

# CEMIS Annual Report 2015



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Editors: Risto Oikari ja CEMIS management

Graphic Design: Tanja Keränen

Translation: Kaisa Eticknap-Seppänen

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# Chairman's Review

Cemis was established to promote networking in research and development that extends beyond organizational and sectoral borders. This work has played a significant role in gathering practitioners together to design and implement educational, R&D and innovation-based projects that support the development of Kainuu.

Throughout its existence, the operational environment of CEMIS has been in a state of flux. It is probable that such changes in research funding and education structures are set to continue. These changes were already visible in the funding of CEMIS' operations in 2015. Nevertheless, as regional funding has decreased, CEMIS has succeeded in increasing its share of EU funding.

These changes in the operational environment are also apparent in CEMIS' member organizations. The VTT (Technical Research Center of Finland) – MIKES (Metrology) merger, pending cooperation with CSC, and organizational changes within KAMK and the University of Oulu as well as new strategies will instigate new objectives within CEMIS' operations. The current mindset within national higher education policy will force each CEMIS practitioner to strengthen expertise according to profile as well as focusing their own areas of excellence.

CEMIS also has to change, due to the changes in the operational environment and among CEMIS' practitioners. New models of cooperation will enable us to compete successfully not only in the national but also in the international arena based on our results and significance – in this competition, dynamic networks are the only way to succeed. In order to achieve our common objectives, the modus operandi of the network must also develop and become more agile. It is good to build on this mindset also in the future.



*Matti Sarèn  
Vice Rector, Cooperation Affairs  
University of Oulu*



*Turo Kilpeläinen  
President/CEO  
University of Applied Sciences*

# Introduction

Established in 2010, CEMIS (Centre for Measurement and Information Systems) is a contract based measurement and information systems research and training center shared by two universities (the Oulu and Jyväskylä University), a research institute (VTT Technical Research Centre of Finland) and Kajaani University of Applied Sciences Ltd. CEMIS consists of the Oulu University Metrology Research Unit CEMIS Oulu, Kajaani University of Applied Sciences Information Systems and machinery and mining competence areas, the Kajaani unit of VTT (two groups, Industrial Internet of Things and MIKES Metrology), and the measurement technology development operations of the Jyväskylä University's Vuokatti Sports Technology Unit. Since 2014, CEMIS' operations have included the School of Mechanical and Mining Engineering. VTT and MIKES merged at the beginning of 2015 to form VTT Oy in Kajaani where research groups specialized in industrial metrology and the industrial Internet of Things conduct their work.

The above mentioned four higher education and research organizations, as well as the City of Kajaani and the Municipality of Sotkamo, are committed to CEMIS' operations. CEMIS is one of the innovation hubs of Oulu University innovation hub, and the only one of its kind outside Oulu. Oulu University

has centralized its Kainuu based technology research and development operations in CEMIS. For KAMK, CEMIS is a major form of inter-university and research institute co-operation and focus of development. For Jyväskylä University and VTT, CEMIS is a form of regional cooperation. The structure of CEMIS is presented in Figure 1.

CEMIS focuses on the development of measurement and information systems expertise within nationally significant application areas such as the mining industry, the bio-economy, environmental monitoring, sports and wellbeing, as well as in game and simulator technologies.

The objective of CEMIS is also to be an attractive international partner in the development of measurement and information systems technology competence. With extensive cooperation, CEMIS aims to create internationally significant competence, new technology and business operations with the research and development services and higher education offered by its Kainuu-situated competence and innovation hub.

CEMIS produces top-class specialists in the field, new technology, and new business for companies and research institutes developing and applying measure-



Figure 1. The Structure of CEMIS – the Centre for Measurement and Information Systems.

ment and information systems, by offering research and development services and university level education in an innovative and international environment. For students intending to fill the specialist posts of the future, the center provides a motivating educational environment; to researchers and specialists who wish to develop themselves, it offers an innovative and international working environment.

CEMIS intends to increase the attractiveness, competitiveness and impact of the partners' research and training provision in the field of measurement and information systems. In order to achieve its aims, CEMIS has set both overall quantitative performance targets as a center for its R&D, educational and innovation activities and partner-scale targets.

A central means of CEMIS' development has been the CEMIS Development Program which defines actions to increase the coordination of operations, cooperation and division of work between partners, the use of shared resources and the visibility of work conducted by the center. 2015 saw the start of the third, two-year development program which has an annual budget of 1.6 million euros and is primarily funded by the East Finland ESF and ERDF programs. The total funding of CEMIS is more than 10 million euros per year, consisting of the actors' own finding, regional development funding (such as the CEMIS Development program) and external competitive funding. Almost 110 measurement and information systems specialists work for CEMIS.



In 2015, five commercially used inventions and two new companies were developed in CEMIS.

Risto Oikari, Director, CEMIS

## Director's Review

CEMIS was established more than five years ago on September 17th, 2010. It was in full operation from the beginning of 2011. Thus 2015 was CEMIS' fifth year of operation. Year 2015 was attributed to the ongoing weak global and national economy, rapid development of international cooperation, and changes in the parent organisations involved in CEMIS: a new rector and third vice rector started work at Oulu University, which also overhauled its strategy; KAMK implemented significant structural changes and updated its strategy; MIKES was joined to VTT, which was turned into an independent company; the City of Kajaani decided to merge the business operations of Measurepolis Development Oy to CEMIS' activities at Kajaani University of Applied Sciences, and cooperation with CSC began with the aim of CSC joining CEMIS in 2016.

Due to these significant changes in the operational environment and among CEMIS' partner organisations, CEMIS also updated its strategy at the end of the year and began updating the CEMIS Collaboration

Agreement in accordance with the new strategy.

CEMIS' main forms of collaboration: the strategy group and management group, cooperation in R&D activities, coordinating project activities, joint marketing and communication, business development, cooperation in prototype engineering, developing shared facilities and environments as well as cooperation within education, continued.

CEMIS develops its operations according to set objectives. The objectives concern development in education, R&D, and innovation activities. The same amount of people was involved in achieving the results as before, approx. 110 persons.

In 2015, CEMIS began its third two-year development program. The content, activities and achieved results are described later on in this annual report.

CEMIS' publishing activities retained their positive level (18 referenced, scientific publications and 36 conference publications). 4 Master's degrees, 10 university of applied sciences Master's degrees and 75 university of applied sciences Bachelor's degrees were accomplished in CEMIS in 2015.

2015 saw a record number of internationally and nationally funded projects: 9 international projects, 20 nationally funded projects and 7 regionally funded (Regional Council of Kainuu or ELY Centre for Economic Development, Transport and the Environment) projects. The total volume of the internationally funded projects was 1.2 million euros and for the nationally funded projects, it was 5.6 million euros. The function of the projects is to develop, among others, metrological standards, machine positioning solutions, metal concentration analyses from waterways, bioethanol production analysis solutions, biogas solutions with the Sotkamo Unit of the Natural Resources Centre, biosensors, athlete testing and coaching, biathlon analyses, para-skiing measurements, analytics for the food industry, simulators for the mining industry and driving instruction, and game and simulation education.

CEMIS' impact is primarily measured according to new commercially viable technology and how many companies have been set up as a result of CEMIS' activities. In 2015, five commercially used inventions and two new companies were developed in CEMIS.

The operations of the Metrology Research Unit of Oulu University, CEMIS-OULU strongly continued competing in obtaining R&D funding and especially in international project volumes. Competitive funding remained at the previous year's level and the share of international funding grew significantly. As a result, new business has been created such as the spin-off company Meoline Oy that started international business operations immediately. The research team has experienced excellent success in implementing Tekes' (Finnish Funding Agency for Innovation) commercialisation projects. In 2015, TEKES allocated funding for three new technology commercialisation projects.

KAMK renewed its strategy, which further strengthened CEMIS' activities. The development of education relevant to CEMIS' operations: smart systems, the game and simulation field and the technology business, continued. KAMK also reinforced its activities in the preparation of national and international projects and the development of the technology business. In 2015, KAMK received funding for five nationally funded R&D projects, among others, for KAMK's first TuTLI project (new knowledge and business from research) funded from Tekes national program. In addition, KAMK participated in preparing three H2020 projects, of which one failed to attract funding and two funding decisions will be made in spring, 2016. KAMK's national R&D funds decreased significantly compared to the previous year since the new projects began at

## CEMIS 2015

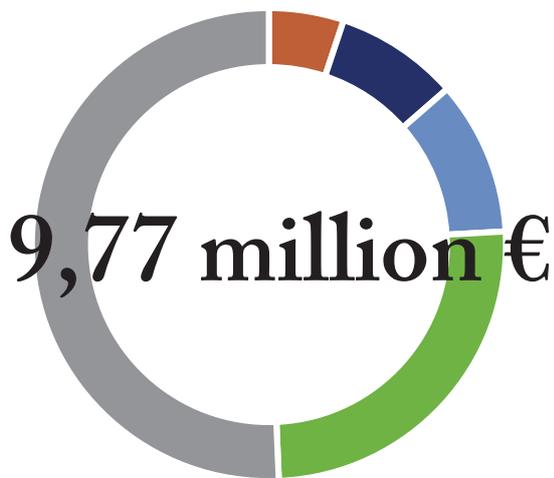
**110** measurement  
and information  
systems experts

**29** national and  
international  
projects

**5** commercially  
used  
inventions

**2** new companies

**54** publications



- Own funding 4,56 million euros (- 5 %)
- Regional funding 2,27 million euros(-29%)
- National funding 0,95 million euros( -14%)
- Business funding 0,76 million euros ( -16 %)
- International funding 0,46 million euros (+ 53 %)

Figure 2. CEMIS funding breakdown in 2015. In brackets difference compared to 2014.

the end of the year. Similarly, the development of international R&D cooperation was not yet visible in terms of funding. However, business funding grew compared to the previous year and exceeded targets despite the challenging economic situation. KAMK also produced publications very actively, producing its own record number of scientific publications. Also, the outcome of one earlier Tekes project was commercialised in 2015.

Jyväskylä University increased its business funding significantly and in general, the proportion of competitive funding in its operations. Jyväskylä University also produced a record number of publications and two new companies founded by students began to operate.

In 2015, MIKES operated first year as a part of VTT. VTT MIKES Metrology's work produced results. MIKES' business funding increased, its international R&D funding tripled and its total volume of competitive R&D funding reached a record level. VTT's second research team in Kajaani, the industrial Internet of Things (IoT), continued to shrink. At the start of 2016, there will only be one person in the team. Thus, VTT decided that from the start of 2016, its research team would no longer be a part of CEMIS. For the past five years of CEMIS' operations, the team's work has produced significant results: three promising

technologies that have been used in several business applications and will be used in the future. The team acquired over one million euros of international, national and business funding to finance its operations.

