Activity Report: Automatic Control 1976-1977

Åström, Karl Johan; Olsson, Gustaf

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ACTIVITY REPORT 1976 - 1977

Karl Johan Åström and Gustaf Olsson

ABSTRACT

The report surveys the activity at the Department of Automatic Control, Lund Institute of Technology, during the academic year 1976 - 77. It covers education and research. About 420 students took courses from the department during the period. 15 MS-theses and 1 PhD-thesis were completed during the academic year. The major areas of research were system identification, adaptive control, computer aided design of control systems and algebraic system theory. The applied research was devoted to adaptive ship steering, control of waste water treatment plants, control of heating and ventilation systems, and biomedical control problems.

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Lund Institute of Technology
Handläggare Dept of Automatic Control
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Karl Johan Åström
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Authors

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1. INTRODUCTION

The report follows the pattern of the previous activity reports. This time we will, however, only give an overview of the research projects because they have been presented in great detail in the previous yearly reports.

A major course revision has been initiated. The idea is to get a good base to revise all curricula. The input is obtained from discussions with colleagues and interviews with people in industry.

With regards to trends the impression from last year report concerning industrial use of interactive computing has been strengthened. There are now several industrial users of the packages IDPAC and SIMNON. We are also of the impression that the industrial use of self-tuning regulators will increase considerably with the availability of cheap microprocessors.

We will thank our sponsors the Swedish Board of Technical Development (STU), the Swedish Institute of Applied Mathematics (ITM), the National Board of Building Research (BFR), and the Scandinavian Council for Applied Research (Nordforsk) for their support of our projects.

2. A CURRICULUM REVISION FOR THE CIV ING PROGRAM

Most courses in the civ ing program have remained invariant for several years. We have therefore initiated a project to gather information for course reforms. We have had internal discussions. Many industries have been visited. Questionaries have been sent out. Colleagues at other universities and engineers have been interviewed. The material obtained is being digested. It will most likely result in revisions of our basic courses and in new courses for continued education.

3. RESEARCH

The major research areas are the following:

STOCHASTIC CONTROL THEORY

COMPUTER AIDED DESIGN

ALGEBRAIC SYSTEM THEORY

APPLICATIONS.

Within stochastic control theory there has been a shift in emphasis from system identification to adaptive control. The major work in system identification has been to round off results on recursive parameter estimation. The major work in system identification is now done within the applications project on ship modeling. It is expected that the work on adaptive control will be a major undertaking also for the years to come. Important areas which have been covered this period are dual control and adaptive prediction. Self-tuning regulators were also implemented in microprocessors. To follow the line of keeping abreast with work done elsewhere, professor Oliver Jacobs, Oxford University, spent a month with our adaptive control project.

A major change of direction was made in the computer aided design project. A commercial version of IDPAC was developed in response to industrial demands. To do this the system development was moved from PDP-15 to UNIVAC 1108. This made possible use of standard FORTRAN (not entirely available on PDP-15). It also gave an opportunity to isolate those parts that by necessity are implementation dependent. All the basic interaction was grouped into one package called INTRAC which is now the basis for all our interactive software. INTRAC can also be used separately to make a set of FORTRAN routines interactive. The availability of the programs have also increased substantially because they are now run under the ordinary time-sharing system.

A first version of a model transformation package MODPAC was also implemented. A substantial work to standardize software was carried out. This led to rules for subroutines in cooperation with other Scandinavian universities and the formation of the Scandinavian Control Library.

The work in algebraic system theory was devoted to development of software for algebraic control problems, algebraic design methods and theory for systems described by the backward shift operator.

