality improvement for high-speed milling by automatic spindle-speed adjustment*, 29, DCT 2007.058, Internal Report (2008)

Theo Wegman, Coaches: H. Nijmeijer, *Nearly periodic structures with tunable vibration confinement*, 55, DCT 2008.022, Internal Report (2008)

R.R.J.J. van Doorn, Coaches: H. Nijmeijer, I. Lopez Arteaga, R. van der Steen, *Physically based modelling of vibrations and force transmission of deformed rotating tyres*, 95, DCT 2008.041, Internal Report (2008)

J.J.B. Biemond, Coaches: H. Nijmeijer, *Chaotic advection in open flows*, 23, DCT 2008-029, Internal Report (2008)

ing. M.H. Jussen, Coaches: H. Nijmeijer, P.C.J.N. Rosielle, R.H.J. Peerlings, *Mass reduction methods for hydraulic cylinder shells in rescue rams*, 48, DCT 2008-039 confidential, Internal Report (2008)

Bart Besselink, Coaches: H. Nijmeijer, N. van de Wouw, *Analysis and validation of self-excited drill string oscillations*, 96, DCT 2008.038, Internal Report (2008)

T. Rutjens B.Sc, Coaches: H. Nijmeijer, N.B. Roozen, A. Hirschberg, *Acoustic excitation due to large amplitude oscillating bodies*, 68, DCT 2008.048, Internal Report (2008)

Marlies van Osch, Coaches: H. Nijmeijer, A. Hirschberg, I. Lopez Arteaga, *Dynamics of a 2D aircraft wing with cavity*, 127, DCT 2008.035, Internal Report (2008)

R. van der Aalst B.Sc., Coaches: H. Nijmeijer, *Dynamic identification of a Mitsubishi PA-10 robotic manipulator*, 42, DCT 2008.050, Internal Report (2008)

X.G.P. Schuurbiers, Coaches: H. Nijmeijer, M.F. Heertjes, *Design for Servo Performance; a study on frequency-dependent variable gains*, 100, DCT 2008.046, Internal Report (2008)

X.G.P. Schuurbiers, Coaches: H. Nijmeijer, M.F. Heertjes, *Design for Servo Performance; a study on frequency-dependent variable gains*, 100, DCT 2008.046, Internal Report (2008)

Alper Denasi, Coaches: H. Nijmeijer, B.T. Verhaar, *Methods for Supervised Learning of Tasks*, 73, DCT 2208.043, Internal Report (2008)

Thijs Kniknie, Coaches: H. Nijmeijer, Y.J. Bellouard, *Dynamics of Shape Memory Alloy coated micro cantilevers - theory and experiments-*, 94, DCT 2008.085, Internal Report (2008)

D.J. Rijlaarsdam, Coaches: H. Nijmeijer, A.Y. Pogromski, N. van de Wouw, *Huygens Synchronization in Various Dynamical Systems*, 100, DCT 2008.0049, Internal Report (2008)

C.S. Kraaij, Coaches: H. Nijmeijer, R.H.B. Fey, N.J. Mallon, *A semi-analytical buckling approach: modeling and validation*, 72, DCT 2008.095, Internal Report (2008)

Ing. E.M.P. van de Wiel, Coaches: H. Nijmeijer, M.B.G. Cloosterman, N. van de Wouw, *Experimental validation of the stability and performance analysis of Networked Control Systems with delays*, 77, DCT 2008.078, Internal Report

(2008)

T.L. Spijkers, Coaches: H. Nijmeijer, W.J.E. Evers, J. Vandenhoudt, I.J.M. Besselink, *Validation and Enhancement of a Tractor Semi-trailer Multibody Simulation Model*, 117, DCT 2008.068, Internal Report (2008)

E.J.P. van den Hoven, Coaches: H. Nijmeijer, R.H.B. Fey, R.M.C. Mestrom, J.T.M. van Beek, K.L. Phan, C. van der Avoort, *Modeling the Nonlinear Dynamics of a Silicon MEMS Resonator Physical analysis, numerical simulations and experimental validation*, 108, DCT 2008.100, Internal Report (2008)

H.W.J.A. Schepens, Coaches: H. Nijmeijer, N.B. Roozen, C. Maaskant, R. Bastiaans, *Modeling and experimental validation of a commercial exhaust*, 111, DCT 2008.014, Internal Report (2008)

