Activity Report: Automatic Control 1985-1987

Dagnegård, Eva; Hagander, Per

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Department of Automatic Control
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Department of Automatic Control
Lund Institute of Technology
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S-221 00 Lund Sweden

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Author(s)
Eva Dagnegård
Per Hagander

Supervisor

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Abstract

The report surveys the activities during the two academic years 1985/86 and 1986/87 at the Department of Automatic Control, Lund Institute of Technology, Lund, Sweden. At the civilingenjör level (≈ Master of Science) seven different courses are given on regular basis. A thousand students have passed during the years. Fortythree students have completed their MSc-theses. Also four Lic Techn theses and two PhD-theses have been completed.

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Eva Dagnegård
Per Hagander

Department of Automatic Control
Lund Institute of Technology

Mailing address:

Department of Automatic Control
Lund Institute of Technology
P.O. Box 118
S–221 00 Lund SWEDEN

Visiting address:

Institutionen för Reglerteknik
Ole Römers väg 1, Lund

Telephone:

Nat 046–10 70 00
Int +46 46 10 70 00

Telefax:

Nat 046–13 81 18
Int +46 46 13 81 18

Telex:

S–33533 LUNIVER

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Appendices

1. Introduction

This report covers the activities of the department in the academic years 1985/86 and 1986/87.

Substantial efforts have been made to renew the courses and teaching laboratories. Work is going on to significantly extend the curriculum by the addition of courses in identification and in adaptive control. The teaching laboratory for the digital control courses has been completely renewed and the courses on computers in control systems have been significantly changed. In summary a thousand students have taken one or several of the seven courses that are given by the department. Further description is given in Section 2.

Research has continued in established areas such as adaptive control and computer aided control engineering. Several full scale application projects have also been carried out in power network stability, boiler turbine modelling, wastewater treatment and biotechnical processes. These projects are described in Section 3.

In Section 4 a brief survey of the laboratory is given. Our interactive software has been extremely successful. In cooperation with STU (the Swedish Board for Technical Development) the software has been sold all over the world to both industries and universities. A new version of Simnon was developed for the IBM-PC.

The 2nd IFAC Workshop on Adaptive Systems in Control and Signal Processes was held at the department during July 1–3, 1986. Further details are given in Section 5.

We want to thank our sponsors, the Swedish Board for Technical Development (STU), the Swedish Council for Planning and Coordination of Research (FRN), the Swedish Board for Energy Source Development (NE), Sydkraft, Vattenfall, the Swedish Water and Wastewater Works Association (VAV), and the Käppala Sewage Works, Lidingö, for their support to our projects.

Certain reports and theses are available for sale from the Department, see further Appendix C.

2. Education

Automatic control courses are taught as a part of the engineering curricula in Applied Physics (F), Electrical Engineering (E), Computer Engineering (D), Mechanical Engineering (M), and Chemical Engineering (K).

During the past two years the following courses were given at the department:

Name of the course (Section)	Number of students	
	1985/86	1986/87
Automatic control, linear systems (F, E, D)	207	169
Automatic control, linear systems (M)	79	94
Process control (K)	73	64
Computer controlled systems (F, E, D)	63	121
Systems engineering (M)	18	9
Computers in control systems (F, E, M, K)	29	24
Applied real-time programming (F, E)	27	38

The figures give the number of students that have passed the courses. Fortythree students have completed their MSc-dissertations in Automatic Control during the period. A list of the MSc-theses is given in Appendix C. Two PhD theses and four Lic Techn theses were completed during the period. Five new PhD students were admitted to the department.

The PhD-courses Linear system, Identification and Adaptive control were given once each during the two years, and new courses in Lisp programming, in Computer Aided Control Engineering, in Implementation of Adaptive Systems, and in Nonlinear Control Theory were also introduced. A common theme has been to introduce computer tools like Simnon, Matlab, Ctrl-C, Idpac, and Macsyma as early as possible during the studies. The application level of projects and exercises was thus increased considerably.

New Courses

All students taking Applied Real-time Programming have now taken the Computer Science course on real-time programming. Our course now extends further, and a special choice of lectures and projects in robotics was introduced during spring 1987.

Planning for two new courses, Identification and Adaptive Control, is currently going. Each of the courses will contain 14 h of lectures, 14 h of problem solving sessions and 4×4 h of laboratory work.

Teaching Laboratory

The teaching laboratory was upgraded during 1985–1987 with now 14 IBM-AT machines with extended graphics. The laboratories and the projects in the Applied Real-time Programming course were the first to be moved to the AT-machines, while the laboratories in Computer Controlled Systems were modified during spring 1987.

Word Processing

Word processing has emerged as an important tool for report and thesis production. TEX is slowly growing to be the departmental standard, and PostScript is used extensively as an intermediate language to handle the inclusion of drawings and graphs from Macintosh or from packages like Simnon. There is a direct connection between our Macintosh Appletalk network and the Vax Dec-net.

Extension courses

There is an increasing demand from industry on courses in the control area. To meet this interest the ambition has been to give at least two courses per term on various topics for engineers from the industry. The courses have given a lot of stimulation for the research and education at the Department. A list of the courses given is shown in Appendix D.

3. Research

Research at the department is oriented along two main parts, theory and applications. The main research areas have been:

Adaptive control
Computer aided control engineering
Expert control
Robotics and sensory control
Power systems
Control of wastewater treatment systems
Control of a continuous chemical reactor
Modeling and control of medical systems

Some of the areas are highlighted below.

Power Systems

A research program is started in order to combine relevant problems from Vattenfall and Sydkraft with the strengths of the department of Automatic Control and the interests of visiting researchers. The program has a strong long range potential. Two main projects were proposed for the first years. Funding is provided for a guest professorship and a research assistant.

Power system stabilization

The purpose of this project is to improve the understanding of the power system stabilization problem. The Nordel system has suffered from two disturbances due to undamped power swings during the last five years. A large number of power system stabilizers have been installed during the past 15 years. There is unfortunately no method for experimental verification of the performance of such stabilizers during system-wide power swings.

One part of the project was to survey possible means and methods for improving the damping of power system swings. Another part was to develop techniques to tune existing power system stabilizers. A third part was to explore new types of power system stabilizers. There may be a potential to explore power system stabilizers based on Kalman filtering methods, adaptive control and self-tuning regulators.

The work was based on the aggregated 12 machine model of the Nordel system. This model, which was originally developed by Vattenfall, is now widely used and trusted within Nordel.

The first guest professor was Dr. David Hill (Univ. of Newcastle, Australia) who did his research together with Björn Wittenmark, Magnus Akke, Bo Eliasson and Sture Lindahl. Several coordination meetings were held, where the research was presented for Sydkraft and Vattenfall.

Thermal power units

During spring 1987 Professor Rod Bell (Macquarie University, Australia) held the professorship. He worked on simulation models for boiler-turbine units together with K. J. Åström and a group at Sydkraft. The models were compared with actual plant data and extensions are going on to include a two boiler system.

Control of Biotechnology Processes

A joint project with the Division of Biotechnology, Chemical Center, on control in biotechnology processes has been funded by STU since 1983. The purpose of the work is to investigate the possibilities for process control using direct measurements of substrate, product and intermediates in the processes. Newly developed biosensors have been applied to well-known processes based on yeast. Our current interest is focused on fed-batch production of baker's yeast. Here measurement of ethanol concentration gives a sensitive indication of the metabolic state of the cells. Identification experiments are performed in closed loop, and parameter estimation is done for models with partially known dynamics. Some optimal control problems are also formulated and investigated using nonlinear control theory.

A new direction of the work is started up. The bacteria *Pseudomonas Cepacia* is grown on the toxic substrate salicylate to produce the enzyme salicylate hydroxylase. The enzyme is used in clinical chemistry to determine salicylate in blood samples. The purpose of the work is to control the substrate addition to be enough for growth without any adverse effect from its toxicity.

Control of a Continuous Chemical Reactor

With STU-sponsoring a project is started together with divisions of the Chemical Center in order to build a small versatile continuous reactor unit for the production of fine chemicals. Four companies, that have participated in the funding, will be responsible for the transfer of the results to chemical practice. A prototype plant is running a test reaction suggested by Perstorp AB. The main control effort is now on the reactor temperature control.

Computer Aided Control Engineering (CACE)

In the end of 1984 a five year long research program called "Computer Aided Control Engineering, CACE" was initiated. It is financed by the National Swedish Board of Technical Development (STU). The total budget is 7.5 MSEK. The responsible researcher is Sven Erik Mattsson.

The achievements in computer technology and computer science have opened new possibilities to improve the CACE tools. The aim of the CACE project is to investigate these possibilities and to develop some prototype systems. Up to now a number of pilot projects has been run.

In one project existing CACE programs were viewed as high level problem solving languages to see which concepts they support. A CACE program should be more than a means for instructing the computer to perform tasks. It should serve as a frame work within which we organize our ideas. Today most CACE programs are merely tools for numerical computations. They do not support symbolic calculations. Neither can they treat qualitative or uncertain information. Their ways of representing systems are in most cases fairly primitive. The system

concept is fundamental in control engineering and the representation of systems in CACE is a key issue. A special study was therefore made and a small prototype to test ideas was implemented.

Of special significance on the hardware side is the new high performance workstations now appearing on the market. Fast graphics to reasonable costs makes it possible to improve the user interface considerably. A prototype simulator for dynamical systems named Hibliz (HIerarchical BLock diagrams with Information Zooming) was implemented to investigate the possibilities to use graphics to describe system structure. Our Iris workstation with powerful graphics was used as the target machine. A program for 3D-animation of an ASEA robot has also been developed. Animation is an interesting way of exploring graphics to represent the behaviour of a system.