The major application fields are:

MODELING OF SHIP DYNAMICS (joint project with the Swedish State Shipbuilding Experimental Tank, Gothenburg)

ADAPTIVE SHIP STEERING (joint project with Kockums Automation AB, Malmö)

CONTROL OF HEATING AND VENTILATION SYSTEMS (joint project with the Department of Building Science, Lund)

CONTROL OF WASTE WATER TREATMENT (joint projects with Datema AB, Nynäshamn, and University of Houston, Texas)

MODELING OF GLUCOSE AND INSULIN (joint projects with the University Hospitals in Malmö and Lund)

4. LABORATORY

Plans have been made for upgrading our teaching laboratories. Several candidates for laboratory processes have been explored. Four microprocessors LSI-11 were bought. Small process control systems were built around the processors.

APPENDIX A - LIST OF PERSONNEL

Professor	Karl Johan Åström
University lecturers *Universitetslektorer*	Gustaf Olsson
	Björn Wittenmark
Research assistant *Forskarassistent*	Per Hagander (PhD)
Research engineers *Forskningsingenjörer*	Leif Andersson
	Hilding Elmqvist (PhD candidate)
	Tommy Essebo (programmer)
	Ivar Gustavsson (PhD)
	Jan Holst (PhD candidate)
	Lars Jensen (PhD candidate)
	Claes Källström (PhD candidate)
	Ann-Britt Nilsson (programmer)
	Lars Pernebo (PhD candidate)
	Tomas Schönthal (programmer)
	Jan Sternby (PhD 1977)
	Johan Wieslander (Tekn lic, PhD candidate)
Teaching assistants *Assistenter*	Bo Egardt (PhD candidate)
	Matz Lenells (PhD candidate)
	Carl Fredrik Mannerfelt (PhD candidate)
	Sven-Erik Mattsson (PhD candidate)
	Per Molander (PhD candidate)

Laboratory engineer *Laboratorieingenjör*	Rolf Braun
Visiting scientists *Gästforskare*	Mr Andrē Barbé, Leuven, Belgium (6 months)
	Prof H R Sirisena, New Zealand (3 months)
	Dr Vsevolod Razevig, Moscow, USSR (6 months)
	Mr Asko Kippo, Univ of Oulu, Finland (5 months)
Technical drawings *Tekniskt biträde*	Britt-Marie Carlsson
Secretaries *Sekreterare*	Eva Schildt
	Eva Dagnegård
	Lilian Andersson (part time)
Typist *Skrivhjälp*	Gudrun Christensen

APPENDIX B - PUBLISHED PAPERS AND CONFERENCE PAPERS

Andersson, L: DISCO - An educational microcomputer controller. IFAC Symp on Trends in Automatic Control Education, Barcelona, Spain, March 30 - April 1, 1977.

Bengtsson, G: Output regulation and internal models - A frequency domain approach. Automatica 13 (1975) 333-345.

Borisson U, Syding R: Self-tuning control of an ore crusher. Automatica 12 (1976) 1-7.

Gillblad T, Olsson G: Computer control of a medium sized activated sludge plant. Proc IAWPR (Int Assoc of Water Pollution Res), Int Workshop on Instrumentation and Control for Water and Wastewater Treatment and Transport Systems, London, May, 1977.

Gustavsson I, Ljung L, Söderström T: Identification of processes in closed loop - Identifiability and accuracy aspects. Survey paper. Automatica 13 (1977) 59-75, 1977.

Hagander P: Random effects in biomedical flow systems. Mathematical Biosciences 36 (1977) 243-255.

Hagander P, Wittenmark B: A self-tuning filter for fixed-lag smoothing. IEEE Transactions on Inf Theory IT-23 (1977) 377-384.

Hagander P, Rutili G, Svensjö E, Arfors K-E: Transport of macromolecules across the capillary membrane. Lymph Circulation 300 Years after Rudbeckius, Uppsala, Sweden, September 26-27, 1977.

Hagander P, Tranberg K-G, Thorell J, DiStefano III JJ: The capability of the 25g IVGTT to characterize insulin release. Scandinavian Society for the study of Diabetes, 12th Annual Meeting, Uppsala, Sweden, May 5-6, 1977. Also in Acta Endocrinologica 85, suppl 209, (1977) 28-29.

