

Tippkeskus

1918
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Department of Computer Engineering
ati.ttu.ee

**Centre for Integrated Electronic Systems and Biomedical Engineering
CEBE
(2008-2015)**

Raimund Ubar

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Department of Computer Engineering

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Overview

- ✓ What is CEBE (structure, research fields, new project activities, mission)
- ✓ Cooperation
- ✓ Short overview about 6 cooperation projects
- ✓ IAB suggestions from April 30, 2009 and CEBE response
- ✓ Formal results (PhD thesis, patents, publications, dissemination, external cooperation)

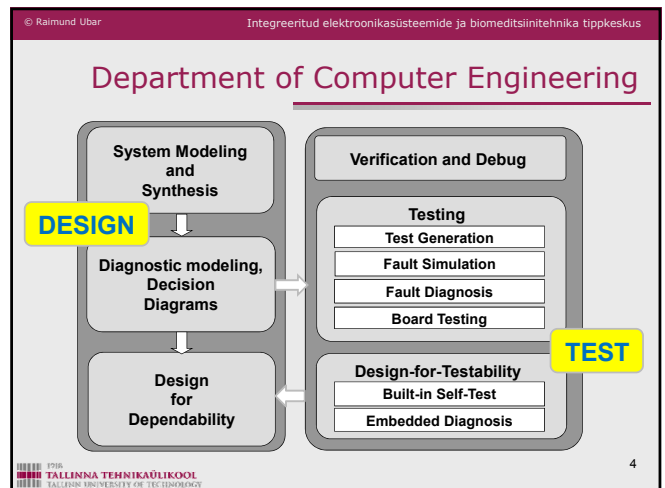
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What is CEBE?

- ✓ CEBE is composed of three research groups financed by three target-financed themes
 - **Design of Reliable Embedded Systems**
Dept. of Computer Engineering (DCE)
 - **Electronic Components and Subsystems for Mission Critical Embedded Systems**
Dept. of Electronics (DE)
 - **Interpretation of Biosignals in Biomedical Engineering**
Technomedicum (TM)
- ✓ CEBE
 - 35 researchers and
 - 54 PhD students (CEBE started with 40)

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Department of Electronics

- ✓ **Electronic components and subsystems of mission critical embedded systems**
 - **Methods for signal and data acquisition**
 - **Signal processing methods and means**
 - **Architectures of reconfigurable processors**
 - **Impedance spectroscopy**
- Semiconductor research**
 - **Technologies for semiconductor metallisation**
 - **Theory of hetero-polytype interfaces**
 - **Compatibility of nanotech interfaces**

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Technomedicum

- ✓ **Interpretation of Biosignals in Biomedical Engineering**
 - **Brain research**
 - **Diagnostics of cardiovascular diseases**
 - **Prediction of sudden cardiac death**
 - **Bio-optical monitoring**

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CEBE New International Projects

2008

- Intelligent Battery Management with National Semiconductor Corporation, USA (2008-2010)
- European Network **ETN TRICE**
- European Network Enhancing Lifelong Learning for the Electrical and Information Engineering Community – **ELLEIEC**
- Experimental research for adaptive failure diagnosis based on structural multi-core emulation test - **ERADOS**. Partners: TU Ilmenau, Goepel Electronic (Germany).
- FP7: Smart Museum: Cultural Heritage Knowledge Exchange Platform - **SMARTMUSEUM** (2008-2010)

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CEBE New International Projects

2009

- FP7 REGPOT**: Centre of Research Excellence in Dependable Embedded Systems - **CREDES** (2009-2011)
- EU TEMPUS** project : Curricula Reformation and Harmonisation in Biomedical Engineering (2009-2012)

2010

- FP7 STREP: DIAMOND** - Diagnosis, Error Modelling and Correction for Reliable Systems Design, Coordinator: TU Tallinn (2010-2012)
- EUREKA-EUROSTAR** project: **COMBOARD** - FPGA-Based Test Acceleration Methodology for Complex Electronic Boards.
- Project with Helsinki-Turku-Tampere sleep research centre