The increasing computer capacity makes it possible to make symbolic calculations. A package for analysis of multivariable linear systems has been implemented in the symbolic manipulation program MACSYMA. It is also possible to output representations that could be accepted by the numerical analysis and design program CTRL-C, the simulation program Simnon and the typesetting program TEX.

Artificial Intelligence (AI), Expert Systems (ES) and Knowledge Engineering (KE) can provide us with interesting and powerful tools. They could provide tools to design help systems for beginners and casual users. Another interesting possibility is that they might provide tools for discussing qualitatively about systems and for handling of incomplete information. An expert system interface which can give goal oriented help has been developed for the interactive data analysis and parameter estimation program Idpac.

The results of the pilot projects have shown that it is possible to improve the CACE tools considerably. The results have been presented at various international conferences and workshops and they have been well received. The department has well established contacts with users of CACE tools as well as with other research groups and companies developing CACE tools. We have collaboration with groups in the UK, France, Israel and USA. Three guest researchers have participated in the CACE program: Professor Wolfgang Kreutzer, University of Canterbury, Christchurch, New Zealand (2 months), professor Mike

Denham, Kingston Polytechnic, UK (1 month), and professor Dean Frederick, Rensselaer Polytechnic Institute, Troy, New York, USA.

The plans for the remaining two years are to develop a larger useful prototype system. We will focus on tools for model development and simulation. Important issues are representation and presentation of system structure and system behaviour. There should be structuring concepts to handle model decomposition, multiple representations and model libraries. The models should be on symbolic forms from which the CACE system could generate efficient code for simulation, code for calculation of stationary points, linearized models, controller code and descriptions that are accepted by other packages. Graphics should be used to present model structure (for example hierarchical block diagrams) and results of analysis and simulations (from simple trend curves to animation). Third party software like various numerical routines will be integrated when possible. To get a better evaluation and faster feedback it is of interest to run an application project.

Robotics and Sensory Control

A laboratory for robotics and sensory control has been initiated. Initial steps in hardware interfaces and software development has been taken. The responsible researcher is Lars Nielsen.

Modeling and Control of Medical Systems

A few projects have been done in the field signal processing and control theory applied to medical problems. The responsible researcher is Rolf Johansson.

One project treats estimation of parameters of ordinary differential equations. The parameters of interest are related to vessel wall elasticity and periferal resistance from ultrasonic data. The purpose is to monitor fetal blood flow by noninvasive methods. The work was made in cooperation with Dr. Gennser at the Department of Obstetrics and Gynaecology, Malmö General Hospital. Another project treats estimation

of parameters related to human posture dynamics. The work is performed in cooperation with the Department of Oto-Rhino-Laryngology, Lund University Hospital.

Two master thesis projects in biomedical engineering has been performed in cooperation with Gambro AB, Lund. Temperature control of blood temperature in a heartlung-machine was made. Another thesis project treated temperature and flow control for hemofiltration dialysis.

4. Laboratory

Computer facilities

During the years 1985–1987 our main workhorse, the Vax 780, has been enhanced with more memory. We have bought a number of personal computers and workstations, and the total computer capabilities of the department are as follows:

- **VAX-11/780** with 10 MB memory and 750 MB disk. The most important programs are Pro-Matlab, Macsyma, CtrlC, TEX, Lisp and our own packages Simnon and Idpac.
- Fourteen **IBM-AT** or compatibles with 640 kB memory and 20 MB disk. They have analog input and output channels (4 or 16 channels in and 2 or 8 channels out) and also some digital I/O. The main use of these computers is for real time control, both in formal lab exercises and projects in the undergraduate courses, and also in research projects by graduate students and faculty. The programming is done almost exclusively in Modula-2, and a library containing a real time kernel and real time graphics has been developed. This library has reached such a state of maturity that researchers wishing to perform a control experiment can concentrate on the control algorithm and let the library take care of the problems of real-time programming. The acheivable sampling rates is up to 100 Hz.

  The same computers are also used for control design. Interfaces are provided to PC-Matlab and to our own new PC-Simnon, so that parameters obtained in a design can be transferred both to Simnon for simulation using a nonlinear model, and to the Modula-2 system for control of the real process.

  The PC-Simnon is very easily available and has grown to a great success.
- Four **Macintoshes**, used for text processing and for creating figures and drawings for the technical reports. A special program on the Vax

enables the inclusion of drawings produced on the Macintosh directly into TEX documents produced on the Vax.

- An **Iris Workstation** with 6.5 MB memory, 150 MB disk and powerful color graphics with 1024×780 pixels and 24 bitplanes. This computer is used mainly in the CACE project described elsewhere in this report.
- A **Sun Workstation System** containing a file server, Sun 3/180 with 380 MB disk and 4 workstations Sun 3/50 with 4 MB memory.
- A **Symbolics 3650 Lisp Machine**

The Suns and the Symbolics arrived very recently, and the department staff is in the process of exploring how to utilize these new and powerful tools. The Vax, the Suns, the Iris and the Symbolics are connected in a computer network (TCP/IP and ethernet).

Laboratory Process

A set of new servo-motors were manufactured and introduced in the CCS-course laboratories. Sequence control on small PLC-systems was developed for a new set of heating processes used in the course Computers in control. An Asea Master system with different types of programming aid has also been utilized in that course.

An industrial manipulator, the ASEA Irb-6 robot with the ASEA S2 control system, is available. Hardware interfaces are under development and the robot will be used in experiments with new control strategies using e.g., a number of IBM-AT:s as controllers.

5. IFAC Workshop

The 2nd IFAC Workshop on Adaptive Systems in Control and Signal Processing was held in Lund 1–3 July, 1986.

The first special IFAC activity on adaptive control was a Symposium on Optimization and Adaptive Control in Rome 1962. This was followed by a symposium on Theory of Self-Adaptive Systems in Teddington in 1965 and the symposium on System Sensitivity and Adaptivity in Dubrovnik in 1968. After that adaptive control was discussed in other symposia mainly the very successful symposium series on Identification and Process Parameter Estimation initiated in Prague in 1967.

In 1981 the Theory Committee of IFAC created a working group on adaptive control chaired by professor Landau. This group initiated several activities in adaptive control. One goal was to try to bring the communities of control and signal processing closer together. A result of the activity was to organize workshops. The first workshop was called Adaptive Systems in Control and Signal Processing 1983. It was held in San Francisco, and the second workshop in the series was held in Lund 1986.

There were three plenary sessions and 192 submitted papers. We believe that this reflects the increasing interest in adaptive control. The papers were selected on the basis of extended abstracts. Of the submitted papers 83 were accepted. Five papers were withdrawn later. To maintain a workshop spirit in spite of the large number of papers we decided to run two applications sessions in parallel and we also introduced two poster sessions. They were held in two rooms each with about 10 papers. The sessions were very well attended and very well received, there was a lively spirit with lots of discussions particularly in the poster sessions. Many participants said that next time they would prefer to have their paper presented at a poster session.

There were 188 participants from 24 countries, Australia, Belgium, Brazil, Canada, China, Czechoslovakia, Denmark, Finland, France, FRG,

Hungary, Israel, Italy, Japan, Mexico, the Netherlands, Norway, Portugal, Sweden, Turkey UK, USA, USSR, and Yugoslavia. Because of the large interest it has now been decided to expand the workshop to a symposium. The next meeting in this series will be held at the University of Strathclyde.

A. List of Personnel

Professor

Karl Johan Åström

University lecturers *Högskolelektorer*

Gustaf Olsson
Björn Wittenmark (on leave 1986/87)
Per Hagander
Rolf Johansson

Research asssociate *Forskarassistent*

Lars Nielsen (on leave Oct 1985 – June 1986)

Research engineers *Forskningsingenjörer*

Leif Andersson
Rolf Braun
Tomas Schönthal (programmer)

Research assistants and Teaching assistants
Forskningsassistenter och Assistenter

Magnus Akke
Mats Andersson
Jan Peter Axelsson
Dag Brück
Ola Dahl
Craig Elevitch (to July 1986)
Kjell Gustafsson
Ulf Holmberg
Tore Hägglund (to August 1985)
Jan Eric Larsson
Mats Lilja
Michael Lundh

Sven Erik Mattsson
Bengt Mårtensson (to June 1987)
Bernt Nilsson
Per-Olof Olsson
Per Persson
Lars Rundqwist
Anders Wallenborg
Karl-Erik Årzén
Ann-Britt Östberg (to January 1986)

Secretaries *Sekreterare*

Annette Andersson (part time)
Eva Dagnegård (part time)
Eva Schildt
Agneta Tuszynski (part time)

Technical drawings *Tekniskt biträde*

Britt-Marie Carlsson

Visiting scientists *Gästforskare*

Carlos Canudas,
Laboratoire d'Automatique de Grenoble, France
(14 Jan – 29 Oct, 1985).

Mukul Agarwal,
Department of Chemical Engineering, University of California,
Santa Barbara, California, USA
(24 June – 20 Sept, 1985).

Dr. Per-Olof Gutman
Electro Optical Ind.,
Rehovot, Israel
(June–July 1985 and 1986)

Professor John F. MacGregor,
McMaster University, Hamilton, Canada
(Aug – Sept, 1985)

Professor Richard Johnson, Jr.,
Cornell University, Ithaca, NY, USA
(17 Sept – 21 Oct, 1985).