Källström C: Computer programs for an adaptive autopilot. Report, Kockums Automation AB, Malmö, Sweden, MB 30.

Källström C G, Essebo T, Åström K J: A computer program for maximum likelihood identification of linear, multivariable, stochastic systems. Preprints 4th IFAC Symp on Identification and System Parameter Estimation, Part 2, pp 508-521, Tbilisi, USSR, September 1976. Also report TFRT-7086.

Leden B: Multivariable dead-beat control. Automatica 13 (1977) 185-188.

Leden B: Output dead-beat control - A geometric approach. Int J Control 26 (1977) 493-507.

Leden B, Hamza M H, Sheirah M A: Different methods for estimating thermal diffusivity of a heat process. Automatica 12 (1976) 445-456.

Olsson G: Estimation and identification problems in wastewater treatment. Invited paper, IIASA Workshop on Recent Developments in Real-time Forecasting/Control of Water Resource Systems, Laxenburg, Austria, October 18-20, 1976. Also report TFRT-7111.

Olsson G: State of the art in sewage treatment control. American Inst of Chemical Engineers, Symp Series 72, No 159 (1977) 52-76. Also report TFRT-7093.

Olsson G: Modeling and identification of a nuclear reactor. In "System Identification: Advances and case studies" (R Mehra and D Lainiotis, Eds), Math. in Science and Engineering 126, pp 519-593, Academic Press, N Y, 1976.

Olsson G, Andrews J F: An analysis of dissolved oxygen profiles in the activated sludge process for the development of control strategies. Submitted for Water Research 1977.

Olsson G, Andrews J F: Estimation and control of biological activity in the activated sludge process using dissolved oxygen measurements. Accepted for IFAC Symp on Environmental Systems Planning, Design and Control, Kyoto, Japan, August 1977.

Olsson G, Hansson O: Modeling and identification of an activated sludge process. Proc 4th IFAC Symp on Identification and System Parameter Estimation, Tbilisi, USSR, September 1976. Also report TFRT-7092.

Olsson G, Hansson O: Stochastic modeling and computer control of a full scale wastewater treatment plant. Symp on Models in Air and Water Pollution, The Institute of Measurement and Control, London, England, September 22-24, 1976. Also report TFRT-7106.

Pernebo L: Notes on strict system equivalence. Int J Control 25 (1977) 21-38.

Sternby J: A simple dual control problem with an analytical solution. IEEE AC-21 (1976) 840-844.

Sternby J: On consistency for the method of least squares using martingale theory. IEEE AC-22 (1977) 346-352.

Söderström T, Ljung L, Gustavsson I: Identifiability conditions for linear multivariable systems operating under feedback. IEEE AC-21 (1976) 837-840.

Wieslander J: A laboratory exercise in a course on computerized control. IFAC Symp on Trends in Automatic Control Education, Barcelona, Spain, March 30 - April 1, 1977.

Åström K J: Self-tuning regulators. NASA CP-003. Proc NASA Workshop on Systems Reliability Issues Future Aircraft, pp 51-67, August 1975.

Åström K J: State of the art and needs in process identification. AIChE Symposium Series 72 No 159 (1976) 184-194.

Åström K J: Flow systems. In "Directions in Large Scale Systems" (Ho Y-C and Mitter S K, Eds). Plenum Press, New York, 1976.

Åström K J: Some aspects on the control of large tankers. In "Analyse de Systèmes et ses Orientations Nouvelles" (Bensoussan and Lions, Eds). Springer, Heidelberg, 1977.

Åström K J: Frequency domain properties of Otto Smith regulators. Int J Control 26 (1977) 307-314.

Åström K J: The role of system identification in process modeling. VDE-Berichte 276 (1977) 13-30.

Åström K J, Källström C: Identification of ship steering dynamics. Automatica 12 (1976) 9-22.

Åström K J, Källström C, Norrbin N H, Byström L: The identification of linear ship steering dynamics using maximum likelihood parameter estimation. Statens Skeppsprovningsanstalt nr 75 (1975) 1-105.

