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Centre of Excellence for Advanced Control Technologies

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Centre of Excellence for Advanced Control Technologies (CoE ACT)

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Control technology

Control technology is associated with informatics, cybernetics and process automation. It is one of the key technologies that can contribute to the increased efficiency of production processes. By promoting the implementation of advanced control solutions and tools, Slovenia has the possibility to improve the competitiveness of production and service enterprises.

Strategy for developing control technology in Slovenia

The Strategy has been prepared by a consortium of partners united within the Process Control Technology Network (PCTN). The PCTN connects three major Slovenian academic institutions and ten engineering firms, the latter being the most important Slovenian suppliers of services and equipment in the area of control technology. In the process of preparing the Strategy, an additional 44 production companies – all users of control technology – have taken part.

Research and technological development areas

The research and technological development topics foreseen within this strategy encompass the following: information technology for production management, the control of complex systems and processes, fault detection and quality control, the support of logistic processes in production, technologies supporting the quality of living and habitation, technologies for reducing pollution in the natural environment, the automation of machines and devices (embedded systems), and, finally, technologies enabling the development of new tools and building blocks for control systems.

Links to other projects and the National Research & Development Programme

The proposal for implementing the CoE ACT has been submitted for co-financing as a complementary programme to the project proposal "Advanced Control Technologies for Increasing Competitiveness". The latter was also co-

financed with European Regional Development Fund (ERDF).
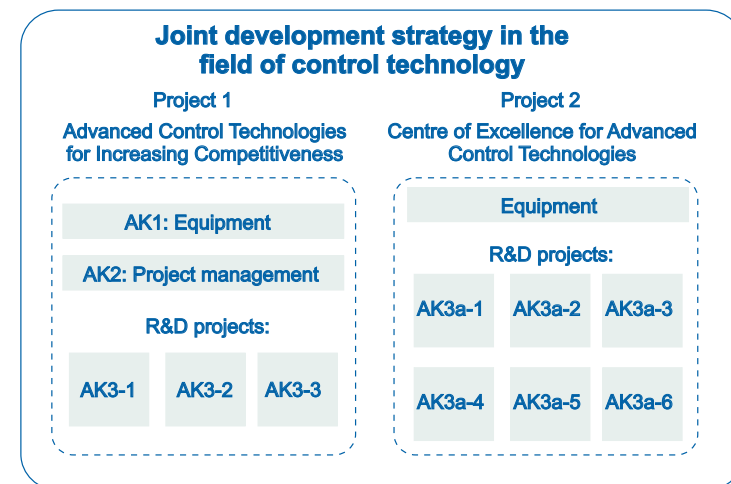
Schematic representation of the two projects aiming at the implementation of the Strategy and co-financed within ERDF

The work within the CoE ACT was set so that it complements the basic and applied research projects co-financed by the Ministry of Higher Education, Science and Technology (or the Slovenian Research Agency) within the "Systems and Cybernetics" research area, as well as in accordance with current EU 6th Framework projects in which the partners of the CoE ACT are involved, i.e., PRISM, CONNECT, PEGASE, BRACCIA, STEROLTALK, ADOPBIO and NextGenCell.

Control technology is also one of the priority areas of the National Research & Development Programme of the Republic of Slovenia.

General objectives

The global objective of the Strategy for developing control technology in Slovenia is the following:

With the proposed development and implementation of control technology we will increase the competitive advantage of engineering firms and end users.

The project's objectives are achieved through the following strategic aims:

a) the development of new products, services and technologies for **suppliers** of control technologies, mainly by working on joint technology-development projects;
b) the introduction and dissemination of new as well as existing technologies for **users** of control technologies, mainly by working on joint demonstration projects;
c) the establishing of the innovative development environment in Slovenia within the area of this technology.

The main factors that determined the successful implementation of the Strategy to date are the following: the interest in knowledge and services within the process control technology, the research excellence of the academic partners, the long tradition of cooperation between some of the main academic and industrial partners of the PCTN, the achievement of some remarkable joint R&D results in the past, and the strong interest of the PCTN partners in cooperating in joint projects.

Partners

Most of the CoE ACT partners are also partners of the PCTN. These include academic partners, engineering enterprises in the areas of automation and the IT support of industrial processes, and industrial enterprises – the end users of control technology. The initial consortium was later extended to include two research groups from the Faculty of Mechanical Engineering, University of Ljubljana, and their industrial partners.