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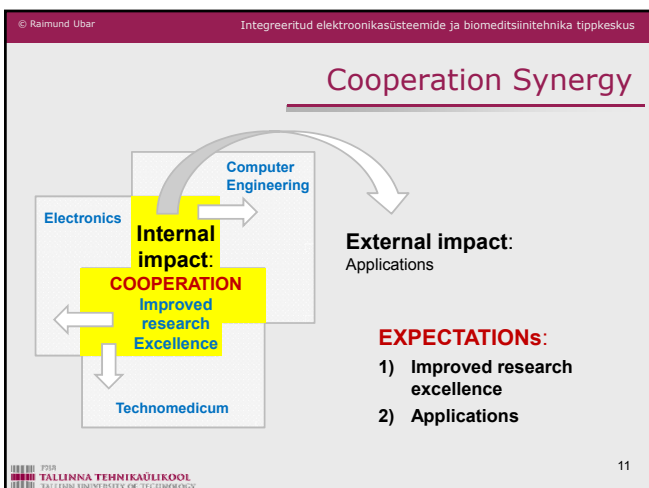
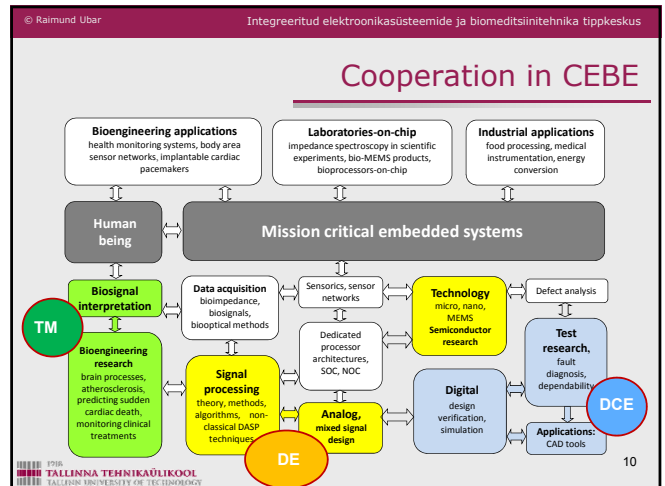
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CEBE

✓ **Mission:**

- To carry out interdisciplinary **R&D** in the fields of
 - electronics design,**
 - digital design and**
 - biomedical engineering**
- by a collaborating consortium
- with **applications** in **medicine, semiconductor and information technologies**

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CEBE Research Teams

- ✓ Tehnomedicum (TM)
 - Cardiology Team**
 - Brain Research Team**
 - Biofluids Optics Team**
- ✓ Department of Electronics (DE)
 - Signal Processing Team (SP)**
 - Semiconductor Devices Team (SD)**
- ✓ Department of Computer Engineering (DCE)
 - Design Team (D)**
 - Verification and DFT Team (V)**
 - Board Testing Team**

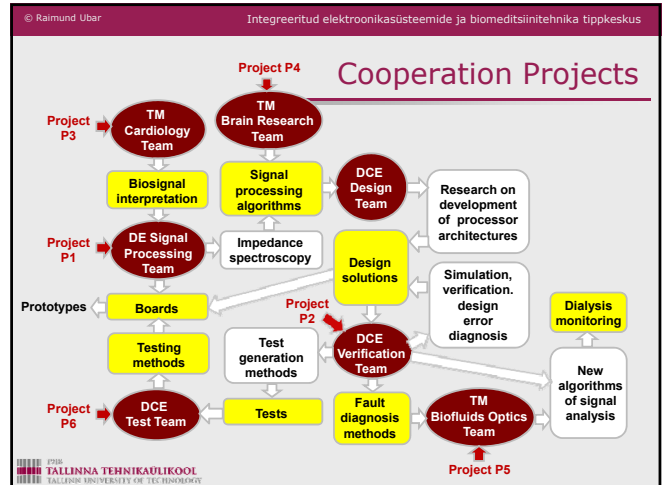
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Cooperation Projects

- ✓ P1. Application Specific Processors for Signal Processing in Biomedicine (**DE/DCE**)
- ✓ P2. Verification, debug, DFT (**DCE: D/V**)
- ✓ P3. Total Peripheral Resistance (**DE/TM**)
- ✓ P4. Evaluation of mental disorders using EEG analyser (**DCE/TM**)
- ✓ P5. Reliable and disturbance free monitoring of dialysis (**DCE/TM**)
- ✓ P6. Testing of complex electronic systems (**DE/DCE**)
- ✓ P7. Semiconductor devices (**DE: SP/SD**)