In 2015, the Center's total funding was 9.77 million euros (-6%) (In brackets difference compared to 2014) which was divided as follows: international funding 0.46 million euros (+53%), national funding 0.95 million euros (-14%), business funding 0.76 million euros (-16%), regional funding 2.27 million euros (-29%) and own funding 4.56 million euros (-5%). By 2017, the Center aims to increase its international funding to 1.4 million euros, national funding, to 1.9 million euros, and business funding to 1.4 million euros.

CEMIS' qualitative objectives in 2015 were to reinforce its attractiveness, competitiveness and impact. Kajaani has retained its position as a metrology expertise hub and it has strengthened its position as a centre of game education and new business. Vuokatti has developed as an international ski sports training, coaching, and research hub. Businesses in both Kainuu and elsewhere in Finland have acquired new experts, technology and the services that they need to develop their business operations. Here in CEMIS, we are happy and proud of these achievements.

In line with CEMIS' updated strategy, CEMIS will continue as a research and education hub specialising in measurement and information systems. In addition to the Universities of Oulu and Jyväskylä, Kajaani University of Applied Sciences, and VTT, CSC will also operate within CEMIS. In the future as at present, CEMIS's task will be to provide companies and research establishments that develop and apply measurement and information systems, top specialists in the field and new technology by offering research and development services as well as higher education, in an innovative and international environment. The central aims outlined in the updated strategy are to

create new technology business and to significantly increase international R&D cooperation and funding. CEMIS has three areas of focus: 1) online measurement solutions for the process industry, particularly in bio-economics, mining, and environmental monitoring (Cleantech), 2) measurement and testing solutions for sports, wellbeing and healthcare applications using sensor solutions, and game and simulator solutions (Sports and Wellbeing) and 3) the development of international technology business based on CEMIS technological expertise and in cooperation with business partners (International Technology Business).



Risto Oikari, Director, CEMIS



By the end of 2015 CEMIS had a record number of internationally and nationally funded projects.

The quantitative objectives of the program are to increase the percentage of nationally competitive funding by 40%, double the amount of international funding, increase business funding by 20%, increase the number of international partners, more or less double the number of theses and to create 8 new companies while commercialising at least 12 new technologies developed in CEMIS.



# The CEMIS development program 2015-2016

To a large extent, CEMIS' operations were developed in the CEMIS Development Programme which began in 2011. The third 2-year funding period of the program started at the beginning of 2015. The aim of the development program is to ensure that the qualitative objectives of the centre are achieved – to increase the attraction, competitiveness and impact of measurement and information systems research and education. The quantitative objectives of the program are to increase the percentage of nationally competitive funding by 40%, double the amount of international funding, increase business funding by 20%, increase the number of international partners, more or less double the number of theses and to create 8 new companies while commercialising at least 12 new technologies developed in CEMIS. The program implements joint

technology development projects in engineering and application fields central to developing local business operations, develops measurement and information systems education, and joint operations in device solution implementation. It also implements the program's marketing and communication functions and promotes the commercial use of the results of centre's research and development projects. The two-year program will mainly be implemented with funding from the East and North Finland ERDF program and a supplementary three-year project funded by the ESF. The total budget of the program is approx. 3.4 million euros. The program is divided into three development packages: the development of education, the development of technology, and the development of service operations.

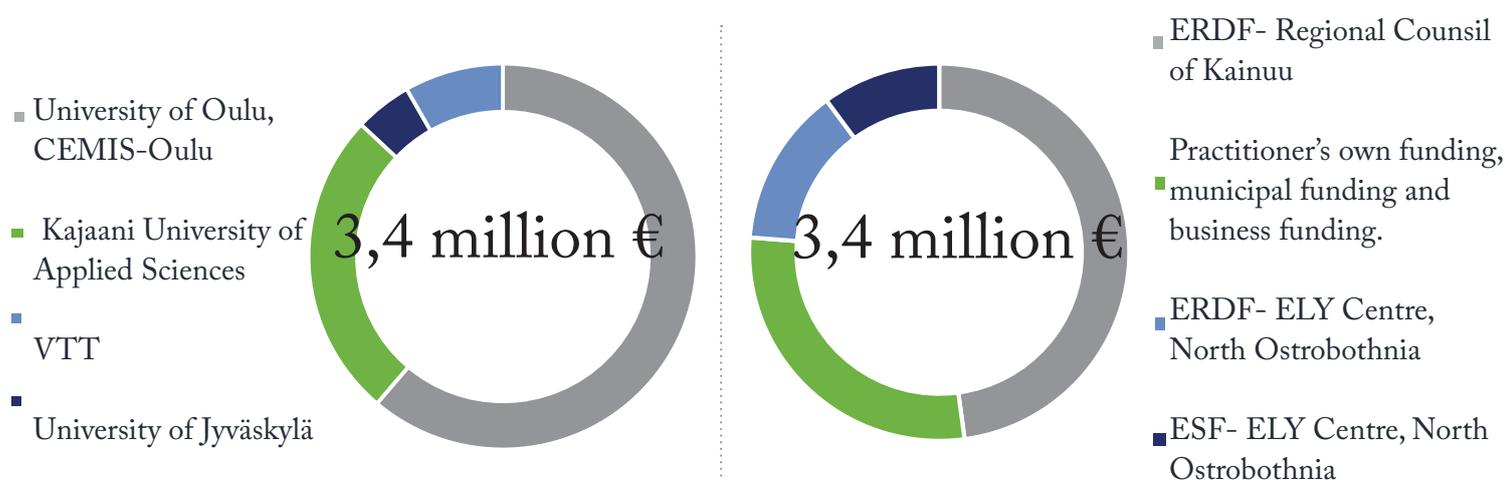
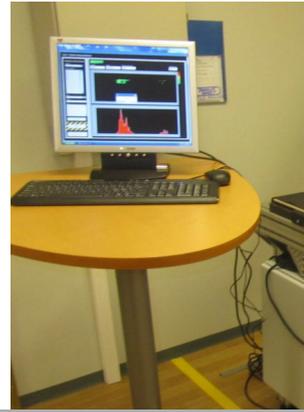


Figure 3. Breakdown of CEMIS-development programme funding by actors and funding sources.



## The operations of the program are divided into five parallel projects

### 1) Measurement Technology Development, Demonstration and Commercialisation (MiKeDeKa) project implemented by Oulu University

The aim of the project is to develop, demonstrate and commercialise measurement technology using previously developed technologies on which measurement systems will be built; also to produce research outcomes and services that can be rapidly applied by the region's businesses and new companies. The key themes of the project's activity are environmental issues such as reducing carbon emissions, industrial emissions and water monitoring. Among other technologies, real time measuring technologies based on electrochemistry and optics are being developed for the aforementioned purposes. The work of the project involves extensive testing of the technologies and methods in the customers' applications. The project's resources will also be targeted at the LIPAT project, coordinated by Jyväskylä University, in developing measurement methods for health and wellbeing applications that specifically serve the development of Vuokatti region as a sports and tourism environment. CEMIS-Oulu's and VTT MIKES Metrology's innovation in the project is the integration of process and phenomena simulation into measurements.

*The estimated budget is 2 109 000 euros and the main funding body is the Regional Council of Kainuu (ERDF).*

### 2) Sports and Wellbeing Technologies Service Business Development (LIPAT) implemented by Jyväskylä University.

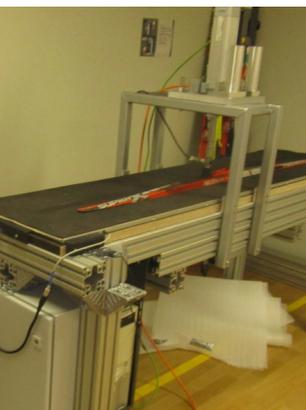
The aim of the project is to start commercial athlete and sports equipment testing activities and to develop existing services in Vuokatti. The project actions are specifically linked to setting up and starting to use a virtual training environment in the Vuokatti Testing

Station and to developing the skiing equipment testing methods of Jyväskylä University. The CEMIS 2015-2016 Program's parallel projects of Oulu University CEMIS-Oulu, Kajaani University of Applied Sciences, and VTT-MIKES are developing 1) non-invasive methods of monitoring physiological stress, strain and recovery using saliva or sweat samples, 2) improving and developing the reliability and repeatability of equipment testing methods, and 3) developing technologies for athlete and fitness testing in virtual environments. A world-class skiing environment and previously developed technologies from well-being to world-class sport will be used to develop new products and services for the needs of business. The objective of the project is to survey the commercial potential and test both athlete and equipment testing methods and wellbeing measurement technologies taking into account the needs of new and potential customers of the services. The CEMIS 2015-2016 program will improve the conditions and measurement methods of Vuokatti skiing research, coaching and testing with a view to commercial use in the future.

*The estimated budget is 164 000 euros and the main funding body is the Centre for Economic Development, Transport and the Environment (ELY-keskus).*

### 3) Simulator and Game Expertise Application in Teaching implemented by Kajaani University of Applied Sciences

This project consists of four development packages. In the first package, the potential of game and simulation environments will be harnessed across all disciplines of studies at KAMK (Mechanical and Construction Engineering, Sports, Wellbeing, Business and Datacentre). The second action package focuses on developing the content of the Smart Systems curriculum which will replace the current Vehicle Information Systems curriculum. The third development package focuses on making more effective use of serious game ideas in



teaching. The aim is to develop an operational model where serious game ideas from companies and communities will create a platform for project learning. The fourth package of the project will extend the already solid range of game education available in Kajaani to Master's level courses.

*The estimated budget is 464 000 euros and the main funding body is the Center for Economic Development, Transport and the Environment (ELY-keskus) (ERDF). The project will last for three years.*

#### **4) Development and Demonstration of Technology Transfer Services, implemented by Kajaani University of Applied Sciences**

The project has three objectives, the common denominator of these being to improve business conditions and operations by developing and focusing KAMK's service provision. The first aim of the project is to create new companies and new business for existing companies. This will be done by ensuring that CEMIS' expertise and services are used more effectively within the business sector by developing KAMK's operational and service model in order to be able to systematically analyse and predict the needs of businesses and transfer expertise to them. In addition, the companies' international cooperation and business operations, as well as CEMIS service business will be developed. Service business conditions will be improved by developing a testing service concept that combines simulators and virtual environments. The concept will be piloted in Vuokatti region in cooperation with Jyväskylä University. The second part of improving conditions for service business operations involves promoting KAMK's device development activities together with CEMIS and other actors. The aim is to create CEMIS's joint team for measurement solution engineering which can offer extensive services to both CEMIS' stakeholders and actors and partners in cooperation: companies, communities and research institutes.