A. Lugungu, Coaches: H. Nijmeijer, I. Lopez Arteaga, *Multibody Modeling and Optimization Applied to a Five Link Rear*, 83, DCT 2008.102, Internal Report (2008)

B.J.M. van Schaik, Coaches: H. Nijmeijer, *Base Parameter Identification and Decoupling of a Double SCARA Robot*, 124, DCT 2008.126, Internal Report (2008)

H. van Beek, Coaches: H. Nijmeijer, R.H.B. Fey, *Influence of shear and axial pretension on the free-vibration behaviour of clamped-clamped beam MEMS resonators*, 48, DCT 2008.127, Internal Report (2008)

J.A. Razenberg, Coaches: H. Nijmeijer, *Torque Vectoring by Brakes (TVbB)*, 88, DCT 2008.125 (confidential), Internal Report (2008)

M. van Berkel, Coaches: H. Nijmeijer, *Explicit soluiton of the ODEs describing the 3 DOF Control Moment Gyroscope*, 38, DCT 2008.104, Internal Report (2008)

T.H.A. van den Broek, Coaches: H. Nijmeijer, N. van de Wouw, D. Kostic, J. Ploeg, *Formation Control of Unicycle Mobile Robots*, 129, DCT 2008.131, Internal Report (2008)

M. Lauret, Coaches: H. Nijmeijer, G.J.F. van Heijst, R.R. Trieling, N. van de Wouw, *Pattern Control in a 2D Flow*, 83, DCT 2008.150, Internal Report (2008)

D.J. Rijlaarsdam, Coaches: H. Nijmeijer, N. van de Wouw, A.Y. Pogromski, *Huygens Synchronization in Various Dynamical Systems*, 100, DCT 2008.049, Internal Report (2008)

R.M.A. van Herpen, Coaches: T.A.E. Oomen, M. van de Wal, O.H. Bosgra, *A Literature Study on Robust-Control-Relevant Identification of High Performance Industrial Systems*, 63, DCT 2008.098, Internal Report (2008)

F.B.J.W.M. Hendriks, Coaches: T.A.E. Oomen, O.H. Bosgra, *High Perfomance Robust Control, System Identification, and Model Validation*, 46, DCT 2008.143, Internal Report (2008)

J.P. Heldens, Coaches: J.W. Philippen, M. Steinbuch, *Passive damping in a rollercoaster coach*, 67, DCT 2008.030, Internal Report (2008)

J.A.G. Wouters, Coaches: W.J.A.E.M. Post, M. Steinbuch, *Path & trajectory generation for an autonomous hydraulic backhoe excavator*, 75, DCT 2008.114, Internal Report (2008)

P.W.M. van Zutven, Coaches: A. Rodriguez-Angeles, C.A. Cruz Villar, H. Nijmeijer, *Design of a bilateral position/force master slave teleoperation systems with nonidentical robots*, 49, DCT 2008.118, Internal Report (2008)

M.J. Verdonschot, Coaches: H. de Rosa, F. Audebert, M. Steinbuch, *Design of a digital closed loop temperature*

control system for a dilatometer, 72, DCT 2008.032, Internal Report (2008)

J.J. Slob, Coaches: P.C.J.N. Rosielle, M.K. Schalkx, M.R.L. Kuijpers, M. Steinbuch, *Design of a 6DOF Motion Based Driving Simulator*, 81, DCT 2008.108, Internal Report (2008)

L. Marquenie, Coaches: P.C.J.N. Rosielle, M. Steinbuch, *Modification of a Formula Student race car engine, for addition of a Continuously Variable Transmission*, 50, DCT 2008.135, Internal Report (2008)

K.G,E. van Dijck, Coaches: P.C.J.N. Rosielle, L.J.M. van den Bedem, *Design of a 4-DOF Minimally Invasive Instrument for Haptic Robotic Surgery*, 97, DCT 2008.148 (CONFIDENTIAL), Internal Report (2008)

K.G,E. van Dijck, Coaches: P.C.J.N. Rosielle, L.J.M. van den Bedem, *Design of a 4-DOF Minimally Invasive Instrument for Haptic Robotic Surgery*, 97, DCT 2008.148 (CONFIDENTIAL), Internal Report (2008)