James H. Taylor,
General Electric Co., Schenectady, NY, USA
(16 – 21 Oct, 1985).

Dr. Wolfgang Kreutzer,
University of Canterbury, Department of Computer Science,
Christchurch, New Zealand
(18 Nov, 1985 – 17 Jan, 1986).

Professor Guy Dumont,
Pulp and Paper Research Institute of Canada,
The University of British Columbia, Vancouver, Canada
(14 May – 4 July, 1986).

Dr. David J. Hill,
University of Newcastle,
Department of Electrical and Computer Engineering,
New South Wales, Australia
(1 Jan – 30 Dec, 1986)

Dr. Mike Denham,
Kingston Polytechnic,
School of Electronic Eng. and Computer Science,
Kingston upon Thames, UK
(5 Nov – 5 Dec, 1986)

Professor Kohei Ohtsu,
Tokyo University of Mercantile Marine,
Department of Navigation,
Tokyo, Japan
(18 March, 1987 –)

Professor Rod Bell,
Macquarie University,
School of Mathematics and Physics,
New South Wales, Australia
(May 5 – June 30, 1987)

Professor Peter Gawthrop,
University of Glasgow,
Department of Mechanical Engineering,
Glasgow, UK
(1 April – 31 July, 1987)

Professor Dean Frederick,
Rensselaer Polytechnic Institute,
Electrical Computer and Systems Engineering Dept.,
Troy, New York, USA
(18 May – 17 July, 1987)

B. Published Papers and Conference Contributions

Årzén, K.-E. (1986): "Use of expert systems in closed loop feedback control," *Proc. American Control Conference 1986*, Seattle, USA, pp. 140–145.

Årzén, K.-E. (1986): "Expert systems for process control," *Proc. 1st International Conference on Applications of AI in Engineering Practice*, Southampton, UK.

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C. Reports

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Dissertations

TFRT-1027 Nielsen, L., "Simplifications in visual servoing," September 1985.

TFRT-1028 Mårtensson, B., "Adaptive stabilization," February 1986.

Final Reports

TFRT-3177 Åström, K. J., "Transient response analysis," September 1985.

TFRT-3178 Åström, K. J., "The adaptive nonlinear modeller," November 1985.

TFRT-3179 Elmqvist, H., "LICS—Language for implementation of control systems," December 1985.

TFRT-3180 Rundqwist, L., "Self-tuning control of the dissolved oxygen concentration in an activated sludge system," Lic Techn thesis, April 1986.

TFRT-3181 Mattsson, S. E., H. Elmqvist, and D. Brück, "New forms of man-machine interaction," September 1986.

TFRT-3182 Nielsen, L., "Control based on image information," November 1986.

TFRT-3183 Hill, D., "Status report on project power system stabilization," November 1986.

TFRT-3184 Larsson, J. E., and P. Persson, "An expert system interface for idpac," Lic Techn thesis, March 1987.

TFRT-3185 Åström, K. J., "Adaptiv reglering," (Adaptive control), November 1986.

TFRT-3186 Holmberg, U., M. Lilja, and S. E. Mattsson, "Combination of symbolic manipulation and numerics," March 1987.

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TFRT-3191 Bell, R., and K. J. Åström, "Simplified models of boiler-turbine units," June 1987.

TFRT-3192 Bell, R., and K. J. Åström, "Dynamic models for boiler-turbine alternator units: Data logs and parameter estimation for a 160 MW Unit," June 1987.

TFRT-3193 Mattsson, S. E. (Ed.), "Programplan för ramprogrammet 'Datorbaserade hjälpmedel för utveckling av styrsystem'," (Plan for the project 'Computer aided control engineering, CACE'), June 1987.

Activity Reports

TFRT-4014 Wittenmark, B., and Dagnegård, E., "Activity report 1984–1985," December 1985.

Master Theses

TFRT-5324 Nilsson, M., "Temperaturreglering, hjärt-lung maskin," (Temperature control of a heart-lung machine), July 1985.

TFRT-5325 Nilsson, A., and K. Petersson, "Konstruktion av en robotarm med adaptiv reglering," (Construction of a robotarm with adaptive control), July 1985.

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TFRT-5329 Nilsson, P., "Loggningsprogram for μ-Mac 5000," (A program for data logging on μ-Mac 5000), September 1985.

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TFRT-5331 Carlsson, L., and G. Frenning, "Temperaturreglering av formspruta," (Digital temperature control of an injection moulding machine), August 1985.

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TFRT-5334 Jönsson, M., "Simulering av en hybrid självinställande regulator," (Simulation of a hybrid selftuning controller), September 1985.

TFRT-5335 Nilsson, P.-A., and S. Nilsson, "En drivrutin för kommunikation mellan Onspec och Cluster controller," (A driver for communication between Onspec and Cluster controller), September 1985.

TFRT-5336 Peterson, L., "Experiments with user interface for computer aided control engineering," September 1985.

TFRT-5337 Jerpander, M., "Demonstrationssystem för Asea Master," (Demonstration system for Asea Master), November 1985.

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TFRT-5347 Birkedal, A., "SIP-systemet. Ett datorsystem för reglertekniska experiment och mätdatabehandling," (The SIP-system. A computer system for experiments in automatic control and experimental data processing), February 1986.

TFRT-5348 Lundgren, P., "Produktionsplanering i livsmedelsindustrin," (Production planning in the foodprocessing industry), April 1986.

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TFRT-5356 Pettersson, B., "Identifiering av parametrar i delvis kända tidskontinuerliga modeller – En implementationsstudie," (Identification of parameters in partioned continuous time models – An implementation studie), November 1986.

TFRT-5357 Mauritsson, R., and M. Grahn, "Olika metoder för autotuning av PID-regulatorer. Implementering och tester," (Different methods for autotuning of PID-controllers. Implementation and tests), November 1986.

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TFRT-5365 Persson, H., "En studie av reglersystemet för tyristorventilens kylsystem," (A study of the cooling control system for thyristor valves), May 1987.

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Internal Reports

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TFRT-7287 Johansson, R., "Global Lyapunov stability and exponential convergence of direct adaptive control with recursive least squares identification," August 1985.

TFRT-7288 Johansson, R. (Ed.), "Systemteknik – Projektarbete våren 1985," (System engineering—Term papers spring 1985), August 1985.

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TFRT-7359 Mattsson, S. E. (Ed.), "Computer aided control engineering CACE (Proceedings of a full-day seminar in Stockholm, March 25, 1987)," May 1987.

TFRT-7360 Wallenborg, A., "State feedback control and data logging with Modula-2," May 1987.

TFRT-7361 Axelsson, J. P., "Optimering medelst lineär sökning – Ett tidsdiskret Simnon system," (Optimization using linear search—A time discrete Simnon system), May 1987.

TFRT-7362 Nilsson, B., "Experiences of describing a distillation column in some modelling languages," June 1987.

TFRT-7363 Lilja, M., "Least squares fitting to a rational transfer function with time delay," June 1987.

Travel Reports

TFRT-8042 Åström, K. J. and L. Andersson, "Besök på General Electric CRD, 20–23 mars 1984," (Visit at General Electric CRD, 20–23 March 1984), September 1985.

TFRT-8043 Axelsson, J. P., "BIO Technica '85 Hannover," October 1985.

TFRT-8044 Årzén, K.-E., "Reserapport AAIEP," (Travel report), May 1986.

TFRT-8045 Mattsson, S. E., K. J. Åström, D. Brück, and T. Schönthal, "A trip to the University College, Swansea, and the Central Electric Generating Board, Gloucester," February 1987.

D. Courses and Seminars at the Department

Undergraduate courses, graduate courses, seminars as well as extension courses, given at the department during the academic years 1985–1987, are summarized here. They are given both by the staff at the department and by invited lecturers.

Undergraduate Courses

Automatic control, linear systems (Reglerteknik AK)
Automatic control for mechanical engineers (Reglerteknik för M)
Process control (Processreglering)
Computer controlled systems (Digital reglering)
Systems engineering (Systemteknik)
Computers in control systems (Datorer i reglersystem)
Applied real-time programming (Tillämpad realtidsprogrammering)

PhD Courses

The following courses have been given:

System Identification 8p (K. J. Åström)	(fall 1985)
Lisp 2p (K. E. Årzén)	(Dec 1985 – Jan 1986)
Linear Systems 10p (P. Hagander)	(spring 1986)
Adaptive Control 6p (K. J. Åström)	(spring 1986)
Computer Aided Control Engineering CACE 6p (K.J. Åström, S.E. Mattsson, P. Hagander)	(fall 1986)
Nonlinear Control Systems 8p (B. Mårtensson)	(spring 1987)
Implentation of Adaptive Systems 5p (K. J. Åström)	(spring 1987)

Extension Courses

The extension program in automatic control offers courses for extended education of engineers in industry. A new extension course in process identification was developed by Rolf Johansson and was held for the first time in January 1986. The course covers off-line methods and real-time methods of parameter estimation as well as detection. Both black box models and estimation of physical parameters are treated in this course.

The following courses have been given during the period:

Simulation of dynamic systems	24–26 September, 1985
Digital Control	22–24 October, 1985
Process identification	20–23 January, 1986
Process identification	10–13 March, 1986
Process identification	22–25 September, 1986
Adaptive control	21–23 October, 1986
Survey of control theory	26–29 January, 1987

All courses demand 3–4 days of attendance and take 16–20 participants. The participants receive some material for preparation when they sign up for the course. One textbook and a file with several hand-outs are included in the price.

Each day of a course usually consists of two or three lectures and one laboratory session of about three hours.