*The estimated budget is 423 000 euros and the main funding body is the Centre for Economic Development, Transport and the Environment (ELY-keskus) (ERDF).*

#### **5) Development of Flow Modelling and a Monitoring Platform Based on UWB and Impulse Radar Technology implemented by VTT**

The VTT CEMIS program's project is strongly integrated into the projects of CEMIS's other partners. VTT's aim is to develop liquid flow modelling expertise required in the more cost-efficient development and reliability assessment of measurement methods developed by CEMIS, in the development and reliability assessment of VTT MIKES Metrology's own liquid flow testing and calibration equipment, and in the R&D projects of local companies. VTT is participating in Oulu University's **MiKeDeKa** project by offering modelling expertise and by implementing reliability assessment of the measurement methods developed during the project. VTT is also participating in Jyväskylä University's Lipat project by advancing the reliability of skiing equipment testing systems under development. In addition, VTT will continue its earlier work in developing the application of ultra-wide band impulse radar technology for measuring material moisture content and detection of foreign objects from their environment, such as human beings among big machineries.

*The estimated budget is 248 000 euros and the main funding body is the Regional Council of Kainuu (ERDF).*

The five aforementioned projects are implementing the program's four focuses of development packages: 1) the cleantec process industry's online measurements 2) sports and wellbeing service business development, 3) simulator and game expertise application in teaching and 4) development and demonstration of technology transfer services. In 2015, the following activities have been implemented in each of the aforementioned topics.

## Cleantec process industry's online measurements

Accurate and precise, rapid and reliable liquid flow measurements provide important information for process control and environmental monitoring purposes. Renewable energy production and modern bio-refinery processes produce sugar compounds and organic compounds, among other products. These industries need new methods of measuring such products real-time and continuously, to extract information on how the processes are functioning and as a result, to create more cost-efficient processes. Ever-stricter environmental permits have also created the need to develop real-time methods and devices to monitor industrial emissions. Depending on the situation, the damage to waterways caused by industrial emissions can be economic (process interruption/shutdown), health-related (heavy metal content of drinking water), ecological (contaminated waterways) or image-related (trust). The Cleantec subproject of CEMIS 2015-2016 programme is developing real-time measurements based on previously developed technologies to meet the needs above and these solutions will be piloted in industrial environments. A new perspective has been brought to development with phenomena and processes modelling conducted by CEMIS Oulu and VTT Mikes Metrology in cooperation.

The actions of the Cleantec project are divided into five work packages:

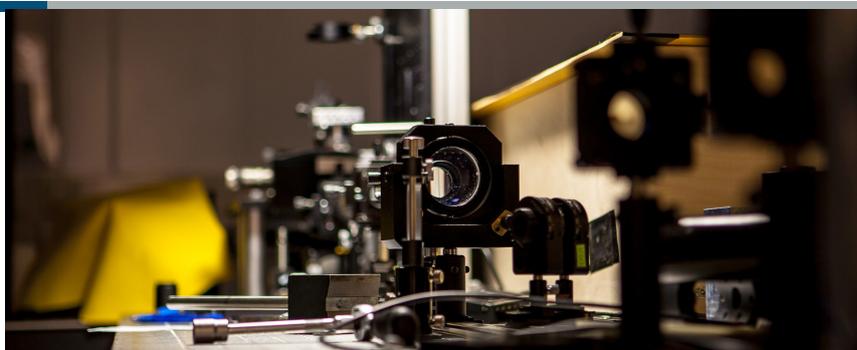
- 1)Modelling expertise to support flow measurements and real-time measuring
  - 2)Optical and chemical measurements in order to meet the measurement needs of renewable forestry and the mining industry
  - 3)Technology and method testing in customers' applications
  - 4)New sensor solutions and technologies
  - 5)Impulse radar technology to monitor material flows
- Modelling expertise was reinforced to support flow measuring and real-time measurements

In the project, VTT Mikes Metrology has grown its modelling expertise in cooperation with CEMIS-Oulu. Simulation and modelling softwares; Comsol, Ansys, Solidworks and Matlab, are taken into use. Simulation models have been compiled for VTT's liquid flow devices in relation to, e.g., flow regulators, the effect of valves on flow, and the effect of pipe bends on the flow profile. In addition, model validation measurements have been implemented using Laser Doppler Velocimetry equipment. The results were published in an article of Flow Measurement and Instrumentation magazine: Experimental and numerical study of a choke valve in a turbulent flow. Using the software, the flow dynamics of a flow chamber used in CEMIS Oulu's field tests was simulated and the use of modelling in a business application was planned. The operations of CEMIS and local businesses both need simulation and modelling. It has been predicted that the use of simulations will increase significantly in RDI. Since simulations are a relatively new and challenging topic for CEMIS, the year 2015 was mainly used for practicing how to use simulation tools within selected fields (liquid flows and optics).

## Optical and chemical measurements were developed and tested for the measurement needs of renewable forestry and the mining industry

During 2015, Capillary Electrophoresis (CE) was used in a variety of ways in the analytics of various process samples in the MiKeDeKa project: 1) industrial sample analytics to assess online measurement applications, 2) to develop new services for the analysis needs of companies to better understand and control processes, 3) as the laboratory's internal reference in the development of optical and sensor based methods, 4) in research cooperation to develop new, more ecological and efficient process methods, e.g., for the use of otherwise unused forest industry side flows and biomasses in the production of bio-ethanol, among other products.

The measured analytes have mainly been sugars



(biomass hydrolysis products as the raw materials of bio-ethanol), acids (among others, an important indicator of how the digestion and fermentation processes work, in, among others, the production of biogas and biofuels), metals (forest industry process parameter), sulfate (industrial discharge waters) and ammonium (municipal and agricultural sewage water treatment). Based on the results from the laboratory analyses, online CE piloting was implemented in an industrial environment in Pori during 27.-31.5.2015. During 2015, a real-time measurement device based on NIR spectroscopy was developed to meet the needs of the paper, pulp and mining industries. New sensor technology has been tested both in a laboratory and the field using several sample types. For the factory tests, process software was created for the device and set up for use. The factory tests involved testing the online software, two different spectroscopy techniques and the durability of the probe under different conditions. The tests mainly focused on functionality and reliability issues and cost efficient component solutions. This is important to ensure the reasonable price of potential commercial products to the end customer. It also enables the development of measurement solutions for smaller production plants, in particular the renewable forest industry and biofuel production. The scale of solutions in such plants is notably smaller than in the regular paper and pulp industry. Also, small plants do not have the opportunity to invest large amount of money in real-time measuring, although they do see a need for real-time measurements clearly.

The online NIR measurements of chemical flows in paper production were conducted in an industrial environment during 17.11.2015–26.1.2016. Based on the experiences and lessons learnt from the above and earlier mining industry spectroscopy experiments, it is now possible to create a measurement device that functions properly and can be produced at a reasonable price. Measurement services will be offered for the purposes of calibration and follow-up experiments with similar chemical flows to those mentioned above.

### **Development of new sensor solutions and technologies**

New business-needs oriented measurement methods and services have been developed and successfully tested within the MiKeDeKa project, and a few companies have already purchased such services from CEMIS Oulu. During the project, a gas chromatographic (GC-MSD) procedure was implemented to analyse solvent residues in a company's products. The analytics required a device equipped with special sample feed technology which was custom built for the laboratory equipment during a previous project. This sample feed technology is not widely in use in chemical laboratories. Therefore, its availability as an analysis service is limited. The analysis was demonstrated to be better suited to examining the company's samples than expected. After preliminary experiments, the company has regularly purchased solvent residue analysis services from the laboratory.

### **Impulse radar technology for material flows monitoring**

In the project, VTT continued the application of ultra-wideband impulse radar technology in wood moisture measurements. According to the results, with impulse radar it is possible to measure moisture content and observe relatively small changes in moisture content although calibrating the measurements is still a challenge. A second use of impulse radar technology was developed for detecting humans in industrial environments consisting of other objects such as big machineries. Algorithms for this purpose have been developed and it has been verified that in addition to place, the impulse radar also detects movement of human beings. The project also continued to develop an embedded system based radar solution. With an embedded system, it is possible to control the radar and read the data it produces with an ARM unit and then transfer the data to a DSP unit for which basic algorithms have also been created. Several R&D projects are being prepared with businesses to further develop radar technology.





## Development of the sport and wellbeing technology service business

### Athlete testing

The athlete testing actions aim to develop even faster methods of measuring the performance of an athlete and to accelerate the analysis phase of existing test methods. CEMIS-Oulu has focused on developing non-invasive methods to monitor physiological stress, strain or recovery status based on saliva or sweat samples, and KAMK has focused on the development of a virtual training environment.

The development of non-invasive measurements using the lactate measurement method from sweat samples has attracted the interest of heart rate monitor manufacturers. The method is yet to be validated, but work has continued as a part of CEMIS' operations. During 2015, it was observed that lactate sensor measurements worked. However, the wide scope of the analysis proved challenging. After finding a suitable solution, the method will be developed further to make it feasible. In other CEMIS Oulu projects, the focus has been on saliva sample lactate measurements. The development of an instant non-invasive mycoplasma test started in 2015, and during this time the aim was to collect saliva samples of positive contagions. Based on a preparatory investigation, it was noted that the contagion phase cannot be verified in commercial tests. The contagion phase is especially important for athletes so that the right medication and treatment process can start, which implies a need for the instant non-invasive mycoplasma test. The transformation of a saliva cortisol level measurement method into a user-friendly quick test continued in 2015 after a Tekes strategic opening project. Utilizing a precise reference method, new liquid chromatography equip-

ment supplemented with a tandem mass spectrometer analyzer, has been set up to measure saliva cortisol. In addition to the reference method for sensor development, measurements can be offered as service analytics to athlete groups or health tourism.

In the virtual environment, several options for automatic treadmill speed adjustment controlled by the user (athlete) were investigated with KAMK. Automatic speed control is a crucial point of development to obtain realistic experiences in the environment. As regards virtual reality, a virtual environment generation tool - RouteGen - was developed at the beginning of the project with the KAMK game development team. The aim was to create a tool enabling the simulation of a real outdoor track based on GPS data, for use in athlete testing. In summer 2015, the staff of Jyväskylä University began to test RouteGen and became familiar with it. Tackling the problems experienced with the HIIHTO wireless server's (wireless data logger) GPS and air pressure sensors began, and this work will continue in 2016. Using the wireless server, it is possible to collect force (skies and poles), EMG (electromyography), GPS, and air pressure data synchronously outside the laboratory environment.

### Sport equipment testing

As regards, developing sports equipment testing, Jyväskylä University has focused on finalizing the cold testing laboratory facilities, initializing the ski tester's new version and starting ski tests. Together as a part of VTT-MIKES' own project, a new version of the force measurement sensor system was designed and integrated into the ski tester. The ski tests started during autumn 2015, and based on the results, the observed deficiencies were corrected at the end of the year. Towards the end of 2015, Jyväskylä University



conducted a race ski pole comparison study on ski pole shafts submitted by the manufacturers, Leki, Start (two models), OneWay, Swix, EXEL, Yoko and Rex. A study report was written and sent to the companies in the study and also to Finnish Ski Associations (cross-country and biathlon). The purpose of the study was not only to provide sports associations with information but also to advertise the ski pole testing method to manufacturers.