Dirk van Haendel, Coaches: P.C.J.N. Rosielle, *A Survey into step sized variable engine displacement*, 25, DCT 2008.155, Internal Report (2008)

I. de Rijk, Coaches: P.C.J.N. Rosielle, C. Werner, M. Steinbuch, *Design of a Metrological Atomic Force Microscope Head*, 65, DCT 2008.141, Internal Report (2008)

Ruud Alaerds, Coaches: P.C.J.N. Rosielle, M. Steinbuch, M.R.L. Kuijpers, M.K. Schalkx, *Ultra smooth actuator*, DCT 2008.152 CONFIDENTIAL, Internal Report (2008)

S.M.F. Dierikx, Coaches: P.C.J.N. Rosielle, I.J.M. Besselink, *Ontwerp van een laag-dynamische bandenmeetproefstand*, 57, DCT 2008.096, Internal Report (2008)

M. Verweijmeren, Coaches: R. Scholte, H. Nijmeijer, *Design of a product mount for an acoustic imaging box*, 64, DCT 2008.036 CONFIDENTIAL, Internal Report (2008)

F. Kamalizadeh, Coaches: R. Scholte, I. Lopez Arteaga, H. Nijmeijer, *Source identification of incoherent sound effects*, 109, DCT 2008.080, Internal Report (2008)

S.W. Boere, Coaches: A. Shukla, H. Nijmeijer, *Transient response in torsional systems with backlash*, 29, DCT 2008.116, Internal Report (2008)

R.W. van Gils, Coaches: M.F.M. Speetjens, H. Nijmeijer, *Feedback stabilization of a pool-boiling system*, 65, DCT 2008.067, Internal Report (2008)

J.G. Vermond, Coaches: R. van der Steen, I. Lopez Arteaga, *Experimental determination of the CCAR tyre characteristics*, 30, DCT 2008.113, Internal Report (2008)

R.M.R. Bruns, Coaches: M. Steinbuch, A.G. de Jager, J.J.M. van Helvoort, *Multiple Model Multiple Controller Adaptive Control*, 73, DCT 2008..097, Internal Report (2008)

R.J.M. Janssen, Coaches: M. Steinbuch, R. Lind, *Applied Vision Based Position Estimation*, 33, DCT 2008.005, Internal Report (2008)

S.R. Bögemann, F.B.J.W.M. Hendriks, Coaches: M. Steinbuch, *Optimal path finding for a mining shovel*, 43, DCT 2008.006, Internal Report (2008)

E.G. Hijkoop, Coaches: M. Steinbuch, *Designing a foosball table actuator*, 49, DCT 2008.015, Internal Report (2008)

W.B.A. Boomsma, Coaches: M. Steinbuch, *Acitve vibration isolation for a 6 degree of freedom scale model of a high precision machine*, 22, DCT 2008.020, Internal Report (2008)

Ruud Tilburgs, Coaches: M. Steinbuch, M.J.G. van de Molengraft, R.J.E. Merry, *Design, optimization and control of a solenoid*, 60, DCT 2008.008 CONFIDENTIAL, Internal Report (2008)

D.W.T. Hennekens, Coaches: M. Steinbuch, *Continuous Impulsive Force controller for FRVFs*, 7, DCT 2008.012, Internal Report (2008)

R.M.R. Bruns, Coaches: M. Steinbuch, *Current Reference Control of a Permanent Magnet AC Motor* , 39, DCT 2008.016, Internal Report (2008)

J.P.A. Bus, Coaches: M. Steinbuch, P.C.J.N. Rosielle, M.A. Hulsen, *The design of a Computerized Planar Motion Carriage for a Seakeeping and maneuvering basin*, 57, DCT 2008.028 CONFIDENTIAL, Internal Report (2008)

E. Stoltenborg, Coaches: M. Steinbuch, *Design of an autonomous football table*, 42, DCT 2008.047, Internal Report (2008)

W.B.A. Boomsma, Coaches: M. Steinbuch, A.G. de Jager, F.P.T. Willems, *Design of closed-loop controller for selective catalytic reduction exhaust after treatment system*, 76, DCT 2008.042 CONFIDENTIAL, Internal Report (2008)