Seminars at the Department

1985

July 26 F. Delebecque and M. S. Steer (INRIA, France): "Demonstration of the interactive system Blaise for control engineering."

July 30 Jan Maciejowski (Cambridge University, UK): "Data structures for use in CACE."

July 30	Charles Herget (Lawrence Livermore National Lab, California): "The Eagles project and the M language."
Aug 29	J. F. MacGregor (McMaster University, Hamilton, Canada): "Control with hard constraints—Applications to chemical process control."
Sept 5	Karl Olof Lind (Sperry, Malmö): "Unix on Sperry computers."
Sept 11	Carlos Canudas and Mukul Agarwal (Lund): "Timedelay estimation."
Sept 13	Lars Nielsen (Lund): "Perceptrones."
Sept 18	Lars Nielsen (Lund): "Picture programs."
Sept 23	Leif Andersson (Lund): "Unix and Eunice."
Sept 23	J.F. MacGregor (McMaster University, Hamilton, Canada): "Control of emulsion polymerization reactors: (i) Objectives and problems, (ii) A study on the control of limit cycles in continuous stirred tank reactors."
Sept 24	C. R. Johnson (Cornell University): "Adaptive IR filters in ADPCM."
Sept 25	C. R. Johnson: "Some basic oddities of sign-sign adaptive identifiers."
Sept 27	C. R. Johnson: "Some implications from averaging theory for adaptive control engineering."
Oct 2	Dean Frederick (Rensselaer Polytechnic Institute): "CACE-III An expert system for the design of control systems."
Oct 3	L. Praly (CAI/ENSMP, Fontainebleau): "A geometric approach for the local analysis of a one step ahead adaptive controller."
Oct 4	Dean Frederick (Rensselaer Polytechnic Institute): "Discussion on man-machine communication."
Oct 16	Ola Dahl (Lund): "Ash line detection."

Oct 16	J. H. Taylor (GE, Schenectady): "Expert system applications to control system design and implementation."
Oct 21	J. H. Taylor (GE, Schenectady): "Nonlinear controller design based on quasilinear system models."
Oct 28	Lars Rundqwist (Lund): "Adaptive control of chemical processes (A conference in Frankfurt)."
Oct 29	E. Mosca (Universita di Firenze, Italy): "Implicit ARX modelling of controlled ARMAX plants."
Oct 30	E. Mosca (Universita di Firenze, Italy): "Application of implicit ARX modelling to adaptive control."
Oct 31	E. Mosca (Universita di Firenze, Italy): "MUSMAR."
Nov 28	Mats Jerpander (Lund): "A demonstration package for the Asea Master System."
Dec 9	John Cassidy (General Electric, Schenectady): "Perspectives on computer aided implementation of advanced control systems."
Dec 13	Bjarne Däcker (Ericsson Telecom, Stockholm): "On real-time programming languages at LM Ericsson."

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Feb 6	Karl-Erik Årzén (Lund): "PICON."
Feb 6	Karl Johan Åström (Lund): "Experiences from a trip to USA."
March 19	Thomas Schönthal (Lund): "Simnon on IBM PC."
March 20	Karl Johan Åström (Lund): "System representations."
March 21	Bo Kågström (University of Umeå): "Kan man styra respektive observera linjära system med osäkra data? (Can linear systems given by uncertain data be controlled?)."
March 24	David Hill (Lund): "Adaptive robust control—Convergence and stability."

March 26 David Hill, Bo Eliasson (Lund), Lars Messing (Sydkraft): "The powersystem stabilization project."

April 14 C. I. Byrnes (Arizona State University, USA): "Nonlinear control systems: An invitation."

April 2 Bjarne Däcker (Ericsson Telecom, Stockholm): "Experiments with programming languages and techniques for telecommunications applications."

April 3 Bjarne Däcker: "Design of an expert system and man-machine interface for operation and maintenance of AXE telephone exchanges."

April 4 Bjarne Däcker: "Comparison between Lisp and Pascal for use in developing programming support system."

April 7–8 Jan C. Willems (University of Groningen, The Netherlands): Three seminars titled "Modelling dynamical systems: Fitting a linear system to an observed time series."

April 10 Hilding Elmqvist (SattControl, Malmö): "Man-machine communication."

April 21 Lars Richter (Asea): "The Asea master system."

April 22 Christos Georgakis (MIT): "The use of expert system techniques for control of chemical processes."

April 23 Tomas Schönthal (Lund): "Computer graphics, an overview."

April 28 W. Levine (Univ. of Maryland/INRIA): "Two examples of computer-aided control systems design using Delight and Marylin."

May 5 Prasad Dhugarti (Univ. of Delaware): "FALCON—An expert system for fault diagnosis in commercial chemical plants."

May 6 David Hill (Lund): "Dissipativeness and stability of nonlinear systems, I: Introduction and dissipativeness."

May 13 David Hill (Lund): "Dissipativeness and stability of nonlinear systems, II: How to design your own stability result."

May 22	David Hill (Lund): "Dissipativeness and stability of nonlinear systems, III: Extensions."
May 22	Bengt Mårtensson (Lund): "My US-trip."
May 27	Kjell Gustafsson (Lund): "Wavefilters."
May 27	D. G. Luenberger (Stanford): "Overview of convergence theory for optimization algorithms."
May 28	Lars Rundqwist (Lund), Bo Egardt (Asea): "Self-tuning control of the dissolved oxygen concentration in an activated sludge system." Lic Techn dissertation seminar.
May 30	Bob King (Univ. of Salford, UK): "Introduction to ARGOS."
June 2	Neil Munro (University of Manchester, UK): "Comparison of some CAD facilities."
June 18	Bengt Mårtensson (Lund): "Tools used for production of my PhD-thesis."
June 19	Per-Olof Gutman (Electro Optics Ind., Israel): "Impressions from the conference: 'Applied Motion Control' 1986."
June 24	Bengt Mårtensson (Lund): "PostScript—An introduction."
June 26	Per-Olof Gutman (Electro Optics Ind., Israel): "Robust and adaptive control of a beam deflector."
June 30	B. Widrow (Stanford University, CA): "Adaptive signal processing."
Sept 4	Brian Anderson (Australian National University, Canberra): "Discussion on control trends and good research topics."
Sept 8	Karl Johan Åström (Lund): "A survey on programs from ETH, Zürich."
Sept 9	Jan Willem Polderman (CWI, Amsterdam): "Adaptive pole assignment."
Sept 11	Lars Nielsen (Lund): "Impressions from USA. My future plans."
Oct 9	Mats Lilja (Lund): "Presentation of PC-Matlab and similar packages."

Oct 10	Anders Svensson (Lund): "Modelling and identification of fetal aorta dynamics." MSc-thesis presentation.
Oct 14	Andrew R. Koenig and Barbarar E. Moo (Bell Laboratories): "An overview of C++."
Oct 27	Karl Johan Åström (Lund): "News from the States."
Oct 29	Bo Pettersson (Lund): "Identification of parameters in partioned continuous time models. An implementation study." MSc-thesis presentation.
Oct 31	Ulf Holmberg (Lund): "Adaptive dissolved oxygen control and simultaneous estimation of oxygen transfer and respiration rates."
Nov 10	Karl Johan Åström et al (Lund): "System representations."
Nov 13	Mats Lilja (Lund): "Introduction to MuMath on the IBM-PC."
Nov 14	Per-Olof Olsson (Lund): "Identification of asynchronously sampled systems." MSc-thesis presentation.
Nov 19	Dag Brück (Lund): "Implementation of Graphics for HIBLIZ."
Nov 20	Sven Erik Mattsson (Lund): "Equation sorting in Simnon and algebraic loops."
Nov 21	Rolf Johansson (Lund): "Global stability properties of direct adaptive control."
Nov 28	Lars Pernebo (Alfa Laval, Lund): "Different methods for auto-tuning of PID controllers."
Dec 1	Jonas Andersson (Lund): "Pulse width modulation of control input to DC motor." MSc-thesis presentation.
Dec 3	L. Gerencser (Hungarian Academy of Science, Budapest): "Recursive estimation of time-varying parameters in continuous time."
Dec 3	Anders Rantzer (Lund): "Upper and lower bounds on the feedback order, necessary to stabilize a given rational transfer function." MSc-thesis presentation.

Dec 5 Hilding Elmqvist (SattControl, Malmö): "Operatörskommunikation med objektorienterad grafik, strukturerade bilder och animering." Docent lecture.

Dec 8 Erik Mårtensson (Lund): "Active damping of oscillation modes in a robot arm." MSc-thesis presentation.

Dec 17 Mats Lilja, Kjell Gustafsson, Bengt Mårtensson (Lund): "GNU Emacs."

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Jan 19 Karl Johan Åström (Lund): "Tuning of PI controllers."

Feb 19 Karl Johan Åström (Lund): "Implementation of PID controllers."

Feb 25 Torbjörn Johansson (IBM, Stockholm): "IBM RT PC and ANDREW." A full-day seminar.

Feb 26 Anders Åberg (Asea Research & Innovation, Västerås): "Asea's activities in the expert system area."

March 19 Per Hansson and Benny Olofsson (Lund): "Control of temperature and flow of the infusion for hemofiltration dialysis." MSc-thesis presentation.

March 20 Jan Eric Larsson and Per Persson (Lund): "An expert system interface for Idpac." Lic Techn dissertation seminar.

March 20 Rune Gustavsson (SICS, Stockholm): "AI and expert systems."