List of partners:

Academic institutions:

Institut "Jožef Stefan", Ljubljana, Slovenia

"Jožef Stefan" Institute, Ljubljana

Faculty of Electrical Engineering, University of Ljubljana

Faculty of Electrical Engineering and Computer Science, University of Maribor

Univerza v Ljubljani
Fakulteta za strojništvo

Faculty of Mechanical Engineering, University of Ljubljana

Engineering enterprises:

INEA

INEA d. o. o., Ljubljana

METRONIK

Metronik d.o.o., Ljubljana

Synatec d.o.o., Idrija

LIKO PRIS d.o.o.,
Vrhnika

Robotina d.o.o.,
Izola

GOAP d.o.o.,
Nova Gorica

TELEM d.o.o., Maribor

ŠPICA International
d.o.o., Ljubljana

FDS Research d.o.o.,
Ljubljana

ETI d.d.,
Izlake

Industrial enterprises – users of R&D results:

LIV Plastika d.o.o.,
Postojna

ALPINA d.d.,
Žiri

Lek d.d., Ljubljana

Domel d.d.,
Železniki

Wastewater treatment plant
Domžale-Kamnik d.o.o.,
Domžale

Financial dimension

The size of the investment in the area of process control technology during the period 2004–2008, in order to implement the proposed strategy, was estimated to be about €26m, with the contribution from the business sector being about €13m, and the rest coming from Structural Funds and other national and international resources. These sums do not include the basic and applied research funding (via the Slovenian Research Agency) and the investments in the establishment and development of the innovation/business infrastructure.

Because of the limited financial resources, only about 20% of the foreseen research and development work has been performed so far. The main financial contribution, about €5,4m, was devoted to the project "Advanced Control Technologies for Increasing Competitiveness". The investments in the formation and initial operation of the CoE ACT were about €1,35m, of which €0,91m was from the ERDF, and about €0,2m came from private funds.

Co-financing was performed through the activities of the Centres of Excellence in the frame of Priority No.1 of Single Programming Document 2004-2006 "Promotion of the productive sector and competitiveness", coordinated by Dr. Darja Piciga, Ministry of Higher Education, Science and Technology of Republic of Slovenia.

Results achieved

The project objectives achieved – and evaluated with the relevant indicators – are shown in the table below.

	Operational objective	Indicator description	Achieved
1	To develop new or improve existing technologies, products and services **for technology providers**	number of new/improved technologies	9
		number of new/improved products	14
		number of new/improved services	4
		number of new patents or technical innovations	3
2	To implement new and improve existing automation and information systems **for the users of technology**	number of implemented demonstration projects	11
		number of (other) R&D results	14
3	To establish an environment supporting innovations	formation and initial operation of the CoE	1
		number of researchers working within the CoE	77
		number of organizations cooperating within the project (programme) of the CoE	19
		number of joint R&D projects	12
		number of joint marketing actions	2
		number of joint promotional actions	7
		number of joint publications	38
		number of implemented seminars, courses, and workshops	20

Future development

The future work of the CoE ACT will be based on the existing strategy prepared by the PCTN, which due to limited financial resources was only partially implemented during the previous period. To this end we plan to stick to the already defined broader research areas, but at the same time give emphasis to some new directions for the work. Some of the anticipated topics are as follows: the rapid prototyping of advanced (nonlinear, multivarible and predictive) control methods; distributed and remote control using internet technologies; model-based production control; technologies for intelligent buildings; the development and industrial application of a methodology for searching for new product opportunities, the development of innovative products for identified opportunities, and the integration of marketing and design functions in a company.

It is also planned to invest in new equipment, adapt the existing laboratories and to build some new laboratories. All the activities will be coordinated with existing and future national and EU projects.

Projects within the CoE ACT

The applied research work and the development of new technologies, products and services (or their improvement) was conducted within the following six projects (denoted as AK3a-1 to AK3a-6).

AK3a-1: Advanced Control Methods

Head of project module: **Prof. Dr. Rihard Karba**
Principal Institution: **Faculty of Electrical Engineering, University of Ljubljana**
e-mail: rihard.karba@fe.uni-lj.si
http://msc.fe.uni-lj.si/

The aim of this project module was to integrate researchers and R&D activities in the area of the most advanced automatic control methods of the two academic partners (the Faculty of Electrical Engineering, University of Ljubljana, and the "Jožef Stefan" Institute). The project includes the search for new advanced technological solutions at three end-users with problem areas suitable for application of more advanced control methods. The work includes a problem analysis of each specific process addressed, the design of an appropriate control concept, the choice or development of the control method and the control system. The activities were performed within five R&D topics.