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Project P1

- ✓ **Application Specific Processors for Signal Processing in Biomedicine** (Prof. P.Ellervee)

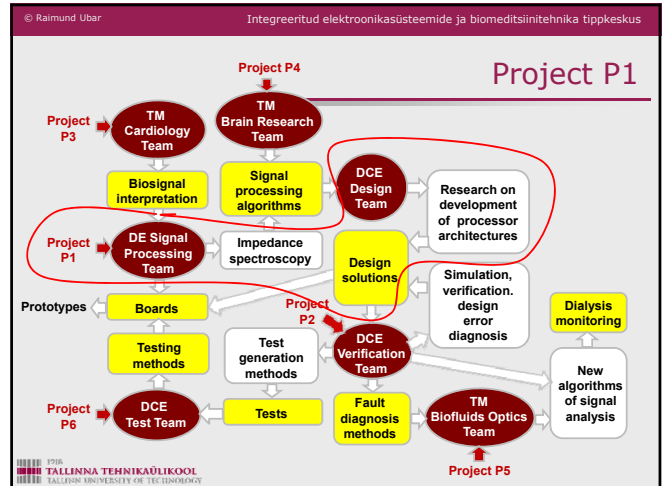
Goals for DE:

- Finding of appropriate excitation waveforms for the fast and wideband impedance spectroscopy;
- Developing of signal processing methods and devices for processing of the response signals in impedance spectroscopy.

Goals for DCE:

- To develop architectures and methods to design application specific processors for signal processing used in biomedical applications.

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Project P1

- ✓ **Results**

Patents:

- US Patent US7706872B2. Method and device for measurement of electrical bioimpedance
- European Patent EP1786322B1. Simultaneous discrete-time analysis of features of substances

PhD thesis

- Paul Annus. Multichannel Bioimpedance Spectroscopy: Instrumentation Methods and Design Principles .

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Project P2

- ✓ **Verification, test generation and fault diagnosis** (Dr. J. Raik)

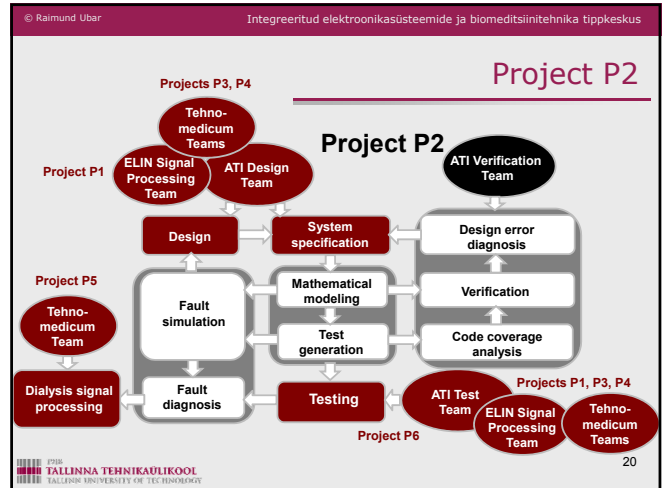
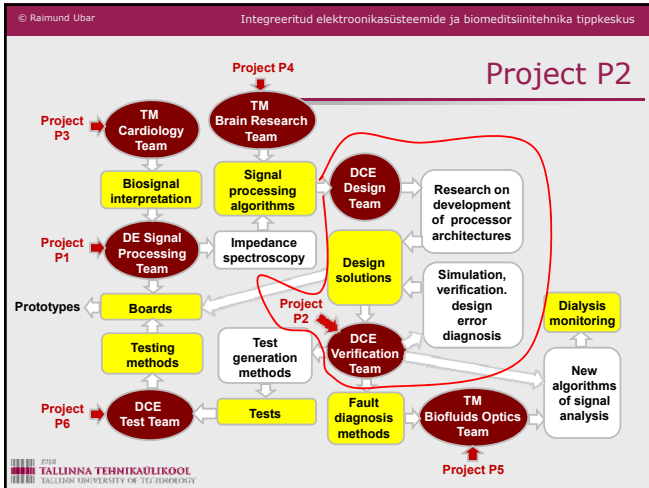
Goals for DCE Design Team:

- To develop architectures and methods to design application specific processors for signal processing used in biomedical applications

Goals for DCE Verification Team:

- To develop efficient methods for verification, self-testing, fault diagnosis and debugging of digital systems with special attention to design of dependable application specific signal processors
- Redesign of given structures for testability and self-test

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Project P2

✓ **Results expected**

Theory:

- New methods for fault simulation, test generation, design error diagnosis, and fault location
- The designs developed in CEBE are being used as benchmark systems for evaluation of the new methods

Applications:

- New methods will be used for verification and error diagnosis in the architectures developed in projects P1, P3 and P4.
- New test generation methods and BIST solutions can be used in the project P6

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Project P2

✓ **Results**

PhD thesis

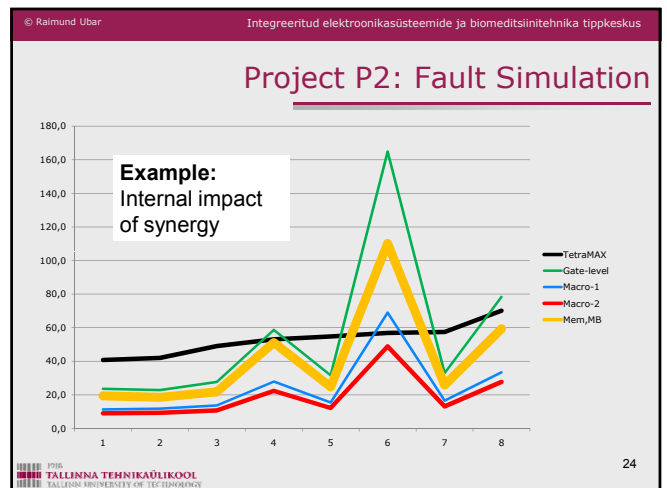
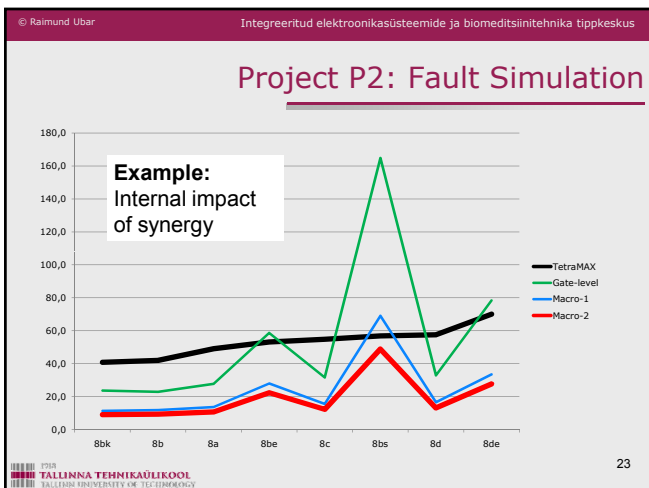
- Maksim Jenihhin. Test Time Minimization for Parellel Hybrid BIST Architectures (2008). Supervisors: R.Ubar, J.Raik.
- Sergei Devadze. Fault Simulation of Digital Systems (2009). Supervisors: R.Ubar, P.Ellervee.
- Vineeth Govind. DFT-based External Test and Diagnosis of Mesh-like Networks on Chips (2009). Supervisor: J.Raik.

Publications:

- 14 journal papers
- Conference papers: DATE, ITC, ETC, DDECS etc.

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Project P3

✓ **Total Peripheral Resistance** (Prof. K.Meigas)

Partners:

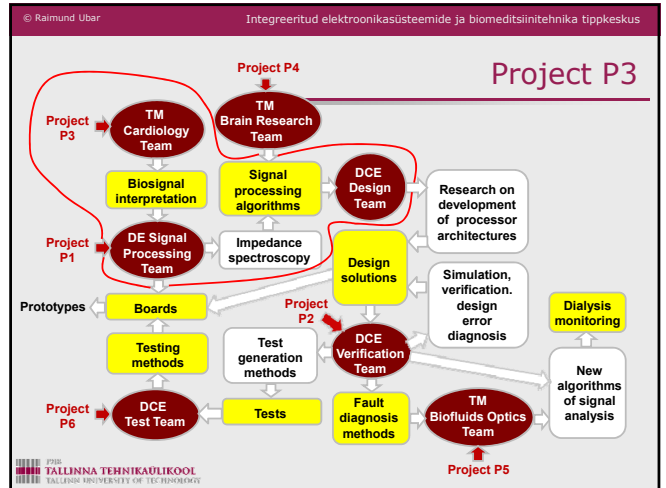
- TM Cardiology Group
- DE Signal Processing Group
- Clinic of Cardiology of North Estonian Regional Hospital
- DCE Design and Verification Teams