APPENDIX C - REPORTS

DISSERTATIONS

TFRT-1012 Sternby J: Topics in dual control. May 1977.

FINAL REPORTS

TFRT-3140 Molander P: An algebraic test for positive realness. Sept 1977.

TFRT-3141 Jensen L, Lange E: Lägesstyrning av pneumatiskt ställdon (Position control of a pneumatic actuator). Nov 1976.

TFRT-3142 Jensen L: Digital reglering av klimatprocesser (Digital control of climate processes). Nov 1976.

TFRT-3143 Lindahl S: Design and simulation of a coordinated drum boiler-turbine controller. Dec 1976.

TFRT-3144 Åström K J: Why use adaptive techniques for steering large tankers? April 1977.

TFRT-3145 Källström C G, Åström K J, Thorell N E, Eriksson J, Sten L: Adaptive autopilots for steering of large tankers. July 1977.

TFRT-3146 Wieslander J: Scandinavian control library, a subroutine library in the field of automatic control. Jan 1977.

ACTIVITY REPORTS

TFRT-4008 Åström K J, Olsson G: Activity report 1975-1976. Nov 1976.

MASTER THESES

TFRT-5184 Lindqvist A: En studie av processdatorsystem för pappersindustrin (A study of computer control systems for the paper industry). Sept 1976.

TFRT-5185 Lenells M: Approximation av en oändligtdimensionell regulator för ett linjär-kvadratiskt problem (An approximation of an infinite dimensional controller in a linear-quadratic problem). Sept 1976.

TFRT-5186 Sjöberg P-O: Mikrodatorsystem med INTEL 8080 för reglerapplikationer (A microcomputer system, based on INTEL 8080, for control applications). Oct 1976.

TFRT-5187 Nilsson A-B, Nivhede L: Interaktiva analysprogram (Programs for interactive analysis). Oct 1976.

TFRT-5188 Månsson C-H: Datorstyrd svetsautomat (A computer controlled welding equipment). Nov 1976.

TFRT-5189 Oscarsson G, Wensheim S: Nivå och flödesreglering på laboratorieprocess (Level and flow control on a laboratory process). Nov 1976.

TFRT-5190 Gustafsson G: Jämförelse av olika dynamiska modeller för sedimenteringen i biologisk vattenrening (Comparison of different dynamical models of secondary sedimentation in biological wastewater treatment). Jan 1977.

TFRT-5191 Jansson T: Simuleringar på sinterverk -75 vid Norrbottens Järnverk AB, Luleå (Simulations of Sintering Plant -75, Norrbottens Järnverk AB, Luleå). Febr 1977.

TFRT-5192 Holender W: Kalmanfilter för kvantiserad utsignal (A Kalman filter for a quantized output signal). March 1977.

TFRT-5193 Wiktorsson G: Implementering av extremalsökande algoritm på mikrodator (Implementation of an extremal searching algorithm on a microcomputer). March 1977.

TFRT-5194 Mannerfelt C F: Undersökning av några duala regulatorer (Examination of some dual controllers). May 1977.

TFRT-5195 Bergman M: Tågstyrning (Train control). April 1977.

TFRT-5196 Axler E: Simulering av produktionssystem (Simulation of a production system). May 1977.

INTERNAL REPORTS

TFRT-7108 Källström C: Simulation of ship yawing. Sept 1976.

TFRT-7109 Källström C: Simulation of ship steering. Sept 1976.

TFRT-7110 Källström C: The Sea Stratus experiments, April 1976. Sept 1976.

TFRT-7111 Olsson G: Estimation and identification problems in wastewater treatment. Nov 1976.

TFRT-7112 Leden B: Fasavancerande kompensering (Lead compensation). Sept 1976.

TFRT-7113 Hagander P: Random effects in biomedical flow systems. March 1977.

TFRT-7114 Åström K J: Limitations of system performance due to time delays, instability, and non-minimumphase characteristics - An example. Dec 1976.