### Service testing

Jyväskylä University started cooperation with Vuokatti Sports company to develop the service business, in order to compile a service price list including all the athlete (cross-country, ski jumping, general tests) and sport equipment tests. In order to attract clients for these services in the future, Jyväskylä University has assisted Vuokatti Sports to prepare a "Development of sports expertise international business in Vuokatti" project together with regional organizations.

As regards athlete testing, co-operation was carried out with e.g. the Finnish Sprint Skiing National Team, Vuokatti Sports and Myontec Oy (EMG clothe manufacturer from Kuopio). As regards virtual environments, co-operation continued with CSE Simulation Oy (CSE Entertainment Oy). As for ski pole testing, the E-Sport Group Oy (EXEL) has been a close collaborative partner. The Finnish Ski Federation and Finnish Biathlon Association together with the Finnish Olympic Committee have been important partners in ski equipment testing development. As well as the project, joint funded project proposals were planned, and submitted to Tekes with SME's aiming to integrate intelligent sensors into sport equipment and thus develop technique training applications (Sportec project plan 02/2015 and PRO-FIT project

plan 11/2015). Several cross-country ski manufacturers and wellbeing companies committed to fund the projects. Besides the CEMIS partners, Tampere University of Technology and VTT's research group from Tampere have collaborated in the project. The co-operation network continued to be broadened and sports services in Vuokatti region continued to be promoted by participating in the largest international sports science conference in Europe (European College of Sports Science) and also in national events.

In 2015, Jyväskylä University submitted 11 project proposals (including two international) which resulted in two regional funded development projects, one Ministry of Education and Culture funded research project, one funding for organizing an international congress from the Federation of Finnish Learned Societies, and one research funding from the International Biathlon Union - leading to approximately 0.4 million euros in project funding. International co-operation continued, especially in the field of Paralympic Skiing (sit-skiing) research with the International Paralympic Committee, the University of Salzburg, the University of Freiburg and Politecnico di Torino. The 3rd International Congress on Science and Nordic Skiing was held in Vuokatti, in June 2015. It brought together 140 participants from 18 countries. In total six peer-reviewed international scientific articles were published.

### SIMPPELI - Simulator and game expertise – application in teaching

The SIMPPELI project, which will last for three years, began at the beginning of 2015 with funding from the European Social Fund granted by North Ostrobothnia ELY Center for Economic Development, Transport and the Environment .

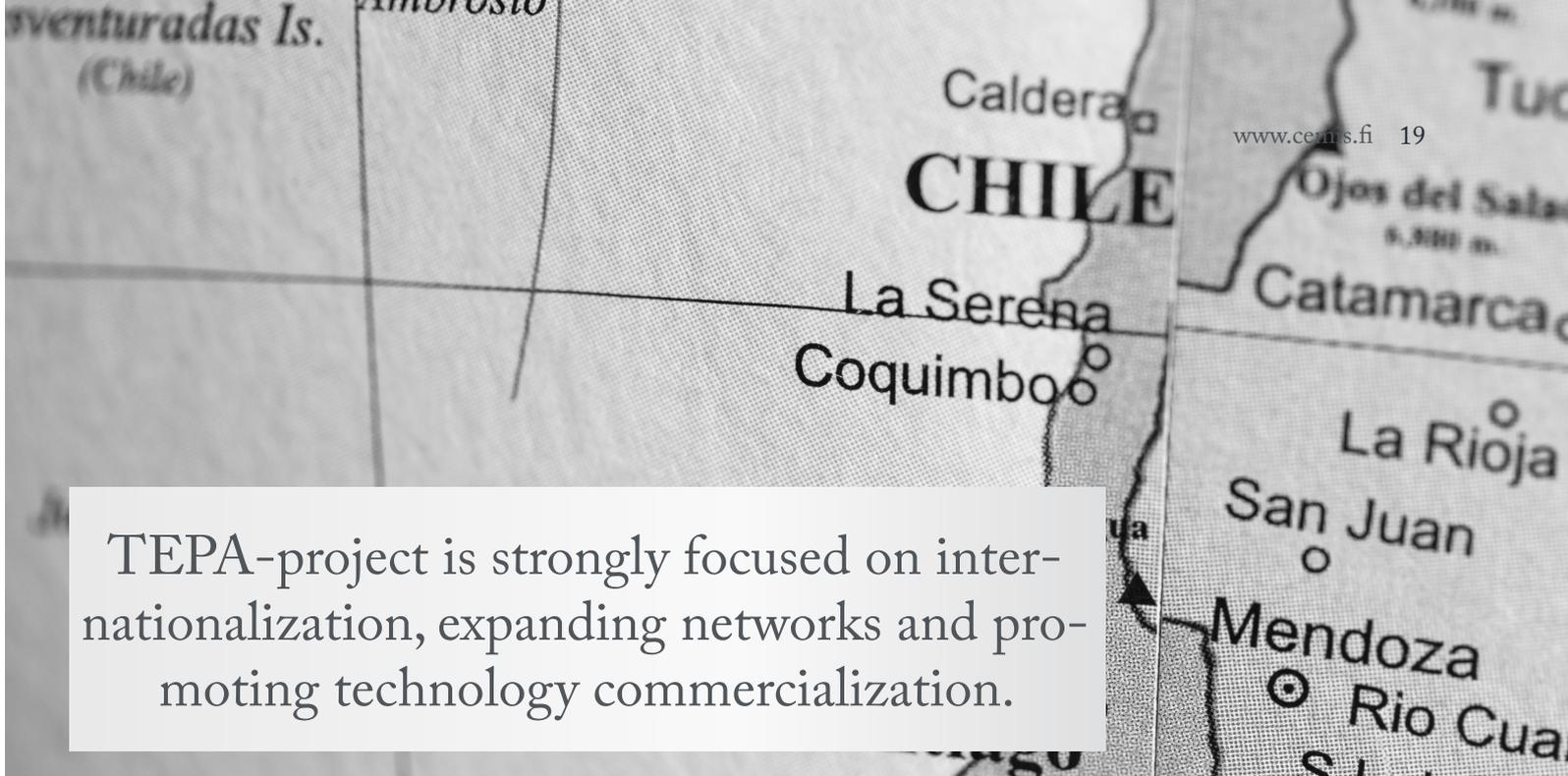
During its first year, SIMPPELI activities were conducted in four work packages. One of the work packages concentrated on finding new, teaching-related applications for existing simulator and virtual environments. Together with a game development team, three teachers from different education areas created the following virtual solution for teaching purposes: a virtual environment to improve the authenticity of teaching scenarios in nursing, a teaching game for evaluating safety homes for the elderly, and a virtual environment approach in service design teaching. The smart systems curriculum was enhanced by creating online course material for basic courses, by identifying similarities between courses and increasing the integration of studies, as well as designing project studies content for application areas such as wellbeing, industry, sports and smart environments. KAMK's stakeholders have gradually shown an increasing interest in serious game applications, thus the SIMPPELI project has generated practices and processes in order to systematically manage and utilize serious games requests in a teaching context. University collaboration in game studies advanced with the piloting of summer school studies in cooperation with the University of Oulu and obtaining approval for the studies to be accepted as University level degree studies within computer sciences. KAMK, the University of Oulu and the University of Lapland have maintained dialogue and jointly planned activities in order to expand the selection of master-level e-courses, especially in serious games. Joint preparation efforts within serious games resulted in the **SeGaBu** project (Serious Games Platform for Business and Education) funded by Häme ELY Center.

### **TEPA - Development and demonstration of technology transfer services**

The aim of this project is to strengthen the utilization of CEMIS' expertise and services in companies. This is achieved by developing an operational model and service business concept at KAMK including systematic analyses and predictions of companies' needs as well as methods for transferring expertise and technologies into companies. The enhanced utilization of technological innovations done in CEMIS and expanded international collaboration networks in new promising market areas are the core drivers for operational model development. A service business concept, generated

in cooperation between the Information Systems and Mechanical and Mining Engineering competence areas, is a central part of the comprehensive model to be created in KAMK. The ultimate goal of the project is to foster the establishment of new companies and to create new business opportunities for existing companies by targeting KAMK services and expertise to better meet the diverse demands of economic life, particularly SMEs.

The device prototyping knowhow of KAMK is strengthened by developing an athlete testing concept utilizing simulators and virtual environments. In this project, KAMK will design and implement a software aiming to automate the generation of virtual training routes based on measured location information (GPS and pressure data). The second focus is the modernization of control methods used in treadmill-based athlete testing. The **TEPA** project collaborates closely with the **LIPAT** project which is also part of the CEMIS 2015-2016 program. Moreover, the development of a joint device development concept within CEMIS is further advanced according to CEMIS' strategy. The purpose of this joint device prototyping team is to provide supporting services not only for CEMIS members but also to other stakeholders: companies, communities, research organizations and other associates. The **TEPA** project is funded by the European Regional Development fund and the funding authority is North Ostrobothnia ELY centre (Centre for Economic Development, Transport and the Environment). In its first year of implementation, the business development part of the **TEPA** project has strongly concentrated on internationalization, the broadening of designated networks and enhancing the commercialization of technologies developed by CEMIS' member organizations. International networking visits focused on creating connections with Chile and Peru, continuously growing Cleantech market areas. As a result, new partners have been found and discussions have opened up market access routes for technologies developed by two SMEs located in the Kainuu region. With the help of the networks created in the **TEPA** project, one company from Kainuu has set up a contract with a partner from Chile for selling and delivering measurement instruments. The national partner network has been strengthened by negotiating



TEPA-project is strongly focused on internationalization, expanding networks and promoting technology commercialization.

collaboration possibilities with around 30 companies, including SMEs and large enterprises. Connecting CEMIS' expertise and technologies into transnational project consortia has been a characteristic feature of project preparation in 2015. The commercialization of the most promising technologies has been supported by preparing TutLi projects (New knowledge and business from research ideas) for Tekes, the Finnish Funding Agency for Technology and Innovation. Technology commercialization, measurement technologies, water purification solutions and circular economy are the themes under which much of the project preparation falls. The most significant project planning and preparation efforts have related to the following funding calls:

- H2020-SPIRE: closed water circulation development for textile and metal industry, CYCLOPS project. The application did not pass the first stage evaluation.
- H2020-Water: closed water circulation development for textile and metal industry, SofiLoop project. Preparation will continue in 2016.
- H2020-SC5-Raw Materials: selective acquisition of valuable substances, ReMAIX project. Preparation will continue in 2016.
- EUROPE AID programme first stage application: technology transfer services in Palestine. Decision pending.
- Tekes-TutLi: multi-parameter method e.g. for bio ethanol production, MPA project, executor CEMIS-Oulu. The project has been accepted and received funding.
- Tekes-TutLi: geopolymer materials for repairing asphalt roads, Georoad project, executor KAMK.