Goals for DCE:

- TM:** Method and prototype of device to monitor the total resistance of peripheral arteries noninvasively and continuously using optical and electrical methods in parallel.
- DE:** Methods for processing of composite impedance signals for adaptive separating of the cardiac component from noise, artifacts, and respiratory component

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Project P3

✓ **Results**

Expected application:

- The monitoring device of the total resistance of peripheral arteries is aimed to be applied in medicine for non-invasive diagnostics of heart-vascular diseases. It is also aimed to be used in research in the related area by TM.

PhD thesis

- Andrei Krivoshei. Model Based Method for Adaptive Decomposition of the Thoracic Bio-impedance Variations into Cardiac and Respiratory Components

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Project P4

✓ **Evaluation of mental disorders using EEG analyser** (Prof. H.Hinrikus, Dr. M.Jenihhin)

Partners:

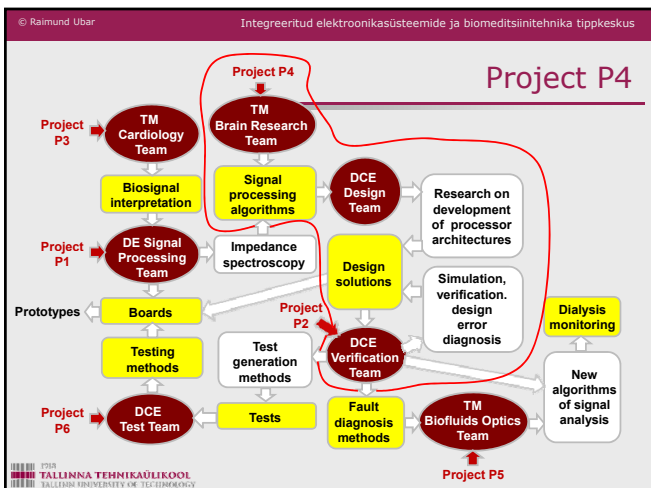
- TM Brain Research Team
- DCE Design and Verification Teams

Goals:

- Elaboration and modification of EEG algorithms for detection of mental disorders;
- Electronic implementation of the algorithms as a specific signal processor;
- Development of portable device based on EEG analysis targeted at evaluation of mental disorders.

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Project P4

✓ **Results**

Patent application:

- US 2009/0054801 Method and device for determining depressive disorders by measuring bioelectromagnetic signals of the brain. Authors: Hiie Hinrikus Maie Bachmann, Jaanus Lass, Anna Suhhova, Viuu Tuulik, Kaie Adamsoo, Ülle Võhma. Published Feb. 26, 2009.

PhD thesis

- Maie Bachman. Effect of Modulated Microwave Radiation on Human Resting Electroencefalographic Signal (2008). Supervisor: H.Hinrikus.

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Project P5

✓ **Reliable and disturbance free monitoring of dialysis** (Prof. I.Fridolin)

Partners:

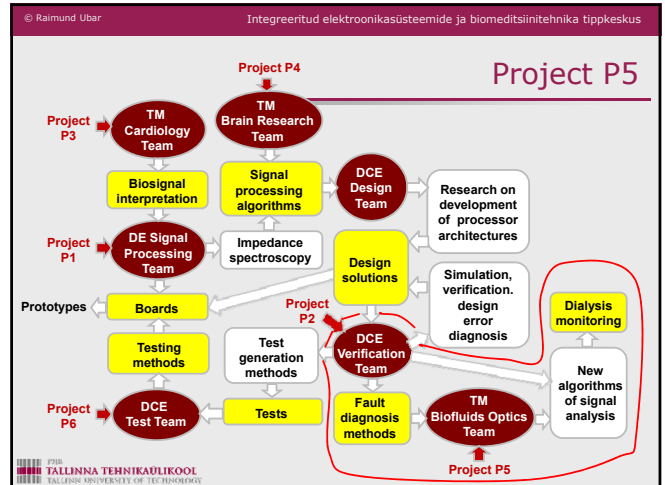
- TM Biofluids Optics Group
- DCE Verification and Diagnosis Team