March 27 Jan Peter Axelsson (Lund): "Start-up of a continuous ethanol production based on analytic solution of a bilinear process model."

April 9 Håkan Persson (Lund): "A study of the cooling control system for thyristor valves." MSc-thesis presentation.

April 14 Peter Gawthrop (University of Glasgow): "Adaptive control."

April 14	Kohei Ohtsu (Tokyo University): "Statistical analysis of the AR type ship's autopilot system."
May 12	Neil Munro (University of Manchester): "ECSTASY."
May 12	John Edmunds (University of Manchester): "CSS, the Control System Software."
May 14	Anders Törne and Martin Uneram (Asea): "Robot programming."
May 19	Peter Gawthrop (University of Glasgow): "Robustness of self-tuning control I."
May 22	Berndt Olsson (Lund): "A lime slaker control system." MSc-thesis presentation.
May 25	Claes Källström (Marintekniska Institutet SSPA): "Dynamic positioning of oil platforms." Docent lecture.
May 25	Peter Gawthrop (University of Glasgow): "Robustness of self-tuning control II."
May 25	Carver Mead (CalTech, Pasadena): "Sound synthesis."
May 26	Carver Mead (CalTech, Pasadena): "Electronic models of neural systems."
May 26	Ulf Holmberg (Lund): "Adaptive dissolved oxygen control and on-line estimation of oxygen transfer and respiration rates." Lic Techn dissertation seminar.
May 26	Rod Bell (Macquarie University): "Boiler turbine modelling and simulation."
May 27	Dean Frederick (Rensselaeer Polytechnic Institute): "Windowing for Simnon."
June 2	Einar Zettergren (Lund): "DA-converters with feedback." MSc-thesis presentation.
June 3	Rod Bell (Macquarie University) and Ann-Britt Östberg (Sydkraft, Malmö): "Informal discussion on modelling of boiler turbine units."

June 10 Karl Johan Åström (Lund): "Optimal adaptive feedforward regulators; On a thesis by M. Sternad, Uppsala."

June 11 Rod Bell (Macquarie University) and Ann-Britt Östberg (Sydkraft, Malmö): "Informal discussion on modelling of boiler turbine units."

June 11 Bengt Schmidtbauer (Chalmers, Göteborg): "Demonstration of a lab process."

June 18 Mats Andersson (Lund): "Impressions from Barcelona; A conference on modelling and expert systems."

June 23 Rod Bell (Macquarie University): "Boiler turbine modelling III."

June 24 Bo Bernhardsson (Lund): 1. "Numerical solution to resistor trimming on silicon chips." 2. "Numerical solution to hot spot temperature distribution on silicon chips."

E. Lectures by the staff

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July 3 — Karl Johan Åström: "The self-tuning regulators revisited," 7th IFAC/IFORS Symposium on Identification and System Parameter Estimation, York, UK.

July 4 — Rolf Johansson: "Estimation and direct adaptive control of delay-differential systems," 7th IFAC/IFORS Symposium on Identification and System Parameter Estimation, York, UK.

July 5 — Tore Hägglund: "Recursive estimation of slowly time-varying parameters," 7th IFAC/IFORS Symposium on Identification and System Parameter Estimation, York, UK.

July 7 — Sven Erik Mattsson: "Identification of wind turbine dynamics," 7th IFAC/IFORS Symposium on Identification and System Parameter Estimation, York, UK.

July 9 — Karl Johan Åström: "Towards intelligent control," Invited paper, IEE International Conference Control '85, University of Cambridge, UK.

Aug 30 — Gustaf Olsson: "Structured identification of activated sludge dynamics," Invited, IAWPRC Specialized Seminar on Modelling of Biological Wastewater Treatment, Copenhagen, Denmark.

Oct 15 — Rolf Johansson: "Lyapunov stability and exponential convergence of direct adaptive control with recursive least squares identification," CNRS GRECO, Laboratoire d'Automatique de Grenoble, Grenoble, France.

Oct 15 — Rolf Johansson: "Identification of continuous-time systems," CNRS GRECO, Laboratoire d'Automatique de Grenoble, Grenoble, France.

Oct 17 Gustaf Olsson: "New results in dynamics of hydraulic propagation in wastewater treatment plants," Environment Canada, Wastewater Technology Center, Burlington, Ontario, Canada.

Oct 23 Gustaf Olsson: "Simple autotuning controllers for the process industry—An executive overview," Weyerhaeuser Technology Centre, Tacoma, Washington, USA.

Oct 28 Lars Rundqwist: "Integral action and mode transitions in self-tuning process control," IFAC Workshop on Adaptive Control in Chemical Processes, Frankfurt, FRG.

Nov 11 Karl Johan Åström: "Control theory and robotics," Courant Institute of Mathematics, New York University, New York, USA.

Nov 13 Jan Eric Larsson and Karl-Erik Årzén: "AI related projects in the CACE project," Department of Computer Science, LTH, A seminar on current AI projects at Lund University.

Nov 15 Karl Johan Åström: "Adaptive control," University of Texas, Austin, Texas, USA.

Nov 15 Gustaf Olsson: "Ny reglerteknik för process- och verkstadsindustrin," (New control methods for the process and manufacturing industry), Royal Swedish Academy of Engineering Sciences (IVA) and STU seminar, Stockholm, Sweden.

Nov 19 Karl Johan Åström: "Adaptive control—Theory and practical aspects," ASME Winter meeting, Miami, Florida, USA.

Nov 20 Karl Johan Åström: "Why control is fun!," Acceptance speech for the Rufus Oldenburger medal, ASME Winter meeting, Miami, Florida, USA.

Nov 21 Rolf Johansson: "Multivariable adaptive control," Laboratoire de Statistique Appliquée, Université Paris XI, Orsay, France.

Nov 27 Björn Wittenmark: "Sampling av signaler och digital reglering," (Sampling of signals and digital control), Course for STF (Svenska Teknologföreningen), Kungälv, Sweden.

Nov 27 Björn Wittenmark: "Adaptiv reglering," (Adaptive control), Course for STF (Svenska Teknologföreningen), Kungälv, Sweden.

Dec 2 Björn Wittenmark: "Self-tuning regulators," IMSOR, Denmark Institute of Technology, Lyngby, Denmark.

Dec 11 Karl Johan Åström and Karl-Erik Årzén: "Intelligent controllers," Meeting of the AI interest group at Lund University, Lund, Sweden.

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Jan 8 Rolf Johansson: "Signal processing aspects of continuous time system identification," CNRS GRECO, Laboratoire d'Automatique de Grenoble, Grenoble, France.

Jan 15 Karl Johan Åström: "Adaptation, auto-tuning and smart control," 3rd International Conference on Chemical Process Control (CPC III), Asilomar, California, USA.

Jan 21 Karl Johan Åström: "Adaptive control systems," NASA, Moffet Field, California, USA.

Jan 23 Karl Johan Åström: "Adaptive control theory," China Lake, California, USA.

Jan 28 Karl Johan Åström: "Adaptive systems," CalTech, Pasadena, California, USA.

Feb 10 Sven Erik Mattsson: "New forms of man-machine interactions," Department of Computer Science and Computer Engineering, Lund, Sweden.

Feb 13 Karl-Erik Årzén: "Expert system applications in automatic control," Dept. of Automatic Control, Linköping Institute of Technology, Sweden.

Feb 28 Rolf Johansson: "Eye movement and balance dynamics," (in Swedish), Dept. of Oto-Rhino-Laryngology, Lund University Hospital, Lund, Sweden.

March 4 Karl Johan Åström: "Matematiska modeller – Erfarenheter och fallgropar," (Mathematical models—Experience and pitfalls), Lund University, Sweden.

March 7 Gustaf Olsson: "Integrated control of sewer networks and wastewater treatment plants during rainfall," One day seminar at Department of Environmental Engineering, DTH, Lyngby, Denmark.

March 11 Gustaf Olsson: "Recursive estimation and adaptive control in biological wastewater treatment," Seminar cosponsored by City of Houston and Rice University, Houston, Texas, USA.

March 18 Björn Wittenmark: "Digital reglering," (Digital control), Course for Elektrolux, Sweden.

April 8 Karl Johan Åström: "Prediktion och styrning av stokastiska processer," (Prediction and control of stochastic processes), Lunds Matematiska Sällskap, Lund University, Sweden.

April 9 Karl Johan Åström: "Adaptive friction compensation," IEEE International Conference on Robotics and Automation, San Francisco, California, USA.

April 10 Carlos Canudas: "Adaptive friction compensation for robot manipulators," IEEE International Conference on Robotics and Automation, San Francisco, California, USA.

April 16 Karl-Erik Årzén: "Expert systems for process control," 1st International Conference on Applications of AI in Engineering Practice, Southampton, UK.

April 16 Gustaf Olsson: "Dynamiska egenskaper och reglertekniska metoder i vattenreningssystem," (Dynamical properties and control methods in water and wastewater systems), Zander o Ingeström, Stockholm, Sweden.

April 16 Björn Wittenmark: "Sampling av signaler och digital reglering," (Sampling of signals and digital control), Course for STF (Svenska Teknologföreningen), Kungälv, Sweden.

April 16 Björn Wittenmark: "Adaptiv reglering," (Adaptive control), Course for STF (Svenska Teknologföreningen), Kungälv, Sweden.

April 16 Bengt Mårtensson: "Adaptive stabilization of multivariable linear systems," Arizona State University, Tempe, Arizona, USA.

April 17 Bengt Mårtensson: "High gain based adaptive stabilization," Arizona State University, Tempe, Arizona, USA.