The two important results of this project are the design of a self-tuning predictive controller for batch processes and a software tool for tuning the controller parameters in more demanding industrial control applications.
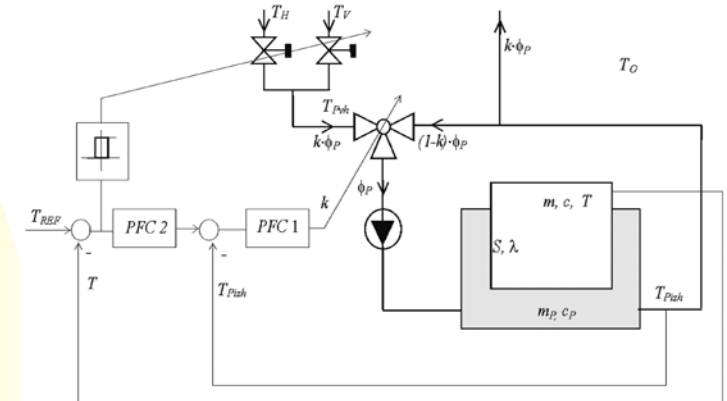
Predictive control of a chemical reactor

## AK3a-2: Automatic Online Process Supervision and Product Quality Control

Head of project module: **Prof. Dr. Đani Juričić**
Principal Institution: "**Jožef Stefan**" Institute
e-mail: dani.juricic@ijs.si
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The main aim of the R&D work within this project module was to perform research, development and the industrial implementation of algorithms, devices and products related to the new generation of systems for automatic process supervision that are capable of the reliable and early detection and localisation of faults in industrial equipment, processes and products. Such systems contribute most directly to the increasing competitiveness of the Slovenian economy in terms of greater productivity, improved product quality and greater flexibility of the production with respect to market changes.

The project resulted in the development of technology for the online quality testing of electrical motors based on vibro-acoustic signals. The result is an automatic control system for the final quality control of electrical motors, implemented at Domel d.d. This system has also been patented. Another topic was devoted to the research and development work in the field of product-quality analysis using machine vision. The results in this area include the design of a controller for optimum illumination in an automatic final-product quality control system, and the design of a system for the automatic quality control of commutators using machine vision, which was implemented in Kolektor, d.o.o.
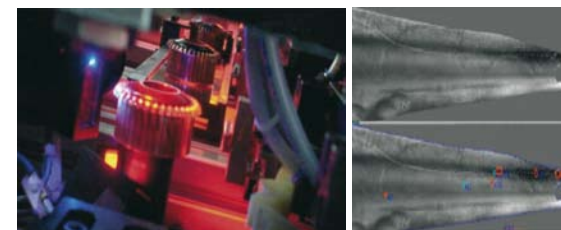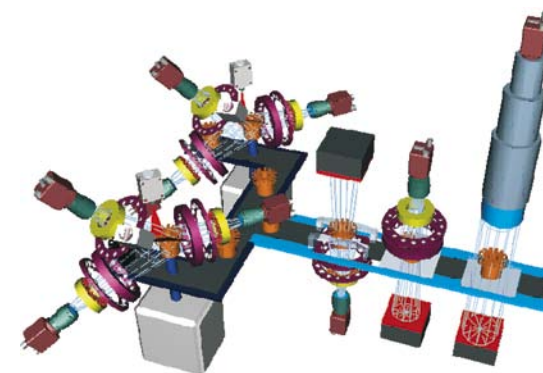
Implementation of a diagnostic system in industry

## AK3a-3: Technologies of Remote and Distributed Control

Head of project module: **Prof. Dr. Boris Tovornik**
Principal Institution: **Faculty of Electrical Engineering and Computer Science**, **University of Maribor**
e-mail: boris.tovornik@uni-mb.si
http://www.au.feri.uni-mb.si/

The aim of this project module was to develop new, remote and distributed control technologies by setting up a laboratory testing system, and by conducting a demonstration project for a user.

The project included the following three sub-projects:

- the use of open-source and internet technologies in the process control,
- a universal system for data acquisition based on public telecommunication processes,
- a control centre and internet-supported control for dislocated processes.