Goals:

- To develop an optical method for on-line monitoring of solutes in the spent dialysate utilizing the UV-absorbance, enabling one to follow a single haemodialysis session continuously
- To develop signal processing algorithms for highly reliable and disturbance free dialysis dose estimation during the dialysis therapy

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Project P5

✓ **Results**

Patent applications:

- Ivo Fridolin, Jana Jerotskaja, Kai Lauri ja Merike Luman. „Optical method and device for measuring concentrations of substances in biological fluids”, PCT/EE2008000026, 2008
- Ivo Fridolin, Jana Jerotskaja, Kai Lauri ja Merike Luman. „Optical method and device for quantitative concentration measurements of compounds in the biological fluids”, EE201000049, 2010
- Fridolin, I., Uhlin F., Jerotskaja, J., Tanner, R., Arund, J. P201000056, 28.06.2010

PhD thesis

- M. Luman (supervisor Prof. I. Fridolin) “Dialysis Dose and Nutrition Assessment by an Optical Method”,

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Project P6

✓ **Testing of complex electronic systems** (Dr. A.Jutman)

Partners:

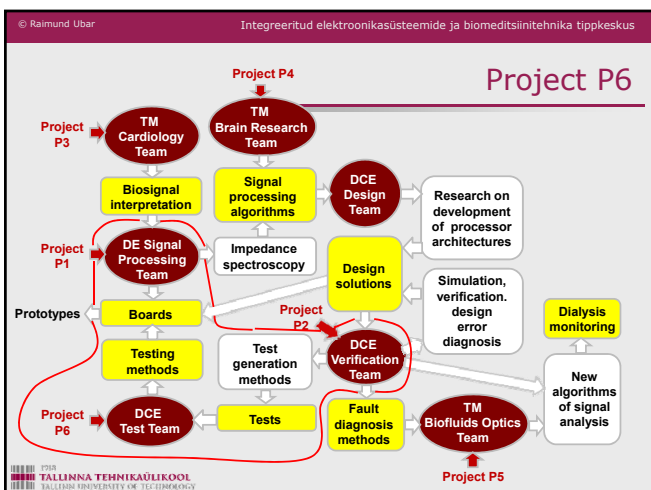
- DCE Test and Verification Teams
- DE Signal Processing Team

Goals:

- Current project is aimed at facilitating testing, diagnostic, and maintenance tasks in complex electronic systems through automation of test access solutions

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Project P7

✓ **Semiconductor devices** (Prof. T.Rang)

Partners:

- DE Signal Processing and Semiconductor Teams
- Power Converters group from the Department of Electrical Drives and Power Electronics

Goals:

- Developing of the practical solution for application of DLTS method for GaAs and SiC based power pin- and Schottky structures for deep energy level detection in sub-contact epilayers.
- Finding an appropriate specification for realization of SiC polytypic heterojunction using diffusion welding (cold joining) technology

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IAB: Suggestions

✓ **Suggestions for synergy creation**

- Cross disciplinary group projects
- At least two initial research groups should participate
- Six cross disciplinary group projects were launched
- Involvement of the potential users
- Projects should be led by young promising researchers
P2 – J.Raik, P4 – M.Jenihhin, P6 – A.Jutman
- Including research groups led by Medical Doctors
P3 - Clinic of Cardiology of North Estonian Regional Hospita
- Dissemination

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IAB: Measures of Success

Suggestions of IAB

- More demonstrated interactions between members of the Centre would be advantageous.
- An immediate solution could be e.g. a joint International Master of Science program with the participation of the cooperating departments.

Jointly developed new Master of Science programs

- Computer & System Engineering
- Electronics and Bionics
- Communicative Electronics
- Biomedical Engineering (modified through collaboration with University of Tartu)

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IAB: Measures of Success

Suggestions of IAB

- Definition of some project demonstrators would make the evaluation of the progress easier and would provide good marketing opportunities for the Centre itself.