The project has been accepted and received funding.

- Tekes-BEAM: export of water technology solutions to developing economies such as Chile, Peru and Palestine. The project has been accepted and received funding.

Development of the athlete testing concept composing of virtual environments and automated treadmill control has begun in close cooperation with the University of Jyväskylä. The game development team of KAMK implemented a software module for the generation of virtual training routes from GPS and pressure data. The first prototype version of the software is ready and it will be integrated either partly or completely into the testing concept during 2016. Device development expertise has increased by designing and implementing hardware and software for automating the treadmill utilized in athlete testing and by developing interfaces for virtual environments. The HIIHTO wireless server, a multipurpose measurement module for sports measurements developed in previous CEMIS projects, was re-evaluated and an updated plan was made. Consolidation of joint device development between CEMIS members involved in the TEPA project was implemented as a minor part. In 2015, tangible co-development of devices was conducted in the BioIN project coordinated by CEMIS-Oulu, where KAMK participated in the implementation of instrument prototyping for insulin measurements from saliva samples. The terms and practices determined in the previous CEMIS program have been followed in joint device development.



# The operations of UNIVERSITY of OULU

CEMIS-Oulu was formed in 2015 from two research groups: Cleantech and, health and wellbeing. The unit was based in Kajaani but also conducted project activities in Vuokatti.

In 2015 the main application areas of the unit's research were: bio-economy (renewable forest industry, bioenergy, utilization of forest biomass), Cleantech (process and environmental applications, especially mining) and health and wellbeing applications (development of biosensors, nutrition, development of Vuokatti area). A fixed-term professorship in optical imaging technology continued in 2015 and was financed jointly by Oulu optoelectronics laboratory projects and project funding from the Kajaani Unit. There were post-graduate degree students in both research teams.

2015 saw the continuation and strengthening of CEMIS' (Centre for Measurement and Information Systems) operations. New CEMIS Development Program projects started in 2015. The aim of the **MI-KEDEKA** project is to utilize existing technologies to build new measurement devices and to produce new services and research results. These outcomes could be utilized by local companies and start-ups in the near future. A special area of research is environmental issues, for example, low-carbon technologies, industrial emissions and water monitoring. For this purpose, real-time measurement technologies based on electrochemistry and optics have been developed and applied. This includes long-term tests in customer applications. The resources of the project are also used in the LIPAT project coordinated by the University of

Jyväskylä, in which new measurement technologies are being developed for the health and wellbeing sector, in particular to support the development of sports and tourism surroundings in the Vuokatti area. A new collaboration between CEMIS-Oulu and VTT MIKES Metrology involves integrating process and phenomena simulation into measurements.

Other organizations in CEMIS are the University of Jyväskylä, VTT Technical Research Centre of Finland Kajaani (including VTT MIKES Metrology, formerly MIKES), and Kajaani University of Applied Sciences. The CEMIS Development Program has further united the region's expertise and strengthened cooperation between the Universities of Oulu (CEMIS-Oulu) and Jyväskylä, as well as cooperation between University of Oulu and VTT by Tekes and regionally financed projects. The Director, Vesa Virtanen, has participated in the work of the CEMIS Strategy and Management Groups. The University of Oulu unit is clearly the largest operator in the CEMIS Development Programme.

CEMIS-Oulu is involved in the national photonics research network Photonics Finland. In 2015 cooperation with the Oulu Innovation Alliance was strengthened, in particular with its Centre of Health and Technology (CHT) and the Centre for Environment and Energy (CEE).

CEMIS-Oulu was involved in 8 Tekes-funded projects.

**1. Cleen/MMEA programme** (TEKES): development of online sensor contamination control and assessing the applicability of biosensors.

**2. MEAN:** (TEKES TUTLI, linked with the Water Programme): Mercury-free automatic online metal analyser

**3. LST-VISION:** (TEKES small strategic opening): New approach to analysing and visualising complex data, started at the beginning of 2012-2015

**4. BEST** (FIBIC-CLEEN SHOKs, TEKES): Future sustainable bioenergy solutions

**5. BIO-In** (TEKES TUTLI): development of a biosensor to detect and analyse insulin

**6. Premium** (TEKES TUTLI): real-time smart control of process liquid metal concentrations

**7. MPA** (TEKES TUTLI): Bioethanol production

optimization; versatile process analyzer

**8. SME-MET IMCEE:** Innovative metallurgical cooperation for environmental efficiency

CEMIS-Oulu was also involved as a metrology developer in the EU EUREKA cluster ITEA 2 programme's **WATER-M** project, which aims to alter water management operating systems and services. Several companies and research institutes from Finland, France and Turkey are participating in the project. The aim is to ensure safe water for domestic uses in all circumstances. Finland's part of the project is financed by TEKES in 2014 – 2016.

CEMIS-Oulu has also participated in the energy and environment strategic centre for science, technology and innovation (CLEEN SHOK), the Measurement, Monitoring and Environmental Assessment (MMEA) research programme and in the CLEEN's and FIBIC's (Finnish Bioeconomy Strategic Centre for Science, Technology and Innovation) joint **BEST** project.

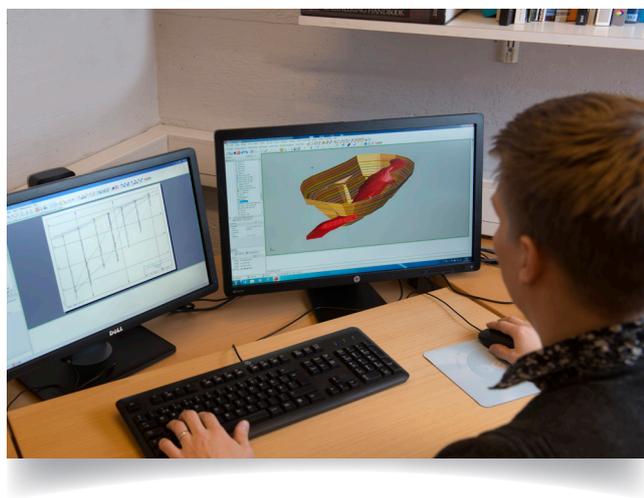
In addition to the CEMIS Development Programme and TEKES projects, CEMIS-Oulu had 16 other ongoing projects. There was extensive cooperation with companies in the Kainuu region and nationally.

**The Kajaani Lab project** aims to create a learning environment in the laboratory, where personnel can deepen their knowledge. It will also enable the laboratory to increase the number of specialists and the broadness and quality of its research services. Also, the utilization of infrastructure is enhanced by personnel training. Knowledge in health technology, production of sensor surfaces with different printing techniques, materials for sensor surfaces and reading devices, is enhanced. Furthermore, the capability to use new simulation tools is one of the aims. The training also provides personnel with new biotechnical tools and better capabilities to utilize and optimize pilots and proof-of-concept tasks. During and after this project, CEMIS-Oulu can better support micro- and SMEs in their development projects and competitiveness. The project supports the start-up and development of bio-refinery, bioenergy and mining industry ventures in Kainuu.

CEMIS-Oulu participated in promoting Vuokatti in the **TESTIKATTI** project, which develops wellbeing, testing and sports services enhanced by analytics. The project will strengthen Vuokatti's competitiveness in sports and wellbeing tourism and will create new cooperation networks between companies, research institutes and other organizations. The project partners are, e.g., The Finnish Olympic Committee, the University of Jyväskylä, KIHU Research Institute for Olympic Sports and Vuokatti Sports.

The aim of the project "Development of Coaching at the Vuokatti-Ruka Sports Academy is to build a simple and robust surveillance system for monitoring the enhancement of physical strain, development and technique. Also, the required testing blocks and evaluation feedback for the aforementioned solution, are being developed for endurance sports athletes in Vuokatti and for athletes of alpine sports in Ruka, as well as tools for their coaches to support their work. The project is a collaboration with the University of Jyväskylä and Vuokatti-Ruka.

The Innovative High-Value Products from Biomass Raw Materials project **BIOHIVA** continued and has networked with Oulujärvi Leader and businesses. The creation of a service research concept for the identification and profiling of bacteria to produce new information for the adjustment of industrial processes to enhance production is on-going in the **BAKOTUS** project in which mining, energy, renewable forestry and food companies are partners. The aim of the project is to develop profiling methods for the identification of



bacteria in the forest and paper industry, mining, the food industry and the bioenergy industry.

**The POTIS** - Potato Waste to Valuable Products project aims to promote sustainable valorization of potato side streams produced in Northern Ostrobothnia via the development and assessment of potential product pathways to their main component fractions. The project is implemented by the University of Oulu and Natural Resources Institute Finland in cooperation with companies along the value chains.

CEMIS-Oulu also implemented the mobile measurement platforms (**LILA**) project in which continuous and autonomous sensors for air and water measurements were set up at mobile device platforms and demonstrated. Additionally, ideas for how to use various operational and cooperation models for environmental applications were generated.

The unit conducted research cooperation with the Sotkamo Unit of Natural Resources Institute, Finland connected with the fields of bioreactor operations and products. The actions of the **KAVERI** project aimed to decrease the nutrient and solids load caused by agriculture in waterways.

The Management and Rehabilitation of Surface Water Bodies Receiving Mine Waters (**KaiHali**) project, aims to develop expertise and business opportunities in the management of mine water discharge to surface waters. The project develops the prediction and modeling of mine water mixing and dilution and the resulting ecological and stratification effects in recipient surface waters. In addition, the project addresses the accumulation of loading into aquatic sediments, the resulting changes in sediment geochemistry, and the increased cost efficiency of sediment survey methodology. In this context, the utilization of an autonomous measurement vessel (ROV) is evaluated. The project is promoted by the Finnish Environment Institute (coordinator), Geological Survey of Finland, Kajaani University of Applied Sciences and CEMIS-Oulu.

**JaMit** - Modeling oil spreading with CFD connected to oil and low metal (Ni, Hg) measurements in mines and harbors. Collaboration with the Environmental and Chemical Engineering group (ECE) of the

University of Oulu and Vocational College, Lappia.

CEMIS-Oulu is also involved in the Vesien hallinta kaivoksessa (Water control in mine) training scheme coordinated by AIKOPA Adult and Continuing Education, aimed at public officers and companies.

The personnel of CEMIS-Oulu is also working in the Kainuu Climate Project, which aims at reducing greenhouse emissions in Kainuu by 25 % by 2020 by including climate protection in the standard operating procedures of companies and municipalities. Companies and municipalities are given advice and training in the means to reduce greenhouse emissions. The project will increase the ability of companies to do climate-responsible business, which can be used to improve company image.