D. Verhagen, Coaches: M. Steinbuch, *Design of a Coriolis mass flow meter*, 87, DCT 2008.040 CONFIDENTIAL, Internal Report (2008)

B. Hu, Coaches: M. Steinbuch, *Modeling and Control Design for the EAST Tokomak Device*, 43, DCT 2008.054, Internal Report (2008)

Geert-Jan Naaijkens, Coaches: M. Steinbuch, P.C.J.N. Rosielle, J. Pijnenburg, *Design of a 6 D.O.F. sample stage for E.S.R.F. with sub micron accuracy*, 85, DCT 2008.061 CONFIDENTIAL, Internal Report (2008)

J.A, van Geenhuizen, Coaches: M. Steinbuch, M.J.G. van de Molengraft, J.H.G. Niessen, *Friction compensation for the printer system*, 58, DCT 2008.018, Internal Report (2008)

J.N.M. Schnackers, Coaches: M. Steinbuch, S.H. van der Meulen, *The Empact CVT*, 71, DCT 2008.058, Internal Report (2008)

S.A.J. de Waal, Coaches: M. Steinbuch, E.P. van der Laan, P.C.J.N. Rosielle, *Design of a belt actuator enhancing car occupant safety*, 68, DCT 2008.053, Internal Report (2008)

R. Hoogendijk, Coaches: M. Steinbuch, M.F. Heertjes, *Improved Decoupling of the Wafer Stage Long Stroke*, 39, DCT 2008.045 CONFIDENTIAL, Internal Report (2008)

H.J.C. Luijten, Coaches: M. Steinbuch, E.P. van der Laan, W.P.M.H. Heemels, *Reference governor design for real-time controlled belt restraint systems*, 71, DCT 2008.063 CONFIDENTIAL, Internal Report (2008)

M. van Leeuwen, Coaches: M. Steinbuch, *Modeling and identification of a precision stage with a walking piezolegs actuator*, 80, DCT 2008.066 CONFIDENTIAL, Internal Report (2008)

A.K. Hanegraaf, Coaches: M. Steinbuch, *High frequency control of a 1-DOF haptics system extended*, 32, DCT 2008.074, Internal Report (2008)

M. Uyanik, Coaches: M. Steinbuch, R.J.E. Merry, M.J.G. van de Molengraft, *Modeling, identification and control of a metrological Atomic Force Microscope with a 3DOF stage*, 104, DCT 2008.052, Internal Report (2008)

Ing. G.J. Castenmiller, Coaches: M. Steinbuch, J.J.T.H. de Best, *Calibration of a fixed camera*, 37, DCT 2008.070, Internal Report (2008)

P.J.H. Maas, Coaches: M. Steinbuch, M.J.G. van de Molengraft, R.J.E. Merry, *Real-time frequency estimation of analog encoder outputs*, 60, DCT 2008.081, Internal Report (2008)

J.F.P.B. Diepstraten, Coaches: M. Steinbuch, G.A. Commissaris, A.G. de Jager, *Modelling and Control of the Power Loop Test Rig*, 93, DCT 2008.062, Internal Report (2008)

A.J. v.d. Meulen, Coaches: M. Steinbuch, R.M. van Druten, *PowerShift Module for heavy duty trucks in long haulage application*, 167, DCT 2008.076 CONFIDENTIAL, Internal Report (2008)

T.M.P. Gommans, Coaches: M. Steinbuch, M.J.G. van de Molengraft, W.H.T.M. Aangenent, *Nonlinear Controller Design for Linear Motion Systems*, 52, DCT 2008.073, Internal Report
ISBN (2008)

J.L. Rijnberg, Coaches: M. Steinbuch, P.C.J.N. Rosielle, *Design of a 6-DOF manipulator with force feed-back for ex-vivo microsurgery*, 91, DCT 2008.144 CONFIDENTIAL, Internal Report (2008)

J.H. Grasman, Coaches: M. Steinbuch, P.C.J.N. Rosielle, R. Hendrix, *Mechanical design and construction of a 5 DOF haptic master device for an eye-surgery robot*, 85, DCT 2008.111, Internal Report (2008)

J.J. Slob, Coaches: M. Steinbuch, *State-of-the-Art Driving Simulators, a Literature Survey*, 14, DCT 2008.107, Internal Report (2008)