Going towards demonstrators

- Project P1: Signal processor designs
- Project P4: Electronic implementation of the algorithms for detection of mental disorders as a specific signal processor

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IAB: Measures of Success

Suggestions of IAB

- Cooperation with the industry should be better demonstrated
- Public awareness of the operation should be more directly targeted. This latter two could be combined e.g. with the organization of a student Competition, supported by the industry.

Student competition

- International conf. MEMOCODE'08 (USA), Student competition on SW/HW Codesign – The student team of DCE won 4. place

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IAB: Measures of Success

Suggestions of IAB

- CEBE should have the target of the research clearly written in one overall sentence.

Mission:

- To carry out interdisciplinary **R&D** in the fields of
 - electronics design,
 - digital design and
 - biomedical engineering
- by a collaborating consortium
- with **applications** in **medicine, semiconductor and information technologies**

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IAB: Measures of Success

Suggestions of IAB

- All subprojects should more clearly join together to support each other for maximum synergy
- New spin-off companies need to be created

CEBE:

- Impact on applications: P1, P3, P4
- Impact on research quality: P2, P5
- Spin-off company Testonica (Partner of FP7 Strep Diamond, EUREKA-EUROSTAR project COMBOARD, joint project with Goepel, Germany)

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PhD (2008-2010)

1. M.Jenihhin. Test Time Minimization for Parellel Hybrid BIST
2. S. Devadze. Fault Simulation of Digital Systems
3. A. Pokatilov. Development of National Standard for Voltage Unit Based on Solid State References
4. V.Govind. DFT-based External Test and Diagnosis of Mesh-like Networks on Chips
5. A.Krivoshei. Model Based Method for Adaptive Decomp of the Thorasic Bio-Impedance Variations into Cardiac and Respiratory Components
6. P.Annus. Multichannel Bioimpedance Spectroscopy: Instrumentation Methods and Design Principles
7. M.Bachman. Effect of Modulated Microwave Radiation on Human Resting Electroencefalographic Signal
8. M. Luman. Dialysis dose and nutrition assessment by an optical method

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Patents Granted (2009-2010)

1. European Patent EP1786322B1. Simultaneous discrete-time analysis of features of substances. Inventors: Min Mart, Land Raul, Parve Toomas, Märten Olev, Ronk Ants. Owner: Tallinn University of Technology. Granted 28.10.2009.
2. US Patent US7706872B2. Method and device for measurement of electrical bioimpedance. Inventors: Min Mart, Kink Andres, Land Raul, Parve Toomas. Owner: Tallinn University of Technology. Granted 27.04.2010.
3. European Patent EP157542A1. Method and device for measurement of electrical bioimpedance. Inventors: Min Mart, Kink Andres, Land Raul, Parve Toomas. Owner: Tallinn University of Technology. Decision to grant the patent by European Patent Office 28.05.2010.
4. Estonian patent EE05166B1. Method and device for synchronizing of decoder of a RFID receiver. Authors: Olev Märten, Alar Kuusik, Aivar Liimets. Granted: 15.04.2009.

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Patents , Publications, Dissemination

- Patent applications – 11
- Publications
 - Journal papers – 74 (ISI WoS – 47, Other - 27)
 - Conference papers – 130
 - Monographies – 6
- Dissemination

Year	Radio	TV	Articles	Seminars/WS	Presentations/Lectures
2008	1		5	2	2
2009	7	3	9	2	8
2010	8	1	4	1	1

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External Cooperation

- **The partners of CEBE in Estonian industry (12)**
 - ELIKO TAK OÜ, Artec Group, Smartimplant OÜ, Cybernetica AS, Elcoteq Tallinn, National Semiconductor Eesti, Ericson Eesti AS, Clifton Ltd, LDIAMON AS, Testonica Lab OÜ, East-Tallinn Central Hospital, North-Estonian Medical Centre, OÜ Quattromed HTI
- **International cooperation (15 countries/36 institutions)**
 - Germany (7), Sweden (6), Poland (3), Russia (3), UK (3), USA (3), France (2), Portugal (2), Austria (1), Belgium (1), Finland (1), Hungary (1), Israel (1), Italy (1), Japan (1)

Thank you!

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