The unit participated in four international projects: in the European Meteorological Research Programme, EMRP, with a project where laboratory moisture analysis devices based on new technologies (NMR, microwave and X-ray technology) are being investigated and their performance compared to the traditional standard of the oven drying method. CEMIS-Oulu is also in the PEOPLE part of the EU FP7 programme's ITN network project EUROMBR which has 12 partners in 8 countries. The project is developing expertise in microbioreactors and it provided resources for one foreign doctoral thesis employee. The unit is participating in the EU-N EIP, the Entrepreneurship and Innovation Programme's Eco-Innovation part, the Envimon project, in which industrial metal emissions monitoring in environment waters is being studied.

The European Commission's Directorate General for Health and Consumers organised a research application in August 2014: Healthy diet: early years and aging population. CEMIS-Oulu's project proposal Nutritional research on the non-invasive screening and diagnosis of malnutrition in elderly persons (**NURSE**) was selected for funding. An agreement was signed with the Commission in December 2014 and the project started at the beginning of 2015 and will continue until the end of June 2016. The project is a collaboration with the Jokioinen unit of Natural Resources Institute, Finland.



The number of international researcher exchanges was 42 person months as planned. There was active international cooperation with more than 10 research institutions e.g. in Italy, Denmark, Russia, the USA and Great Britain. The number of scientific articles produced was relatively good: 4 referenced international scientific articles, one patent and 20 conference and other publications or presentations. The unit's employees participated in international and national evaluation tasks (scientific magazines, pre-evaluator of Ph.D. thesis, and assessment of international project applications). There was one notification of an invention.

The unit's budget was approx. 3.2 million euros. It had 54 employees during the year 2015 and it accumulated up to 42 person work years. 12 persons with a Ph.D. diploma were engaged, which accumulated up to 26 % of the person work years.



# The operations of Kajaani University of Applied Sciences

The year 2015, the first year of the current CEMIS program, was at the same time the fifth year of co-operation within CEMIS – the Centre for Measurement and Information Systems. In 2015, KAMK started to develop a new strategy aiming for the year 2024. The updated vision of KAMK “from proactive towards smart” lead to a re-evaluation of KAMK’s education and research activities in relation to CEMIS. KAMK’s new fields of excellence: game and measurement applications in the School of Information Systems as well as production systems in the School of Mechanical and Mining Engineering, will support KAMK’s role in CEMIS in the future. In addition, the other schools of KAMK will be more closely affiliated to CEMIS than before.

**Information systems competence area – Smart systems education launched, intense focus on the theme of serious games within projects**

Smart Systems degree studies, in line with the new curriculum structure, was offered as blended studies through the joint application system, in spring 2015. In total, there were 65 applicants for 20 study places. In the future, smart systems know-how will be embedded in all the studies offered by each school at KAMK, since smart applications constitute a common denominator in the KAMK’24 strategy. This orientation also provides a good basis for technology applications and multidisciplinary innovations in smart home care, the area of excellence of the School of Health. The special requirements of smart systems studies have been taken into consideration by allocating an appropriate laboratory for education, development and research activities. The Game Technology option is still available for those who wish to improve their skills in engineering and accomplish a degree at KAMK.

The three-year SIMPELI project started at the beginning of 2015 with regional ESF funding. This

project has contributed significantly to the improvement and development of education provided within the Information Systems competence area. The activities of SIMPPELI have concentrated on 1) the planning of Smart Systems studies and the creation of new course contents, 2) the diversification of simulator and virtual environment usage in teaching, 3) the systematization of management processes regarding serious games-related requests/assignments and 4) the development of master-level courses in game education. In addition to the SIMPPELI project, serious and applied games are intensely visible in the Serious Gaming Research Lab project, which began in April 2015 with funding from the Tekes ERDF. This project aims at developing solutions and services for serious games testing, research and evaluation, especially targeted at companies operating in this sector. The third project on the same theme, SeGaBu – Serious Games Platform for Business and Education, received funding from Häme ELY Centre for Economic Development, Transport and the Environment, in autumn 2015. The objective of SeGaBu is to produce novel and innovative eLearning based education in serious games. KAMK is a coordinator of this two-year project and its partners are Oulu University of Applied Sciences, the University of Oulu and the VirtualAMK network development unit from Tampere University of Applied Sciences. Successful collaboration concerning measurements and virtual environments in sports and wellbeing has continued with the University of Jyväskylä (JYU) in the TEPA project which is thematically linked to JYU's LIPAT project. Both of the aforementioned projects are part of the CEMIS 2015–2016 programme. As far as measurement technologies and virtual solutions in sports applications are concerned, the activities of TEPA have focused on developing a virtual environment based testing concept for athletes. In particular, KAMK has developed automated software solutions for automated virtual route generation and designed improved systems and algorithms for treadmill control.

The Information Systems competence area's project portfolio also includes two education oriented projects funded by the Ministry of Education and Culture: Digital Services degree education in the ICT sector and Smart Systems (conversion course) in the ICT-sector. These projects are being implemented by KAMK and

Oulu University of Applied Sciences. Along with other funding instruments, Information Systems participated in several internal development projects. Project preparation which did not lead to funding included the international KIN-TECH project (Interreg BSF, theme: serious games business and education, and two sports technology related Tekes projects: Sportec and Profit. However, the service business has shown signs of growth, especially in applied games development. Transnational networks and contacts have been promoted by maintaining dialogue with KAMK's strategic co-operation partner universities as well as presenting the work, results and knowledge of KAMK/CEMIS at international events. The total volume of the project portfolio in the Information Systems competence area was approx. € 1.0 M, in 2015.

The studies offered by the Information Systems competence area remained attractive among applicants. This was evident from the amount of primary applicants, 378, which was almost as high as the record from 2013, 382 primary applicants. The application data indicated Data Center studies are gradually becoming more popular. Most of the applicants were not from the Kainuu region.

Data Center and Game degree education was promoted at national events such as the Northern Game Summit (NGS) and Nordic Digital Business Summit (NDBS), both of which gathered wide audiences. KAMK and CSC (IT Center for Science) deepened mutual collaboration by means of designing a data science course and by preparing joint projects under the theme of big data (GreenDataNetwork).

In 2015, a total of 36 Bachelor and 10 Master's degrees were produced in the Information Systems competence area. Altogether 4 publications were published, being either scientific peer-reviewed articles or trade/conference articles. The education provision and R&D activities of the Mechanical and Mining Engineering competence area, consisting of mechanical, civil and infrastructure engineering, have been affiliated to CEMIS since 2014.

The development of expertise in mining engineering has been a central part of KAMK's activities, both in education and R&D, for several years. At the begin-

ning of 2015, KAMK started to prepare education collaboration and joint courses in mining with Lapland University of Applied Sciences and the University of Oulu mining faculty. The aim of these activities is to improve the attraction and impact of studies in this field. During 2016 and 2017, the objective is to pilot mining degree education given in English, implemented jointly between the aforementioned universities. This form of education is to be permanently launched in 2018.

### **Mechanical and mining engineering established itself in CEMIS**

Research and development activities in the Mechanical and Mining Engineering competence area consisted of projects funded from several sources: Tekes, ESF, ERDF, businesses, Ministry of Education and Culture and KAMK's own funding. In total, the volume of projects within this competence area was approx. € 0.7 M. These projects were jointly conducted with CEMIS member organizations as well as other research and education institutes. Funding received from companies is an indicator of successful actions. Specialization in geopolymer research and development work has indicated to raise a lot of interest among industry. Mechanical and Mining Engineering project personnel members participated in the preparation of three international H2020 projects: Cyclops, Sofiloop and ReMAIX. The first two projects focus on the development of closed water circulation systems for the textile and metal industries, the last, ReMAIX, focuses on the selective

capture of valuable substances. Tekes granted TutLi funding for GeoRoad projects, which investigate the suitability of geopolymers in tarmac road repairs and examine the business potential of new material solutions.

Within these projects many potential co-operation universities in the mining field have been contacted, collaboration agreements signed and networking visits conducted. The first staff and student exchanges to Sweden and Germany also occurred in 2015. A concrete example of profitable multidisciplinary collaboration is the Kaivi-project which focused on the development of a virtual learning environment in mining education. It was prepared with Lapland University of Applied Sciences and is funded by North Ostrobothnia and Lapland ELYs. A joint education module, designed earlier by KAMK and Lapland University of Applied Sciences, began in 2015. To enhance attractiveness and competitiveness, the ROKK Academy brand was designed and launched at the Euromining 2015 exhibition in Tampere where KAMK and Lapland University of Applied Sciences shared a 20-m<sup>2</sup> stand. The objective of such cooperation is to gain a similar level of recognition as the Oulu Mining School (OMS), European Mining Course (EMC) and Mining Education Australia (MEA). Inevitably this requires many years of hard work to be conducted at KAMK in collaboration with CEMIS. During 2015, The Mining and Mechanical Engineering competence area prepared project activities contributing



to KAMK's new strategic alignments. Robotics as a theme, robotics education development and a related laboratory environment will most likely become key elements in Mining and Mechanical engineering in the near future. These themes are also present in our excellence area "production systems".

The number of graduates in the Mechanical and Mining Engineering competence area was 38 in 2015. Personnel produced a total of 6 publications categorized as peer-reviewed scientific articles or trade/conference articles.

### **CEMIS Business Development (CBD) team strengthened their role in technology commercialization and international network building**

In 2015, the CBD team continued successful commercialization activities concerning R&D results produced within CEMIS. The aim of CBD is to serve equally all CEMIS members and to provide expertise as a service for companies and other organizations. The CBD team, coordinated by the KAMK's principal lecturer in R&D, expanded its networks both nationally and internationally. Members of the team participated in the international PDAC mining exhibition held in Canada as well as attended the Medica exhibition, a large health technology event organized in Germany. The development of international networks was aligned with CEMIS' focus areas, thus concentrating on the most promising and growing market areas such as South America (Chile, Peru and Brazil) and the Middle East (Palestine territory, Lebanon, Saudi Arabia and the United Arab Emirates). Furthermore, the CBD team attended water-related networking events in Paris (ACQUEUA) and in Amsterdam (Aquatech). As a result, a project was prepared for the EuropeAid funding program in collaboration with Palestinian partners. H2020 funding program calls have been systematically followed since the first draft version of the work programme was released. The CBD team participated in the preparation of three H2020 projects: Cyclops, Sofilooop and ReMAIX, the first of which did not receive funding and the preparation of Sofilooop and ReMAIX will continue in 2016. All of these projects are related to the following themes:



measurement technologies, water purification solutions and circular economy. In order to accelerate the commercialization of promising technology innovations created in CEMIS, funding was applied for from the Tekes TutLi funding instrument. Two commercialization projects were allocated funding: MPA (CEMIS-Oulu) and GeoRoad (KAMK). Additionally, the Tekes BEAM programme granted funding for preparing a project on business-driven water technology export. The CBD team was also involved in the preparation of a sports technology development project (Sportec, Tekes funding) and started to plan a project with a water monitoring theme for the Interreg Baltic Sea Region program. The above project is being jointly planned with the IT Center for Science (CSC) and The Finnish Environment Institute (SYKE).