The important results within this project are the concept of using an open-source code technology for remote and distributed control, the design of a methodology for the safe operation and stability testing of an industrial remote-control system, the development of a universal data-acquisition system based on public telecommunication processes, and the setting up of a control concept for the remote control of industrial energy systems.
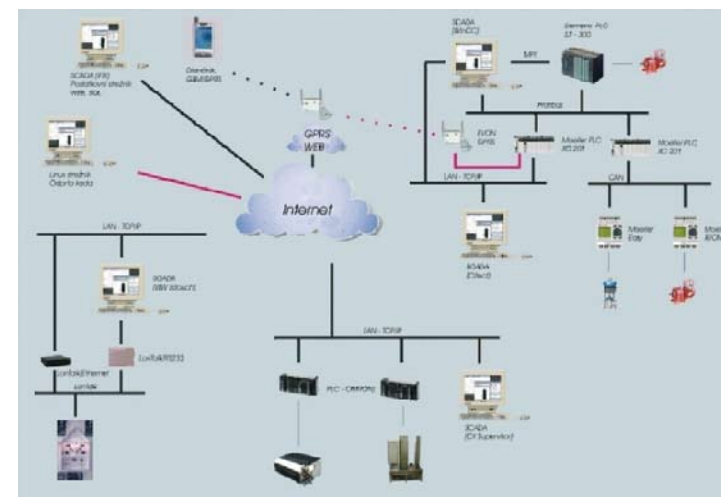
*The concept of remote and distributed control*

AK3a-4: Decision Support System for Production Control

Head of project module: **Dr. Vladimir Jovan**
Principal Institution: "**Jožef Stefan**" **Institute**
e-mail: vladimir.jovan@ijs.si
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The aim of these R&D activities was to develop additional modules within a production information system that enable correct and timely decisions related to the efficient control of production processes. By implementing additional decision-support software modules that are used for solving partially structured problems in production control (planning, scheduling, traceability of the production processes, the assessment of production efficiency, etc.), the existing production systems are upgraded with a new functionality that forms the basis for the decision support in production control. A part of the research activities was also devoted to the decision-support methodology in production management using key performance indicators, as well as to the design of the production model of a case-study production system in the process industry.

The developed concepts were implemented in production information systems at different industrial sites and used, e.g., for production traceability at Ljubljanske mlekarne d.d. and Droga d.d., for production monitoring at Kolektor Pro d.o.o., as well as for production scheduling at LIV plastika d.o.o. An additional important result is the development of a production model in the Matlab software tool, which allows the testing of advanced production control algorithms using simulation.
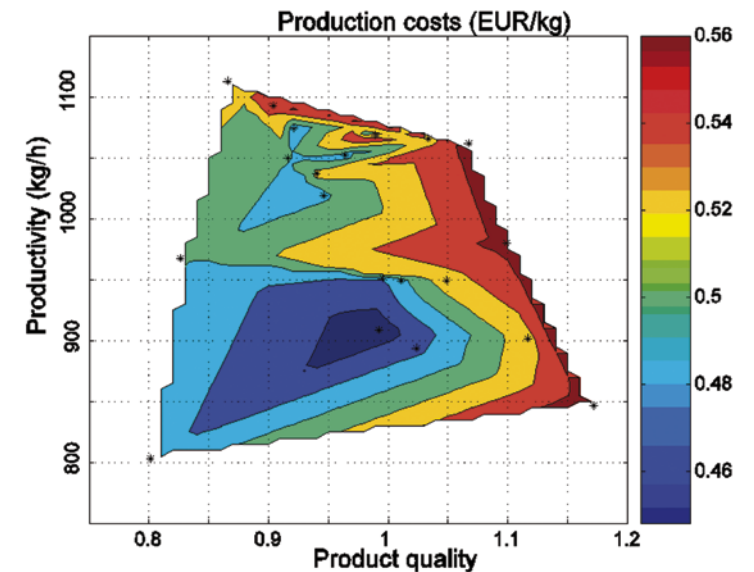
Production model simulation results: estimation of the production costs in a polymerisation plant, Mitol d.d.