April 23 Karl-Erik Årzén: "Expertsystem för processreglering" (Expert systems for process control)," Perstorps AB, Perstorp, Sweden.

April 24 Jan Eric Larsson "Ett expertsystemsnitt för Idpac," (An expert system interface for Idpac), The Swedish AI Society's Annual Workshop SAIS '86, Linköping, Sweden.

April 24 Karl-Erik Årzén: "Kunskapsbaserade regulatorer," (Knowledge based controllers), The Swedish AI Society's Annual Workshop SAIS '86, Linköping, Sweden.

April 30 Bengt Mårtensson: "Adaptive stabilization of multivariable linear systems," University of California, Berkeley, California, USA.

May 5 Bengt Mårtensson: "Adaptive stabilization of multivariable linear systems," University of Maryland, College Park, Maryland, USA.

May 13 Lars Rundqwist: "Självinställande reglering," (Selftuning control), Spring meeting, Swedish Association for Water Hygiene (FVH), Stockholm, Sweden.

May 14 Gustaf Olsson: "Process technology—Modelling, simulation and estimation," (in Swedish), Spring meeting, Swedish Association for Water Hygiene (FVH), Stockholm, Sweden.

May 30 Karl Johan Åström: "Towards intelligent control," Invited paper, Control Systems '86 Symposium, The Swedish Forest Products Research Laboratory (STFI) and The Swedish

Association of Pulp and Paper Engineers (SPCI), Stockholm, Sweden.

June 11 Lars Nielsen: "A visual servo," 1st IFAC Workshop on Digital Image Processing in Industrial Applications, Vision Control, Helsinki University of Technology, Otaniemi, Espoo, Finland.

June 11 Ola Dahl: "Ash line control," 1st IFAC Workshop on Digital Image Processing in Industrial Applications, Vision Control, Helsinki University of Technology, Otaniemi, Espoo, Finland.

June 18 Karl-Erik Årzén: "Use of expert systems in closed loop feedback control," American Control Conference 1986, Seattle, WA, USA.

June 19 Jan Eric Larsson: "Knowledge representation by scripts in an expert interface," American Control Conference 1986, Seattle, WA, USA.

July 1 Karl Johan Åström: "A comparison between robust and adaptive control of uncertain systems," 2nd IFAC Workshop on Adaptive Systems in Control and Signal Processing, Lund, Sweden.

July 9 Bengt Mårtensson: "Adaptive stabilization without high-gain," Conf. on Modelling and Adaptive Control, Sopron, Hungary.

July 12 Björn Wittenmark: "Adaptive control—An overview," Tsinghua University, Beijing, China.

July 12 Björn Wittenmark: "Adaptive systems in control and signal processing—A report from the workshop in Lund," Tsinghua University, Beijing, China.

July 14 Karl Johan Åström: "Representation of system connections," SERC-STU Workshop on Graphical Front Ends for CACE, UMIST, Manchester, UK.

July 14 Sven Erik Mattsson: "Hierarchical block diagrams and information zooming," SERC-STU Workshop on Graphical Front Ends for CACE, UMIST, Manchester, UK.

July 15 Sven Erik Mattsson: "Representation and visualization of systems and their behaviour," SERC-STU Workshop on Graphical Front Ends for CACE, UMIST, Manchester, UK.

July 15 Björn Wittenmark: "Digital control systems," East China Normal University, Shanghai, China.

July 15 Björn Wittenmark: "Design methods for digital controllers," East China Normal University, Shanghai, China.

July 16 Björn Wittenmark: "Adaptive control—An overview," East China Normal University, Shanghai, China.

July 17 Björn Wittenmark: "Self-tuning regulators," East China Normal University, Shanghai, China.

July 18 Björn Wittenmark: "Applications of adaptive control," Shanghai Automation Society, Shanghai, China.

July 21 Karl Johan Åström: "Adaptive friction compensation in robot drives," DFVLR, Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt e.V., Oberpfaffenhofen, München, FRG.

July 21 Sven Erik Mattsson: "Hierarchical block diagrams and information zooming," DFVLR, Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt e.V., Oberpfaffenhofen, München, FRG.

July 21 Björn Wittenmark: "Adaptive systems in control and signal processing—A report from the workshop in Lund," East China Normal University, Shanghai, China.

July 24 Björn Wittenmark: "Dual control theory," East China Normal University, Shanghai, China.

Aug 12 Bengt Mårtensson: "Dynamic high-gain stabilization of multivariable linear systems, with application to adaptive control," SIAM Conference on Linear Algebra in Signals, Systems and Control, Boston, Massachusetts, USA.

Aug 13 Bengt Mårtensson: "Integrating different symbolic and numeric tools for linear algebra and linear systems analysis,"

SIAM Conference on Linear Algebra in Signals, Systems and Control, Boston, Massachusetts, USA.

Aug 13 Rolf Johansson: "Modelling and identification of fetal aorta dynamics," (in Swedish), Dept. of Obstetrics and Gynaecology, Malmö Hospital, Malmö, Sweden.

Aug 29 Karl Johan Åström: "Expert control," Introduction to a round table discussion on expert systems in Automatic Control, IFAC Symposium on Large Scale Systems, Zürich, Switzerland.

Sept 2 Gustaf Olsson: "A cooperative project between Sweden and Canada on measurement and control problems in wastewater treatment," Wastewater Technology Centre, Burlington, Ontario, Canada.

Sept 3 Gustaf Olsson: "Expert systems for process diagnosis," Wastewater Technology Centre, Burlington, Ontario, Canada.

Sept 9 Björn Wittenmark: "Adaptive control—An overview," University of Newcastle, Australia.

Sept 19 Karl Johan Åström: "A perspective on control engineering," Keynote talk, IEEE Workshop on the Challenge to Control, Santa Clara, CA, USA.

Sept 24 Karl Johan Åström: "System representations," IEEE Control Systems Society Third Symposium on Computer-Aided Control System Design (CACSD), Arlington, Virginia, USA.

Sept 26 Karl Johan Åström: "Artificial intelligence and automatic control," Introduction to a panel discussion, IEEE Control Systems Society Third Symposium on Computer-Aided Control System Design (CACSD), Arlington, Virginia, USA.

Sept 26 Karl Johan Åström: "A simulator for dynamical systems using graphics and equations for modelling," paper by Elmqvist and Mattsson, IEEE Control Systems Society Third Symposium on Computer-Aided Control System Design (CACSD), Arlington, Virginia, USA.

Sept 30	Rolf Johansson: "Practical problems of adaptive control," (in Swedish), NSF – Norske Sivilingeniørers Førening (Norwegian Engineering Society), Geilo, Norway.
Sept 30	Rolf Johansson: "Adaptive control," NSF, Geilo, Norway.
Oct 1	Karl Johan Åström: "AI as a tool for control system design," Du Pont, Delaware, USA.
Oct 2	Karl Johan Åström: "Representation of system structure," Advanced Decision Systems, California, USA.
Oct 6	Karl Johan Åström: "Software needs for computer aided control engineering," HP Research, California, USA.
Oct 7	Björn Wittenmark: "Basic ideas in adaptive control," University of Newcastle, Australia.
Oct 13	Björn Wittenmark: "Model reference control," University of Newcastle, Australia.
Oct 20	Karl Johan Åström: "Comparison of robust and adaptive control," University of California, Berkeley, USA.
Oct 20	Björn Wittenmark: "Self-tuning regulators I," University of Newcastle, Australia.
Oct 21	Björn Wittenmark: "Some applications of adaptive control," University of Queensland, Brisbane, Australia.
Oct 27	Björn Wittenmark: "Self-tuning regulators II," University of Newcastle, Australia.
Oct 30	Karl Johan Åström: "Knowledge based automatic control," (in Swedish), Infologics, Stockholm, Sweden.
Nov 3	Björn Wittenmark: "Stochastic adaptive control," University of Newcastle, Australia.
Nov 7	Ulf Holmberg: "Adaptive dissolved oxygen control and on-line estimation of oxygen transfer and respiration rates," AIChE Annual Meeting, Miami Beach, Florida, USA.
Nov 10	Björn Wittenmark: "Practical aspects and implementation of adaptive control," University of Newcastle, Australia.

Nov 19 Dag Brück: "Implementation of graphics for HIBLIZ," Dept. of Computer Science and Computer Engineering, Lund, Sweden.

Dec 2 Gustaf Olsson: "Expertsystem för processindustrin – En översikt," (Expert systems for process industries—An overview), STU Workshop on Information Technology in the food industry, SIK, Göteborg, Sweden.

Dec 11 Rolf Johansson: "Direct adaptive control—Global Lyapunov stability and exponential convergence," 25th IEEE Conference on Decision and Control, Athens, Greece.

Dec 12 Rolf Johansson: "Identification of continuous-time dynamic systems," 25th IEEE Conference on Decision and Control, Athens, Greece.

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Jan 13 Gustaf Olsson: "Measurement needs in wastewater treatment," Wastewater Technology Centre, Burlington, Ontario, Canada.

Jan 15 Gustaf Olsson: "Measurement analysis in wastewater treatment," Wastewater Technology Centre, Burlington, Ontario, Canada.

Jan 21 Gustaf Olsson: "Expertbaserade styrsystem," (Expert based control systems), STU Workshop on the DUP program, Uppsala, Sweden.

Jan 22 Sven Erik Mattsson: "On differential/algebraic systems," Dept. of Automatic Control, Linköping Institute of Technology, Linköping, Sweden.

Jan 29 Björn Wittenmark: "Self-tuning regulators—An overview," Australian National University, Canberra, Australia.