There has been a demand for Kainuu based technology innovations. For example, as a result of interest in water sector technologies, organizations from Chile and Peru have started negotiations to purchase such technologies. A small number of devices have already been made based on a trade agreement with a Chilean partner. As a result of the intense marketing of technology commercialization activities to local companies, CBD has been more widely recognized. Partly due to these marketing efforts CBD has designed and executed one survey project as a direct assignment to a local company, in 2015.

In total, CBD participated in the preparation process of about 10 national and international projects. Two peer-reviewed journal articles were also published.



# The operations of VTT Oulu

When VTT and MIKES merged as VTT Oy, MIKES became one of the research areas within VTT Oy. Two business areas operate in Kajaani: Knowledge intensive products and services (KIPS) and Smart industry and energy systems (IND). VTT Oy operates in Kajaani in the former MIKES facilities located in the Renforsin Ranta business park.

## VTT MIKES Metrology

VTT MIKES-Kajaani (KIPS) has operated in Renforsin Ranta business park since 2011 in custom made facilities. The main functions are traceability services and maintenance of the national measurement standards concerning force, torque, mass (20 kg ... 2000 kg) and water flow. In addition, VTT MIKES-Kajaani is involved in the Ministry of Employment and Economy's consultative commission work concerning metrology. VTT MIKES-Kajaani is responsible for such action

in force and water flow. The latest flow measurement day was held 17.9.2015 with 28 participants.

There were eight employees in VTT MIKES-Kajaani in 2015, of which seven were full-time employees. **Petri Koponen** (PhD) is the team leader. Koponen also worked as the program manager of the MMEA program of CLEEN Oy (since 1.9.2015 CLIC Innovation Oy) between 1.5. – 30.9.2015. MIKES-Kajaani was originally established by **Aimo Pusa**, who was also the head of the unit until 2011. After that Pusa worked in MIKES-Kajaani as a part-time specialist until the end of 2015.

VTT MIKES-Kajaani has offered possibilities to local students to do practical training and to carry out their diploma work and thesis. The laboratory has also offered summer jobs.

VTT MIKES-Kajaani has participated actively in the activities of the European metrology organization, EURAMET, for example by participating in its meetings concerning the quantities for which VTT MIKES-Kajaani is responsible. VTT MIKES-Kajaani cooperates actively with the national metrology institute of Germany, PTB, concerning the traceability of force, torque and water flow. Tampere University of Technology has been an important domestic collaborator in the development of the measurement standard of water flow.

VTT MIKES-Kajaani participated actively in the CEMIS development program. VTT MIKES-Kajaani participated in planning the modernization of the equipment used for sports gear testing, and by calibrating detectors used for measuring sport performances. Modelling know-how has been expanded in cooperation with CEMIS-Oulu. VTT MIKES-Kajaani was involved in seven research projects during 2010-2015 (**Painevesi, LUMO, Analytical Photonics, Cleen/MMEA, TARRA, NICK, EMRP Force, BEST ja Biovesi, EMPIR Torque, FloModNode**).

**EMRP** (European Metrology Research Programme) Force is one of 33 ongoing EU projects in VTT MIKES. The goal of these metrology related projects (EMRP and EMPIR) is to integrate European

metrology research into common goals. In the EMRP Force project, VTT MIKES-Kajaani is developing new calibration methods together with ten other national metrology institutes, and doing research on how to improve the measurement of forces and the dissemination of the quantity of force. In addition, parasitic components and different loading effects are analyzed to consider these effects when the device is used in industrial applications. The goal is to examine the relationship of the time used for measurement and the loading, in order to better understand the relationship between time and loading in different force ranges.

**EMPIR Torque** is a new EU project that started in the summer 2015. This project focuses on the development of transfer standards for wind energy nacelle test benches in the MN·m range which can also withstand the high non-torque loading present in such facilities.

FloModNode project funded by Kainuun liitto is one of the five parallel development projects in CEMIS 2015-2016 program. In this project VTT MIKES-Kajaani is developing its modelling know-how regarding phenomena occurring in water flow. This is important in order to understand for example the effect of various structures on flow profile. Modelling can significantly reduce the carbon footprint of product





development by saving resources and energy. In addition to developing its own expertise, one objective of VTT MIKES-Kajaani is to participate in the projects of other CEMIS members ensuring the reliability of measurement methods and estimating the uncertainty of measurements.

VTT MIKES-Kajaani activities have been communicated actively in EURAMET meetings. One peer reviewed article has been published as a result of the development of flow measurements (Experimental and numerical study of a choke valve in a turbulent flow. / Huovinen, M.; Kolehmainen, J.; Koponen, P.; Nissilä, T.; Saarenrinne, P. in: Flow Measurement and Instrumentation, Volume 45, 2015, s. 151-161).

During its first five years of operation, VTT MIKES-Kajaani has had 200 – 300 clients annually, of which 95 % are located outside Kainuu. Foreign clients outnumber the ones from Kainuu, suggesting that location has not hindered the demand.

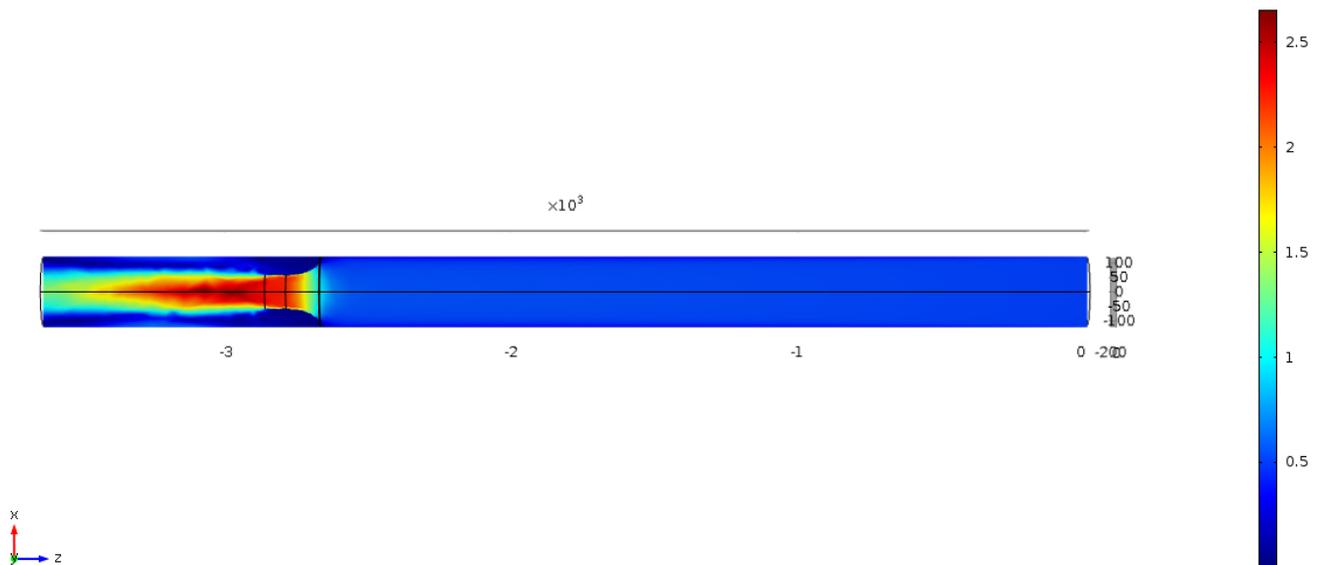
## VTT Kajaani Industrial IoT

The employees of VTT Kajaani, industrial IoT (IND) are continuing to develop their expertise in the research topics that were initiated in Kajaani: ultra-wide band

(UWB) impulse radar technology and UWB radio technology. UWB impulse radar technology research began in the **CEMIS UWBIT** project (2014 - 2015) and continued in work package 5 of CEMIS' CleanTec project. UWB radio technology research began several years ago, and the development of position technology based on UWB radio for use in harvesters etc. was conducted in the Puomi project.

UWB impulse radar technology has been further investigated in work package 5 of the CEMIS CleanTec project, where one focus was the moisture measurement of materials. Also, research on person and object detection has continued. This technology has been tested with several machine manufacturers and several applications during 2015. The use of UWB impulse radar technology in industry was also investigated in the S-Step project of FIMECC.

The research and development of UWB radar technology was conducted in the **PUOMI2020** project ordered by the Forum for Intelligent Machines (FIMA) during 2014 – 2015. In this project, VTT produced the boom head positioning system and wireless data transfer of CAN bus adapters. The project was conducted with the Tampere University of Technology (TUT).



*Development of the flow nozzle simulation model. The purpose is to find out the flow profile and the pressure difference in the calibration device.*

Both technologies have attracted the interest of industry and the positioning system will be further developed with Hilla funding with the University of Oulu and Oulu University of Applied Sciences during 2016 – 2017. Overall, there is intensive discussion with industry concerning UWB impulse radar projects.

Two persons from IND worked in Kajaani during 2015, and they worked in the above-mentioned projects, some in both and some in just one. In 2016, the personnel of the VTT industrial IoT group will be reduced to one person.

In 2015, the projects in Kajaani concentrated on developing UWB impulse radar technology know-how (CEMIS CleanTec and PUOMI2020). Due to a lack of resources, part of the work had to be transferred to the team's other sites in Oulu, Tampere and Espoo.

The use of UWB impulse radar technology in industry was investigated in the S-Step project of FIMECC. However, after a few months, the project was discontinued.

Although there is only one researcher in Kajaani from the industrial IoT group, research on both (UWB) impulse radar technology and UWB radio technology will continue in Kajaani in at least two projects.

From 2017 onwards, industrial IoT group will not be involved in CEMIS.



# The operations of University of Jyväskylä

## General Review

Sports Technology Unit of Jyväskylä University, located in Vuokatti, was established in 2004 and has focused on Masters and Doctoral level education as well as research and development activities. In 2015, the unit employed 12 people at most but, by the end of the year, there were nine employees. A part of the salary paid to two employees was provided by Jyväskylä University and another part by the Finnish Ski Association / the Olympic Committee of Finland. Larger ongoing ventures included “Active life and work – ALIWO” (Kainuu ELY Centre for Economic Development, Transport and the Environment, ESF), “Sports expertise as an export product” (Kainuu ELY, ERDF), “Development of coaching at the Vuokatti-Ruka Sports Academy” (Regional Councils of Kainuu and North-Ostrobothnia, ESDF), CEMIS (Kainuu ELY, EEDF) as well as “Development of a

disabled sit-ski athlete’s classification system” (Ministry of Education and Culture). In 2015, the Unit’s total budget was approx. € 890 000, 20 % of which was contributed by Jyväskylä University.