TFRT-7115 Åström K J: Control of systems with uncertain parameters. Jan 1977.

TFRT-7116 Åström K J, Olsson G: Kurser i Datorteknik vid LTH. Diskussionsdag 9 december 1976 (Courses in Computer Science at LTH. Discussion meeting Dec 9, 1976). Jan 1977.

TFRT-7117 Pernebo L, Sternby J: A comparison of two suboptimal dual controllers on a first-order system. April 1977.

TFRT-7118 Carlqvist P, Due L, Fabretto J, Fogelberg L, Kvist B, Ljung L, Lundström M, Strååt O, Upadhyaya L, Walle P O: Automatic control of a road vehicle (projectwork in the systems techniques course, spring 1977). Aug 1977.

TFRT-7119 Brink O, Johansson G, Johansson R, Olesen H, Persson Å, Pålsson T, Rading L, Rosenwald K, Tengvall F: Reglering av ångpanna (Boiler control) (projectwork in Reglerteknik AK (linear systems), fall 1976). June 1977.

TFRT-7120 Razevig S: Simulation of nonlinear stochastic differential equations. May 1977.

TRAVEL REPORTS

TFRT-8022 Åström K J: Visit to the Department of Automatic Control, ETH, Zürich, February 1977. May 1977.

APPENDIX D - GRADUATE COURSES AND SEMINARS

Seminars and graduate courses, given at the department during the year, are summarized here. They are given by the staff at the department, by invited lecturers, or in cooperation with other departments at the Institute.

PHD COURSES

The following PhD courses were given:

Modeling (K J Åström)

Control System Design (K J Åström) with guest lecturers
H S Sirisena, Univ of Canterbury, New Zealand
A G J MacFarlane, Univ of Cambridge, England
D Q Mayne, Imperial College, London, Enlgand
O Jacobs, Univ of Oxford, England

System Theory (P Hagander)

Optimization Theory (P Hagander)

The courses on modelbuilding and control system design were given for the first time. The contents of the courses are listed below.

Modeling:

1. Introduction
2. Principles of modeling
3. Review of physics
4. Examples
5. Model simplification
6. Composition of simple models. Interconnection
7. Examples

Control System Design:

1. Introduction
   Control theory as control system design
2. Regulator structures
3. Review of relevant theory
   Pole placement. State feedback. Observers. Kalman filtering. LQG-theory. Algebraic system theory. Frequency response.
4. Pole placement design
5. Frequency response
   Generalized root loci. Characteristic loci. Inverse Nyquist.

The following individual PhD tutorials were also given to individual studies:

Stochastic Control (S-E Mattsson)

Linear Quadratic Control (M Lenells)

Nonlinear Systems (P Molander)

Stochastic Processes (P Molander)

Identification and Adaptive Control (P Molander)

Identification (Å Knutsson)

SEMINARS

Dr Don Rutherford, University of Manchester (UMIST), England.
"Computerized equipment for teaching automatic control", Aug 20, 1976,
"Applications of microprocessors in process control and instrumentation", Aug 23, 1976,
"Fuzzy mathematics", Aug 25, 1976,
"Applications in automatic control of fuzzy mathematics", Aug 26, 1976.

Prof Peter Falb, Brown University, Providence, R I, USA.
"Differential Geometry and Dynamic Systems", five lectures:
"Introduction", Aug 19, 1976,
"Overview of applications to nonlinear systems", Aug 24, 1976,
"Overview of applications to linear systems", Aug 27, 1976,
"Overview of applications to linear systems", Aug 31, 1976,
"An application to nonlinear filtering", Sep 1, 1976.

Prof George N Saridis, Purdue University, Lafayette, Ind, USA.
"Self-organizing control and learning systems", Sep 9, 1976.
"Hierarchically intelligent control of a bionic arm", Sep 13, 1976.