Jan 30 Björn Wittenmark: "Some applications of adaptive control," Australian National University, Canberra, Australia.

Feb 9 Karl Johan Åström: "Computer aided control engineering," CEGB, Gloucester, UK.

Feb 12 Karl Johan Åström: "Automatic tuning of simple regulators," Imperial College of Science and Technology, London, UK.

Feb 12 Karl Johan Åström: "Towards intelligent control," 4th Computing and Control Lecture, The Institution of Electrical Engineers, London, UK.

Feb 13 Karl Johan Åström: "Adaptive control," lecture at the 25th year jubilee of the Engineering Physics Department at Lund Institute of Technology, Lund, Sweden.

March 3 Björn Wittenmark: "Some applications of adaptive control," University of New South Wales, Sydney, Australia.

March 5 Björn Wittenmark: "Adaptive stability augmentation or how to use a priori knowledge," University of Newcastle, Australia.

March 6 Rolf Johansson: "Identification of human posture dynamics," Department of Oto-rhino-laryngology, Lund University, Lund, Sweden.

March 6 Rolf Johansson: "Mathematical analysis of fetal pulse waves," Department of Obstetrics and Gynaecology, Lund University, Lund, Sweden.

March 25 Karl-Erik Årzén: "Expert control," Karl Johan Åström: "Computer aided control design—A perspective," and "Continuation of the CACE project and discussion," Ulf Holmberg: "Symbolic formula manipulation," Jan Eric Larsson: "Expert system interfaces," Sven Erik Mattsson: "The CACE project—An overview," and "Hibliz—A simulator using hierarchical block diagrams." All the lectures was held at a joint, full-day seminar about Computer Aided Control Engineering (CACE) arranged together with the Swedish National Board for Technical Development (STU) in Stockholm, Sweden.

March 25-26 Gustaf Olsson: "Dynamics, estimation and control of wastewater treatment systems," Graduate course, Luleå Institute of Technology, Luleå, Sweden.

April 6 Karl-Erik Årzén: "Knowledge based controllers," Joint SERC-STU Workshop on Expert Systems and Databases in Computer Aided Control System Design, Cambridge, UK.

April 6 Karl Johan Åström: "Expert control methods for assessment of achievable control performance," Joint SERC-STU Workshop on Expert Systems and Databases in Computer Aided Control System Design, Cambridge, UK.

April 6 Per Persson: "An expert system interface for Idpac," Joint SERC-STU Workshop on Expert Systems and Databases in Computer Aided Control System Design, Cambridge, UK.

April 15 Jan Peter Axelsson: "Control of baker's yeast production," Department of Pure and Applied Biochemistry, Chemical Center, LTH, Lund, Sweden.

May 6 Karl Johan Åström: "Automatinställning," SattControl, Stockholm, Sweden.

May 7 Rolf Johansson: "Educational software," Uppsala University, Sweden.

May 18 Jan Eric Larsson: "Ett intelligent hjälpsystem för Idpac," (in Swedish), The Swedish AI Society's Annual Workshop SAIS'87, Uppsala, Sweden.

May 19 Gustaf Olsson: "Automation of wastewater treatment systems," invited keynote, The European Water Pollution Control Association Symposium, München, FRG.

May 20 Karl Johan Åström: "Expert systems and feedback control," University of Maryland, USA.

May 27 Björn Wittenmark: "Some applications of adaptive control," University of Newcastle, Australia.

June 3 Lars Nielsen: "Perspective area-invariants," 5th Scandinavian Conference on Image Analysis, Stockholm, Sweden.

June 4 Lars Nielsen: "SeeHear," 5th Scandinavian Conference on Image Analysis Stockholm, Sweden.

June 4–5 Karl Johan Åström: "PID-control," "Interconnection of simple regulators," "State feedback and Kalman filters," "Predictive Control," "Autotuning," "Adaptive control." Lectures given in a five days course in mechatronics, organized by PECEE (A European Programme in Continuing Education of Engineers), held in Leuven, Belgium.

June 15–29 Björn Wittenmark: Minicourse in adaptive control with the following lectures: "Adaptive control—An overview," "Model reference control," "Self-tuning regulators," "Stochastic adaptive control," and "Practical aspects and implementation," University of California, Santa Barbara, California, USA.

June 26 Karl Johan Åström: "Stochastic control theory," Invited paper at First International Conference on Industrial and Applied Mathematics, Paris, France.

F. Travels

During 27–28 August 1985 sixteen members of the department made a study tour to Linköping, Sweden, where the Saab factories were visited.

Leif Andersson participated in the international conference 'Ada: Managing the Transition,' held in Edinburgh 6–8 May 1986.

Karl Erik Årzén participated in the 1st International Conference on Applications of Artificial Intelligence in Engineering Practice held in Southampton, UK, in April 1986, where he also presented a paper. Also in April he participated in the Swedish AI Society's Annual Workshop SAIS'86 in Linköping, Sweden, and presented a paper. Årzén visited USA in June 1986. He participated in the American Control Conference in Seattle and presented a paper. He also visited a number of universities and companies: MIT AI lab in Cambridge, MIT Dept. of Chemical Engineering in Cambridge, Lisp Machine Inc. in Cambridge, Boeing Military Airplane Co. in Seattle, Reasoning Systems in Palo Alto, Systems Control Technology in Palo Alto, and Advanced Decision Systems (ADS) in Palo Alto. During the visits informal seminars about the research at the Department in Lund were given.

In April 1987, Årzén participated in the Joint SERC-STU Workshop on Expert Systems and Data Bases for Control System Design and Application, held in Cambridge, UK, where he presented a paper.

Karl Johan Åström visited UK in July 1985, where he participated in the 7th IFAC/IFORS Symposium on Identification and System Parameter Estimation in York. He also participated in a meeting of the steering committee for the SERC project on Computer Aided Control System Design. He visited IFAC Council, Boston, and he visited Leeds and Northrup to discuss adaptive control. In November he made a trip to USA, where he visited the University of New York and the University of Texas, Austin. He participated in the ASME Winter Meeting to receive the Rufus Oldenburger medal and present a paper. Also in November

he received "KTH's Stora Pris", which is a great reward given from a foundation at the Royal Institute of Technology (KTH) in Stockholm, Sweden.

In January, 1986, Åström visited California, USA, to participate in the 3rd International Conference on Chemical Process Control (CPC III) in Asilomar and present a paper. During the same trip he visited NASA and gave a lecture on Adaptive Control Systems. He also visited Lawrence Livermore National Laboratory (LLNL) to discuss CACE with Charlie Herget and Don Gavel. He visited China Lake, where he gave two seminars. Finally, he visited CalTech, Pasadena, and gave a seminar. In February Åström visited the Central Electricity Generating Board (CEGB), Barnwood, Gloucester, UK, for discussions about computer aided control engineering and modelling of power plants. In April he participated in the IEEE International Conference on Robotics and Automation, San Francisco, California, and presented two papers.

In July 1986 Åström participated in the 2nd IFAC Workshop on Adaptive Systems in Control and Signal Processing, held in Lund, and presented a paper. He was also the chairman of the International Program Committee which organized the workshop. On 13–19 July he visited University of Manchester, UK, to participate in the SERC-STU Workshop on Graphical Front Ends for CACE and presented a paper. After that he went to Germany where he visited DFVLR in Oberpfaffenhofen to discuss CACE, animation and robotics. He also gave a seminar there. On 27–30 August 1986 Åström visited Zürich, Switzerland. There he participated in IFAC Symposium on Large Scale Systems and gave an introduction to a round table discussion. He also participated in a meeting with the IFAC Council. During the same trip he also visited ETH in Zürich.

In the middle of September 1986 he went to USA where he spent five weeks. He participated in IEEE Workshop on the Challenge to Control, held in Santa Clara, California, where he made a keynote talk. He participated in IEEE Third Symposium on Computer-Aided Control System Design (CACSD), 24–26 Sept, Arlington, Virginia, and presented two papers. During his stay he visited Pentagon to listen to presentation of AI activities in the US army, and he visited DuPont in Delaware to

discuss advanced process control. He also visited several companies and universities in California: Advanced Decision Systems, HP Research, UC Berkeley, UC Santa Cruz, Reasoning Systems, Integrated Systems, Apple, IBM, Systems Control. He gave seminars at many of the places he visited.

In November 1986, Åström visited IVA in Stockholm to receive the Chester Carlsson medal in information science.

1987 Åström visited Apple Computer in Cupertino on January 27 – February 3. In the middle of February he spent a week in England, where he visited CEGB in Gloucester to discuss CACE, Imperial College of Science and Technology in London, and The Institution of Electrical Engineers, London. He also gave seminars during the visits. In April 1987 he participated in the Joint SERC-STU Workshop on Expert Systems and Data Bases for Control System Design and Application, held in Cambridge, UK, and presented a paper. In May he made a trip to USA, where he visited University of Maryland and also gave a seminar.

Åström was one of the lecturers of a five days course in mechatronics, organized by PECEE and held in Leuven, Belgium, 1–5 June 1987. He gave five lectures. Later in June he participated in the 1987 American Control Conference in Minnesota, USA. He participated with an invited paper in the First International Conference on Industrial and Applied Mathematics, held in Paris, France, 29 June – 3 July, 1987.