AK3a-5: Product Information Management during the Complete Lifecycle

Head of project module: **Prof. Dr. Jože Duhovnik**
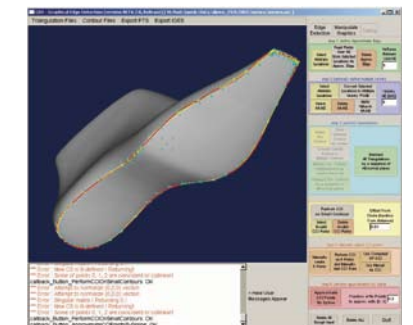Principal Institution: **Faculty of Mechanical Engineering, University of Ljubljana**
e-mail: joze.duhovnik@lecad.uni-lj.si
http://www.lecad.uni-lj.si/

The purpose of the project was the development of a system for the information management of the whole product life cycle. The activities were mainly focused on the research and development of the following:

- the utilisation of modules for the design of alternative solutions;
- the design of an archive to facilitate developmental activities and the preparation of a catalogue of spare parts considering design changes;
- the inclusion of characteristic product structures in the bidding process;
- the development of 3D models with characteristic features suitable for various analyses;
- a responsive and user-friendly PLM (Product Life Cycle Management) system.

The most important result of the project was a methodology for integrated product development in a distributed environment, which was partially or wholly utilized during various industrial collaborations. As a member of the product-development team in Domel d.d. we were active in developing a new generation of vacuum-cleaner motors and a blower for fuel cells. As a knowledge institution we were involved in the development of computer-aided tools for the process of shoe design (Alpina d.d.). Based on our knowledge and experiences of development processes we have registered (at The Slovenian Intellectual Property Office) a trademark: "Global Product Realization".
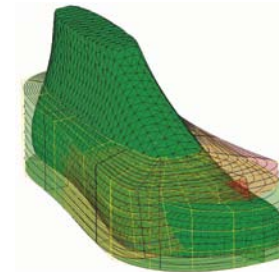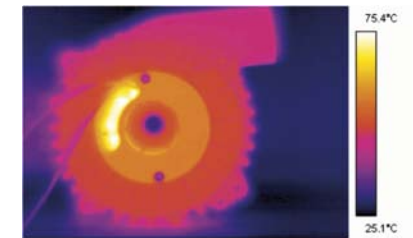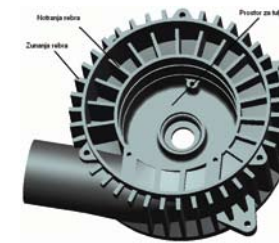
Development of a blower and development of a computer aided tool for shoe design

AK3a-6: Project Management in the System of Orders

Head of project module: **Prof. Dr. Marko Starbek**
Principal Institution: **Faculty of Mechanical Engineering, University of Ljubljana**
e-mail: marko.starbek@fs.uni-lj.si
http://www.fs.uni-lj.si/laps/

The project module deals with a dilemma faced by many companies: how to retain or improve competitive advantage in comparison with other companies or service providers on the global market. The researchers in this project found the answers and solutions to this dilemma by putting into effect a project-oriented approach, extended with concurrent engineering elements.

The aim of the project was to analyse the current situation in both the management of individual production and new-products development, to overview the existing methods for individual production management, to design a general model for the project-oriented management of orders, as well as to run appropriate simulations. The main goal of this project was to design a system for the project management of orders with the following features:

- suitable for various types of companies and orders (development of new products, the order of standard products tailored to customer needs);
- simple for incorporation into the existing company business system;
- adaptable enough to the specific requirements of various customers.

Some of the important results of this project are the methodology for the design and management of individual production, and the implementation of several demonstration projects related to the project-oriented management of orders and integrated product development (Faculty of Mechanical Engineering, LIV Plastika d.o.o., ETI d.d.).

Teamwork during the project-planning phase for the development of a new product

Project to develop the R&D infrastructure of the CoE ACT
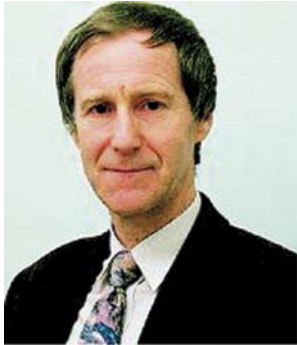
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In parallel with the above-mentioned projects, the partners of the CoE ACT also modernise, up-grade and complement their research laboratories, equipment and other more advanced technological and research infrastructures. The project of up-grading the existing equipment involves 17 investments, including the following:

• the purchase of new computer, control and measuring equipment,
• the purchase of new electronic devices,
• the purchase of new software,
• the purchase of new, dedicated machine tools,
• the up-grading of the process laboratories.

New research equipment at "Jožef Stefan" Institute

Researchers of the LECAD laboratory (Faculty of Mechanical Engineering, University of Ljubljana) with new equipment

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