Prof K J Åström, Lund.
"Actual problems in control, with emphasis on the research at the Department", Sep 10, 1976,
"Control system design I", Sep 14, 1976,
"Control system design II", Sep 17, 1976,
"Control system design III", Oct 8, 1976.

Prof G Goodwin, Univ of Newcastle, Australia.
"System identification", Sep 16, 1976.

Dr John Ockendon, Oxford.
"Differential equations arising in industrial problems", two seminars, Sep 28 and 29, 1976.

Dr P J Gawthrop, Univ of Oxford, England.
"New interpretations of the STC", Oct 19, 1976.
"The stochastic tracking problem", Oct 20, 1976.

Mr André Barbé, Leuven, Belgium.
"Level crossing problems in control", Oct 27, 1976.

Prof Donald Wiberg, System Science Dept, Univ of California, Los Angeles, USA. "Triangular covariance factorizations for Kalman filtering", Oct 29, 1976.

Johan Wieslander and Hilding Elmqvist, Lund.
"The control program library", Nov 3, 1976.

Dr Ivar Gustavsson, Lund.
"Identification of closed loop systems", Nov 10, 1976.

Mr Krister Lundberg, Eur Control, Säffle.
"Mätgivare och ventiler" ("Sensors and valves"), Nov 26, 1976.

Mr Sture Lindahl, Swedish State Power Board (Vattenfall), Stockholm.
"Model building: power boilers", Nov 26, 1976.

Prof K E Bollinger, Univ of Manchester (on leave from Univ of Saskatchewan), England.
"Views of tuning power plant controllers", Dec 6, 1976.

Prof Donald Wiberg, UCLA, Los Angeles, USA.
"Optimal control location for some classical PDE", Jan 12, 1977.

Prof H R Sirisena, New Zealand.
"Reduced order observers for estimating linear functions of the state", Jan 21, 1977,
"On decoupling linear multivariable systems using output feedback", Jan 28, 1977.

Prof Lennart Ljung, University of Linköping.
"Convergense analysis of the extended Kalman filter (EKF) used as a parameter estimation for linear systems. The relation between the EKF and other recursive identification methods", Jan 25, 1977.

Dr Ivar Gustavsson, Lund.
"Rekursiva skattningar av parametrar i dynamiska system" ("Recursive estimation of parameters in dynamical systems"), Feb 3, 1977.

Dr Per Hagander, Lund.
"Reläservon" ("Relay servo systems"), Feb 4, 1977.

Dr S Razewig, Moscow.
"Simulation of non-linear stochastic differential equations", March 9, 1977.

Mr Leif Andersson, Lund.
"Description of the LSI-11 computer", March 11, 1977.

Mr Lars Pernebo, Lund.
"Introduction to the graduate course in design of feedback systems, given by Prof A G J MacFarlane", March 10, 1977.

Prof Alistar G J MacFarlane, Univ of Cambridge, England.
"The use of complex variable methods for the analysis and design of linear multivariable feedback systems", five lectures, March 15 - 18, 1977.

Dr B Francis, Cambridge, England.
"Perfect regulation and feed-forward control of multivariable systems", March 17, 1977.

Prof H R Sirisena, New Zealand.
"New results on reduced order observers", March 25, 1977.

Prof David Mayne, Imperial College, London.
"Feasible direction algorithms for optimization problems with equality and inequality constraints", March 29, 1977,
"A cut map algorithm for a class of computer aided design problems", April 1, 1977,
"Linear estimation of ARMA systems", April 4, 1977.
"A feasable directions algorithm for optimal control problems with control and terminal inequality constraints", April 13, 1977,
"An exact penalty function algorithm for optimal control and terminal equality constraints", April 15, 1977,
"Relaxed control and the convergence of optimal control problems", April 22, 1977.

Prof K J Åström, Lund.
"Two examples of poleplacement design", March 31, 1977.

Dr Consuelo de Padilla, Venezuela.
"A sensitivity approach to the dual control problem", April 21, 1977.