E.M.M. Demarteau , Coaches: M. Steinbuch, P.W.J.M. Nuij, B.A. Hennen, *Launcher position control*, 61, DCT 2008.124, Internal Report (2008)

M.N. de Beukelaar, Coaches: M. Steinbuch, D.W.J. van Raaij, *Wrijvingsidentificatie van een 1-DOF systeem*, 21, DCt 2008.105, Internal Report (2008)

S.L.H. Verhoeven, Coaches: M. Steinbuch, *Optimal Control of a Multi-Actuated By-Wire Vehicle*, 69, DCT 2008.112, Internal Report (2008)

C. Cilli, Coaches: M. Steinbuch, *Programming by Demonstration on a Robot Arm in 1D*, 65, DCT 2008.120, Internal Report (2008)

Y.Shen, Coaches: M. Steinbuch, W. Vroemen, *Dynamic model of AA-CVT*, 39, DCT2008.132 (confidential), Internal Report (2008)

Lia Neervoort en Petra Aspers, Coaches: M. Steinbuch, H. Nijmeijer, *Annual Report 2007*, 47, DCT 2008.001, Internal Report (2008)

Hai Nguyen Tuan, Coaches: M. Steinbuch, G.Z. Angelis, *Stabilization of a passive magnetic bearing model with Nforcer motors*, 22, DCT 2008.148, Internal Report (2008)

Lisanne Ravensbergen, Coaches: M. Steinbuch, K. Van der Grinten, M. Vogels, *Stand alone crutch. Design of a portable foot stand for a (forearm) crutch*, 39, DCT 2008.149, Internal Report (2008)

Jannis D.G. van Kerkhoven, Coaches: M. Steinbuch, *Design of a Formula Student race car chassis*, 77, DCT 2008.154, Internal Report (2008)

B.R. Rampadarath, Coaches: M. Steinbuch, M.F. Heertjes, *Wafer Stage Long Stroke ILC with Nonlinear Q-filtering*, 35, DCT 2008.123, Internal Report (2008)

D.J. Kessels, Coaches: M. Steinbuch, M.J.G. van de Molengraft, R.J.E. Merry, E. Verschueren, *Repetitive control of a walking piezolegs actuator*, 92, DCT 2008.129 CONFIDENTIAL, Internal Report (2008)

Wang, Coaches: M. Steinbuch, *Dynamical modeling of the TWINSCAN system*, 51, DCT 2008.133, Internal Report (2008)

W. Ooms, Coaches: M. Steinbuch, *Impulsive control for increased responsiveness of serial chain virtual linkages*, 26, DCT 2008.130, Internal Report (2008)

I. Dockx, Coaches: E. Steur, L. Kodde, *Experimentele synchronisatie van Hindmarsh-Rose zenuwcellen*, 63, DCT 2008.089, Internal Report (2008)

M.G.J.M. Maassen, Coaches: M. Tomizuka, X. Fan, M. Steinbuch, *Intelligent Power Assisted Bicycles*, 56, DCT 2008.059, Internal Report (2008)

B. Ciardelli, Coaches: P.A. Veenhuizen, G.A. Commissaris, *Control of the oil temperature on the Power Loop Test Rig*, 68, DCT 2008.013, Internal Report (2008)

B.J.M. de Vries, Coaches: P.A. Veenhuizen, T.A.C. van Keulen, M. Steinbuch, *Online Energy Management of a Hybrid Vehicle*, 80, DCT 2008.075, Internal Report (2008)

A. Ayemlong Fokem, Coaches: F.P. Wijnheijmer, M. Steinbuch, *Feedforward Design Strategy for Improving Motion Simulator Performance*, 83, DCT 2008.147, Internal Report (2008)

S.W. Boere en P.W.M. van Zutven, Coaches: M. Wisse, H. Nijmeijer, *Knee flexion during push off in limit cycle walkers*, 26, DCT 2008.011, Internal Report (2008)

E.J.W. Roebroek, Coaches: N. van de Wouw, N.J.M. van Dijk, *Experimentele validatie van oppervlaktekwaliteit bji hogesnelheidsfrezen*, 29, DCT 2008.101, Internal Report (2008)