By the end of 2015, the Sports Technology Unit has produced 56 Master’s graduates, with a graduation percentage of more than 50. In 2015, four students graduated with a Master’s degree. There were four doctoral students two of whom are expected to graduate in the following year. Three out of four of the doctoral degrees are supervised by a second primary supervisor from a foreign partner University (University of Salzburg and Politecnico di Torino) and two of them will be double degrees. Five Master’s degree graduates from the Sports Technology Unit found employment. Two companies were created by students. From the very beginning, interdisciplinary coopera-

tion, business centeredness and internationality have been the values of the unit, led by Professor Vesa Linnamo. Linnamo has launched and prepared the Master's degree education project and will continue to lead the Unit. In May 2015, Professor Linnamo was awarded the Lönnrot medal by the Finnish Cultural Foundation. The prize was presented to the innovative physical exercise and wellbeing researcher in Vuokatti on 7.5.2015, during the annual celebration of the Kainuu Regional Fund of Finnish Cultural Foundation.

## Cemis activities

Regional cooperation in the Centre for Measurement and Information Systems CEMIS also continued in 2015, with the start of the third CEMIS development program. As a part of CEMIS cooperation conducted over the years, skiing measurement systems, biosensors and sensors measuring the properties of snow have been studied.

Within the CEMIS consortium, Vuokatti Sports Technology Unit coordinates sports and wellbeing technology measurement development with the aim of identifying methods and services with the commercial potential to reinforce Vuokatti's status as world-renowned skiing research, coaching and testing environment. Athlete or equipment testing services developed in

different projects over recent years have been hindered by slow analysis and demo-stage measuring methods and consequently, it has not been possible to fully commence the commercialization of such services.

The core aim of Jyväskylä University's CEMIS project "Sports and Wellbeing Technologies Service Business Development", which began in February, has been to focus on methods which could potentially be commercialized in the future. The main actions focus on developing cross-country skiing athlete and equipment testing methods. As a part of athlete testing, a virtual training environment (Figure 1.) is now in use as a result of cooperation with Kajaani University of Applied Sciences. Equipment testing development has primarily involved finalizing the development of a cold-conditions testing laboratory and its ski tester and the start of ski tests. The Finnish Ski Association and Biathlon Association as well as The Olympic Committee of Finland, and VTT MIKES Metrology have also been intensely involved in this work.

The commissioning of the virtual training environment has been promoted collaboratively by Kajaani University of Applied Sciences and Vuokatti Sports company. Cooperation with Oulu University CEMIS Oulu has involved developing non-invasive cortisol, testosterone and mycoplasma measurement methods from sweat samples. In addition, the project is also surveying regional and other Finnish wellbeing and sports technology businesses that may be able to benefit from the results of the project.

Overall, CEMIS has enabled the unit to transform its laboratory and Vuokatti's athlete testing environments so that it is possible to adapt them for the purposes of different projects and user groups.

## Other project and research activities

2015 saw progress in international research aiming to develop a sit-ski athlete (disabled athletes) competition classification system. Cooperation was conducted with the Universities of Freiburg, Salzburg, Torino and Leuven, as well as the Para-Olympic Committee. The definitive aim of the research is to develop methods of determining sit-skiers' trunk disabilities using a dynamic



Figure 1: Virtual training environment at the Vuokatti Testing Station



*Figure 2. The Finnish Ski Association's ski maintenance project manager and employee of the Sports Technology Unit, Teemu Lemmettylä, demonstrating the ski tester in the cold conditions laboratory.*

balance test. The research includes a wide selection of different variables from balance and muscle activity measurements to movement analysis. The research and cooperation involved researchers from different countries visiting Vuokatti for several weeks. One doctoral thesis on the topic will be finalized in the near future. CEMIS cooperation also enabled the use of developed measurement methods in the aforementioned doctoral thesis, for example, the dynamic balance measuring system and the Coachtech feedback system.

Cooperation with South Korea has intensified over a longer period (e.g. in the Sports Technology Unit's "Sports Expertise as an export product" 2014-2015 project and the preparation project, 2013, related to the aforementioned project). The intention has been to create opportunities for international cooperation to enable winter sports athletes to come and train and be coached in Vuokatti. The first cooperation partner candidate was South Korea. As a result of this connection, the Deputy President of the South Korean Ski Association visited Vuokatti in April and subsequently the country's biathlon, cross-country skiing, and disabled skiing teams spent approximately one month in Vuokatti during September-October on a testing camp. The ambassador for South Korea

in Finland, Mr. Chang Donghee (Figure 3.), visited Vuokatti in October 2015, and was also introduced to the operations of CEMIS in Kajaani.

CEMIS's operations are partly aligned with the ongoing Vuokatti-Ruka Sports Academy coaching development project. Concrete inter-project synergy involves the testing of demo-stage measuring methods during the analysis of young athletes, in the form of the roller-skiing test at Vuokatti Testing Station (implementation of treadmill control) and non-invasive mycoplasma measurement methods. The aim of the Academy project is to survey measurement methods that could benefit the daily coaching of athletes at the sports academy. Instruction will be given to coaches and athletes in the most suitable methods for detecting possible surplus strain in young athletes. Piloting the analysis methods will be implemented with the athletes of the academy. The project has also begun marketing the IB High School to Asia: Japan, Korea and China.

The ALIWO project developed preventative occupational wellbeing interventions and services according to demand and in line with future challenges. The final seminar of the project, "Motivate for Change" took place in Kaukametsä Hall in Kajaani, in April.

39 managers, with at least five people working under them, were the subject of research in the project. The results of the project, among other information, were presented during the seminar. Significantly, the results indicated that in addition to wellbeing technology, personal meetings were also required to increase activeness and wellbeing. Approximately 100 people attended this open event.

A collaborative application for research funding submitted to the International Biathlon Union, in cooperation with KIHU Research Institute for Olympic Sports, the Finnish Biathlon Association and Salzburg University, received a positive decision in spring, 2015. The aim of the research is to create a simulated biathlon environment for the Vuokatti Testing Station, which will be used to examine the impact of tiring on the biomechanics of skiing and shooting performance. The research set-up was piloted in Vuokatti in the summer and the actual analyses will be conducted in 2016.

In autumn 2015, project preparation for developing international winter sports expertise business operations began, in cooperation with Vuokatti Sports. Intensive cooperation with Vuokatti Sports also advanced the coaching feedback system Coachtech's range of sports test data for cross-country skiing and sprinting. In the same year, Coachtech was installed for the benefit of the Pajulahti Sports Institute and Kuortane Olym-



Figure 3. South Korean ambassador, Mr. Chang Dong-hee (third from the right) visiting CEMIS at Kajaani University of Applied Sciences.

pic Training Center. Vuokatti emphasizes the use of Coachtech in Nordic ski sports while Pajulahti and Kuortane use it for athletics (particularly sprinting). Coachtech was developed as a result of Jyväskylä University's project activity and Vuokatti Sports' training center development grant from the Ministry of Education and Culture.

The Vuokatti team has published (cumulative figures from the year 2004 in brackets) 6 (60) original scientific articles, 3 (17) books or chapters in books, 11 (141) international congress abstracts, and has been invited to deliver 6 (57) presentations, 4 (39) of which were international presentations. In addition, the unit has been active in organizing international scientific congresses."The 3rd International

Congress on Science and Nordic Skiing" was organized in Vuokatti in June, 2015, and it attracted approx. 140 participants for 18 different countries. The theme of the congress was, "From science to practice", which was also the topic of the final panel discussion (Figure 4). CEMIS was present as one of the organizers of the congress. The Sports Technology Unit received funding from the Federation of Finnish Learned Societies (TSV) to organize the congress.

Figure x. The panel discussion members of ICSNS 2015: Biathlon Senior Coach, Marko Laasonen, Skiing



Figure 4. The panel discussion members of ICSNS 2015: Biathlon Senior Coach, Marko Laasonen, Skiing Researcher, Øyvind Sandbakk, High Performance Unit Director, Mika Kojonkoski, Skiing Researcher Jussi Mikkola and Researcher and Coach, Olli Ohtonen.



# Publications

During 2015 CEMIS produced in total 17 international scientific, peer-reviewed articles and 36 professional and conference articles. In addition to that, CEMIS produced 4 Master's theses, 10 Master's Degrees as well as 75 Bachelor of Engineering and Bachelor of Business Administration theses.

## **Doctoral thesis:**

**Riikka Keskinen;** The acute physiological and biomechanical responses of plyometric exercise in young and elderly women.

**Teemu Lemmettylä;** Fascicle-tendon interaction in V2 skate cross-country skiing; a case study

**Eija Santala;** Unen laadun ja pituuden vaikutukset fyysiseen aktiivisuuteen ja submaksimaaliseen aerobiseen kestävyYTEEN.

**Timo Vilppo;** Prediction of maximal oxygen uptake by bioimpedance analysis and bioimpedance derived variables.

**Scientific publications:**

Räty J. and Peiponen K-E; Inverse Abbe-method for observing small refractive index changes in liquids, *Talanta* 137, 143-147, 2015

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# Contact Information



Risto Oikari  
Director  
CEMIS

Centre for Measurement and Information  
Systems  
PL 21 (Kuntokatu 5) | 87101 KAJAANI  
Tel. +35844 710 1410  
E-mail: risto.oikari@cemis.fi  
www.cemis.fi



Anas Al Natsheh  
Ph.D., Senior Business Advisor

Business Development and International  
Connections  
PL 52 (Kuntokatu 5)  
87101 KAJAANI  
Tel. +35844 7101 228  
E-mail: anas.alnatsheh@cemis.fi  
www.kamk.fi



Jari Kähkönen  
Head of School of Engineering

Kajaani University of Applied  
Sciences, Information Systems  
Competence Area  
PL 52 (Kuntokatu 5, Taito 1)  
87101 KAJAANI  
Tel. +35844 7101 303  
E-mail: jari.kahkonen@kamk.fi  
www.kamk.fi



Vesa Virtanen  
Director, Professor

Oulu University Metrology Unit,  
CEMIS-OULU  
Kehräämöntie 7  
87400 KAJAANI  
Tel. +35840 839 7023  
E-mail: vesa.virtanen@oulu.fi  
www.cemis.oulu.fi



Vesa Linnamo  
Professor

Jyväskylä University,  
Sports Technology Unit  
Kidekuja 2  
88610 VUOKATTI  
Tel. +35840 504 4800  
E-mail: vesa.linnamo@jyu.fi  
www.jyu.fi



Petri Koponen  
Group Manager

MIKES Kajaani Site  
Tehdaskatu 15, Puristamo 9P19  
87100 KAJAANI  
Tel. +35840 660 9709  
E-mail: petri.koponen@vtt.fi  
www.mikes.fi

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