Jan Sternby, Lund
"Dual control, an example", April 27, 1977.
"Consistency of least squares identification", April 29, 1977.
"Regulators for time varying stochastic systems", May 2, 1977.

Dr S Razewig, Moscow.
The cut off problem in frequency locked loops", May 6, 1977.

Prof Granino Korn, Univ of Arizona, USA.
"Digital simulation", May 9, 1977.

Prof Oliver Jacobs, Univ of Oxford, England.
"Monte Carlo comparisons of adaptive controllers", two lectures, May 10 and 13, 1977.

Prof John Casti, Univ of Arizona, USA.
"The Bezoutiant matrix and canonical forms for linear systems", May 17, 1977.

Prof A V Oppenheim, MIT, Cambridge, USA.
"Speech processing as a system identification problem", May 23, 1977.

APPENDIX E - LECTURES BY THE STAFF

1976

July 5-9 K J Åström: Five lectures on system identification:
Industrial experiences,
Computer aided design packages,
Recursive estimation,
Prediction error methods and maximum likelihood identification,
Identification of closed loop systems.
University of Manchester, Manchester, England.

Sep 21-27 IFAC Symposium on Identification and System Parameter Estimation, Tbilisi, USSR:

K J Åström (co-authors C Källström, T Essebo): A computer program for Maximum Likelihood Identification of linear multivariable stochastic systems.

I Gustavsson (co-authors L Ljung, T Söderström): Identification of processes in closed loop - identifiability and accuracy aspects. Invited survey paper.

G Olsson (co-author O Hansson): Modeling and identification of an activated sludge process.

J Wieslander (co-author I Gustavsson): IDPAC - an efficient interactive identification program.

T Söderström (co-authors L Ljung, I Gustavsson): Analysis of some on-line identification methods.

B Wittenmark (co-author L Ljung): On a stabilizing property of adaptive regulators.

Fall 1976 P Hagander: Graduate course at the Medical Faculty, Lund University (20 lectures). "Metoder för analys och karakterisering av fysiologiska förlopp" ("Methods for the analysis and characterization of physiological phenomena").

Oct 20 G Olsson: Estimation and identification problems in wastewater treatment. IIASA workshop on recent developments in real-time forecasting/control of water resource systems, Laxenburg, Austria.

Nov 10 G Olsson: On the use of dissolved oxygen profiles in the control of activated sludge plants. University of Houston, Houston, Texas, USA.

Dec 15 K J Åström: Some aspects on the control of large tankers. Colloques IRIA Analyse de Systèmes et ses Orientations Nouvelles, Versailles, Rocquencourt, France.

1977

Feb 8 K J Åström: Stochastic control theory and some of its industrial applications. ETH, Zürich, Switzerland.

Feb 10 K J Åström: Maximum likelihood and prediction error methods for system identification. ETH, Zürich, Switzerland.

Feb 10 G Olsson: Control of activated sludge plants. Water Research Centre, Stevenage, England.

Feb 10 K J Åström: Identification of ship steering dynamics. ETH, Zürich, Switzerland.

Feb 14 K J Åström: Self-tuning regulators. ETH, Zürich, Switzerland.

March 8 G Olsson: Modellbyggnad och reglering av biologiska reningsverk (Modeling and control of biological wastewater treatment processes). 3 lectures. Department of Biology, University of Gothenburg, Sweden.

March 11 G Olsson: Interactive simulation and data analysis. Institute of Technology, Lyngby, Denmark.

March 16 K J Åström: Axplock ur reglerteknikens tillämpningar (Selected applications in automatic control). IVA, Stockholm, Sweden.

April 25 K J Åström: The role of system identification in process modeling. VDI/VDE Tagung Prozessmodelle, Wiesbaden, Germany.

April 28 K J Åström: Adaptive control of stochastic systems. Ruhr-Universität Bochum, Germany.

May 16-20 IAWPR Int Workshop on Instrumentation and Control for Water and Wastewater Treatment and Transport Systems, London, England:

T Gillblad and G Olsson: Computer control of a medium sized activated sludge plant.