Jan Peter Axelsson made travels during the fall 1985 related to the yeast project: On August 2 he visited Gist Brocades and discussed control difficulties in commercial baker's yeast produdction with van den Broecke, 'coordinating manager automation and producdtion services, Yeast Division'. In October 8–10 he went to Hannover and visited the conference BIO technica'85. In December 11–13 he participated in the 1st IFAC symposium on Modelling and Control of Biotechnological Processes in The Netherlands, where he presented a poster.

Dag Brück participated in the Joint SERC-STU Workshop on Graphical Front Ends for CACE held at UMIST, Manchester, UK, on 14–18 July, 1986. In February 1987 he visited the University College of Swansea, Wales, UK, to discuss common interests in man-machine interfaces.

In connection to this he also visited the Central Electricity Generating Board (CEGB) in Barnwood, Gloucester, UK.

Ola Dahl visited Espoo, Finland, in June 1986 to participate and present a paper in the 1st IFAC Workshop on Digital Image Processing in Industrial Applications, Vision Control. In June 1987 he participated in the 5th Scandinavian Conference on Image Analysis, held in Stockholm, Sweden.

Ulf Holmberg attended the 3rd IFAC/IFIP Symposium CADCE'85, Computer Aided Design in Control and Engineering Systems (Advanced tools for modern technology) at the Technical University of Denmark, Lyngby, Denmark, July 31–August 2, 1985. In December 1985 he participated in the 1st IFAC Symposium on Modelling and Control of Biotechnological Processes in The Netherlands, and presented a paper. In November 1986, Holmberg participated in the AIChE Annual Meeting, Miami Beach, Florida, USA, where he also presented a paper.

Tore Hägglund visited York, England, in July 1985 to participate and present a paper in the 7th IFAC/IFOR Symposium on Identification and System Parameter Estimation.

Rolf Johansson spent six month with Laboratoire d'Automatique de Grenoble, France, during 1985. The visit was financed by Centre National de la Recherche Scientifique (CNRS) of France and Naturvetenskapliga Forskningsrådet (NFR) of Sweden. The visit was organized by Dr. J. M. Dion, Dr. L. Dugard and Dr. I. D. Landau of Laboratoire d'Automatique. Johansson took part in the research activities organized by CNRS GRECO and gave several seminars.

Jan Eric Larsson attended the 3rd IFAC/IFIP Symposium CADCE'85, Computer Aided Design in Control and Engineering Systems (Advanced tools for modern technology) at the Technical University of Denmark, Lyngby, Denmark, July 31–August 2, 1985. In April 1986 he participated in the Swedish AI Society's Annual Workshop SAIS'86 in Linköping, Sweden, where he presented a paper. In June 1986 he visited USA, where he participated in the American Control Conference in Seattle and presented a paper. He also visited a number of universities and

companies: Dept. of Mechanical Engineering at Carnegie-Mellon University in Pittsburgh, MIT AI Lab. in Cambridge, Lisp Machine Inc. in Cambridge, MIT Dept. of Chemical Engineering in Cambridge, Boeing Military Airplane Co. in Seattle, Reasoning Systems in Palo Alto, Dept. of Electrical Engineering at Berkeley, and Stanford University. Seminars and discussions were held in connection with the visits.

Sven Erik Mattsson participated in the 7th IFAC/IFORS Symposium on Identification and System Parameter Estimation at the University of York, United Kingdom, 3–7 July, 1985. Together with Karl Johan Åström he also went to Manchester to discuss CACE projects with Professor Neil Munro and Dr. Simon Goodfellow (UMIST) and Professor Dean Frederick (Rensselaer Polytechnic Inst., Troy, New York). He also attended the 3rd IFAC/IFIP Symposium CADCE'85, Computer Aided Design in Control and Engineering Systems (Advanced tools for modern technology) at The Technical University of Denmark, Lyngby, Denmark, July 31–August 2, 1985.

In July 1986 Mattsson participated in the Joint SERC-STU Workshop on Graphical Front Ends for CACE in Manchester, UK, 14–18 July. After that, 21–22 July he visited Professor J. Ackermann's group at the DFVLR-Institut für Dynamik der Flugsysteme in Oberpfaffenhofen, München, FRG. In February 1987 Mattsson visited the University College of Swansea, Wales, UK. He visited the Dept. of Electrical and Electronic Engineering and Dept. of Mathematics and Computer Science to discuss man-machine interfaces and a possible collaboration. During the same trip he also visited the Central Electricity Generating Board (CEGB) in Barnwood, Gloucester, UK.

Bengt Mårtensson spent one month in the USA during April and May 1986. He participated in the conference "Differential Geometry: The Interface Between Pure and Applied Mathematics" in San Antonio, Texas. He visited the following universities, where he also gave seminars: Arizona State University, Dept of Electrical and Computer Engineering and Dept of Mathematics; University of California, Berkeley, Department of Electrical Engineering; University of Maryland, College park, Department of Electrical Engineering and the Systems Research Center; Harvard University and Massachusetts Institute of Technology.

In July 1986 Mårtensson participated in the Conference on Modelling and Adaptive Control in Sopron, Hungary, and presented a paper. In August the same year he particiapted in the SIAM Conference on Linear Algebra in Signals, Systems and Control, held in Boston, Massachusetts. There he presented two papers.

Lars Nielsen spent the year 1985–86 as a visiting researcher at Caltech, Pasadena, USA. He was working with professor Carver Mead and his group at the Department of Computer Science. Nielsen constructed a servo consisting of a vehicle under computer control. Different vision chips were mounted on the vehicle and investigated under motion. He also made some test chips integrating optical sensors and pulse control servos. Together with Misha Mahowald and Carver Mead he was working on design and test of a large chip that combines visual and auditory signal processing.

In June 1986 Nielsen visited Finland to participate in the 1st IFAC Workshop on Digital Image Processing in Industrial Applications, Vision Control, where he presented a paper. In June 1987 he participated in the 5th Scandinavian Conference on Image Analysis, held in Stockholm, and presented two papers.

Gustaf Olsson participated in August 1985 in a specialist workshop on Modelling of Biological Wastewater Treatment, sponsored by the International Association for Water Pollution Research and Control, and held in Lyngby, Denmark. He made a two week tour to USA-Canada in October 1985 as part of an on-going cooperation on control of wastewater treatment plants with the Wastewater Technology Centre, Burlington, Ontario and the Weyerhaeuser Company, Tacoma, Washington. He also participated in the IFAC Symposium on Modelling and Control of Biotechnological Processes, Noordwijkerhout, The Netherlands, 11–13 Dec, 1985. He chaired a session and had a common paper with Ulf Holmberg presented by the latter.

Another trip to Houston, Texas (Rice University and the City of Houston projects) was made in March 1986. In May 1986, Gustaf Olsson was the external examiner of a doctoral thesis (Thomas Nybrant) in automatic control at the Uppsala University. In June he organized a visit of a delegation from the Wastewater Technology Centre (WTC), Burlington,

Ontario, to Sweden. This was the start of a mutual technology exchange program between the Swedish Water and Waste Water Works Association and the Canadian WTC. In August 1986 he participated in the IAWPRC biennal world congress in Rio de Janeiro in August 1986 as session chairman and discusser. He continued to the USA and Canada for further cooperation in research projects in Seattle and in Burlington. Another trip to Canada and USA was made in November.

Olsson has been active in establishing a cooperative agreement between the Swedish Water and Wastewater works Association (VAV) and the Wastewater Technology Centre in Burlington, Canada. As part of this program a small workshop was held in January 1987 in Burlington. In March he held a two day concentrated graduate course at the Institute of Technology in Luleå. He also presented an invited paper at the European Water Pollution Control Association in München, FRG, in May 1987.

Per Persson attended the 3rd IFAC/IFIP Symposium CADCE'85, Computer Aided Design in Control and Engineering Systems (Advanced tools for modern technology) at the Technical University of Denmark, Lyngby, Denmark, July 31–August 2, 1985. In April 1986 he participated in the Swedish AI Society's Annual Workshop (SAIS'86) in Linköping, Sweden. In April 1987 he participated in the Joint SERC-STU Workshop on Expert Systems and Data Bases for Control System Design and Application, held in Cambridge, UK, where he presented a paper.

Lars Rundqwist visited Frankfurt, Germany, in October 1985 to participate in the IFAC Workshop on Adaptive Control in Chemical Processes, where he presented a paper. In May 1986 he visited Stockholm, Sweden, to give a lecture at the Swedish Association for Water Hygiene.

Tomas Schönthal went to Great Britain in February 1987, where he visited the University College of Swansea, Wales, to discuss common interests in man-machine interfaces. During the same trip he also visited the Central Electricity Generating Board (CEGB) in Barnwood, Gloucester, UK.

Björn Wittenmark was the external examiner of a doctoral thesis (Bengt Lennartsson) at Chalmers Institute of Technology, Gothenburg, in May

1986. On 1–3 July Wittenmark participated in the 2nd IFAC Workshop on Adaptive Systems in Control and Signal Processing, which was held in Lund. He was a member of the International Program Committee which organized the workshop and he was also responsible for the final program.

Wittenmark was on sabbatical leave during the academic year 1986–1987. He spent the year at Department of Electrical and Computer Engineering, University of Newcastle, Australia. During the visit in Australia he made research in the area of adaptive control together with G.C. Goodwin, R.J. Evans and R.H. Middleton. He also visited and lectured at University of Queensland, Brisbane, Australian National University, Canberra, and University of New South Wales, Sydney.

On the way to Australia he lectured and visited in China at the following places: Tsinghua University, Beijing, East China Normal University, Shanghai, and Shanghai University of Science and Technology. On his way back he lectured at Department of Chemical and Nuclear Engineering, University of California, Santa Barbara.