G Olsson: Convenors report on 'control system philosophies'.

June 6 G Olsson: New ideas on control methods for the activated sludge process. Dept of Civil Engineering, Univ of Houston, Houston, Texas, USA.

June 10 P Hagander: Okända begynnelsevärden (Unknown initial conditions). Seminar at a one day workshop on Kalman filtering and smoothing, Dept of Information Theory, Chalmers Inst of Technology, Gothenburg, Sweden.

June 20 J Sternby: Dual styrning (Dual control). Swedish Inst for National Defense, Stockholm, Sweden.

June 22 H Elmqvist: SIMNON - An interactive simulation program for nonlinear systems. Paper, Simulation 77, Montreux, Switzerland.

APPENDIX F - TRAVELS

Leif Andersson participated in the IFAC symposium on Trends in Automatic Control Education in Barcelona, Spain, March 30 - April 1, 1977. During the same travel he also visited the University of Technology, Delft, Netherlands.

Hilding Elmqvist participated in the conference Simulation 77 in Montreux, Switzerland, June 22-24, 1977, and presented a paper there. Before the conference he visited the Fachgruppe für Automatik, ETH, Zürich, Switzerland, June 16-21.

Ivar Gustavsson participated in the 4th IFAC Symposium on Identification and Systems Parameter Estimation in Tbilisi, USSR, Sep 21-27, 1976.

Jan Holst participated in the 4th IFAC Symposium on Identification and Systems Parameter Estimation in Tbilisi, USSR, Sep 21-27, 1976.

G Olsson participated in the 4th IFAC symposium on Identification and Systems Parameter Estimation in Tbilisi, USSR, Sep 21-27, 1976. In October he was invited to the IIASA Workshop on Recent Developments in Real-time Forecasting/Control of Water Resource Systems, Laxenburg, Austria. The workshop lasted Oct 18-20, 1976. On Nov 8-12 he participated in a meeting between the Sparling Division of Environtech and the Department of Civil Engineering, Univ of Houston, in Houston, Texas. He has acted as program co-chairman for the IAWPR Int Workshop on Instrumentation and Control for Water and Wastewater Treatment and Transport Systems. The program committee met in London on February 8, 1977. The workshop took place in London on May 16-20. During June and July 1977 he has been a visiting professor at the University of Houston. He also participated in the 1977 JACC conference in San Fransisco, June 1977.

Johan Wieslander participated in the 4th IFAC Symposium on Identification and Systems Parameter Estimation, Tbilisi, USSR, Sep 21-27, 1976, and the IFAC Symposium on Trends in Automatic Control Education, in Barcelona, Spain, March 30 - April 1, 1977.

Björn Wittenmark participated in the 4th IFAC Symposium on Identification and Systems Parameter Estimation, Tbilisi, USSR, Sep 21-27, 1976.

Karl Johan Åström visited University of Manchester (UMIST) and Imperial College (IC), London, in July 1976. In September he visited the Soviet Union to participate in the 4th IFAC Symposium on Identification and System Parameter Estimation in Tbilisi. He also visited the Institute of Control Sciences in Moscow. In December 1976 he participated in the IRIA Symposium on New Directions in System Analysis, Versailles, France. In February 1977 he visited Zürich, Switzerland, to explore the possibilities of a closer cooperation between ETH and LTH. In April he visited Wiesbaden, Germany, to participate in the VDI/VDE Meeting on Process Modeling. In May Åström was external examiner on the dissertation by C Doncarli, Nantes, France, for the degree "docteur d'etat". In June 1977 he participated in the 5th IFAC/IFIP Symposium on Digital Computer Applications to Process Control, The Hague, Netherlands. During the year Åström has been associate editor of Automatica, International Journal on Control, Journal of Mathematical Analysis and Applications, and Mathematical Biosciences. He also participated in a special IEEE panel to evaluate the IEEE Transactions on Automatic Control.