

CEMIS Annual Report 2017

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Chairmen's Review

The economic upturn that began in 2017 has clearly highlighted opportunities and needs for co-operation and teamwork, with an ongoing emphasis on developing and implementing new technology and generating expertise. Responding to these challenges is a key goal of the CEMIS operating approach.

CEMIS establishes and supports regional, national and international operating conditions by combining research, development and innovation expertise from universities and other research organisations. These factors support modernisation, development and internationalisation of the Kainuu region and facilitate the emergence of co-operation networks that benefit everyone, generating added value not only for parent organisations, but especially for project partners.

The core strength of CEMIS is living in the moment while also looking to the future. Making that future attainable and developing present potential requires the agility to identify the right operating approaches. This also challenges CEMIS to rediscover its own path and mode of added value generation in each project. CEMIS has enjoyed remarkable success in this pursuit, with the determination of its parent organisations remaining a key condition for more profound and stronger relevance in future.

We look forward to further development of co-operation through CEMIS and its projects in coming years!



*Matti Sarén
President and CEO
Kajaani University of Applied Sciences*



*Arto Maaninen
Vice Rector for Cooperation
University of Oulu*

Introduction

CEMIS (Centre for Measurement and Information Systems) is a contract-based research and education centre for measurement technology and information systems founded in 2010 by the University of Oulu, the University of Jyväskylä, VTT Technical Research Centre of Finland Ltd., CSC - IT Center for Science Ltd. and Kajaani University of Applied Sciences.

CEMIS comprises the Measurement Technology Research Unit (MITY) of the University of Oulu, the School of Information Systems and the School of Engineering (Mechanical and Mining Engineering) of Kajaani University of Applied Sciences (KAMK), the VTT Kajaani unit including MIKES Metrology operations, the Vuokatti Sports Technology Unit of the University of Jyväskylä, and the CSC Kajaani unit.

Together with the City of Kajaani and the Municipality of Sotkamo, all five of these CEMIS members are committed to CEMIS operations.

For the University of Oulu, CEMIS is one of its innovation centres and the only one of its kind outside of Oulu. In Kainuu, University of Oulu has focused its technological research and development activities in CEMIS. For KAMK, CEMIS is a significant form of university and research institute cooperation, and one of the central targets in the development activities. For the University of Jyväskylä, CSC and VTT, CEMIS is a form of regional cooperation.



Picture 2.1. CEMIS's focus areas and member organisations with their main expertise.

CEMIS member collaboration is based on a joint strategy group and a management group, RDI co-operation, project co-ordination, joint marketing and communications, business development, co-operation in prototypes, developing joint facilities and environments, and co-operation in education.

Reliability is a key CEMIS value. Members seek to be reliable partners achieving results for their own organisations and for one another, and also for regions, customers and other partners. CEMIS also ensures the reliability of its own new metrological solutions and of their measurements.

CEMIS aims to be a sought-after international partner in the development of measurement and information technology expertise. Through extensive research and development services and university education, the Kainuu-based centre of expertise and innovation provides a wide range of internationally significant knowhow for creating new technologies and businesses.

By offering research and development services and university education in an innovative and international setting, CEMIS produces leading specialists, new technology and new business for companies and research institutes developing and applying measurement and information systems. The centre provides a motivating educational environment for students with an interest in working in specialist posts, and an innovative, international working environment for researchers and experts seeking to develop and progress in their careers.

CEMIS's mission is to increase the attractiveness, competitiveness and effectiveness of its members' research and education activities in measurement and information system. To achieve this goal, CEMIS has set quantitative productivity targets for R&D, education and innovation, for the centre itself, and individually for each organisation involved.

A CEMIS Development Programme defining measures for co-ordinating operations, co-operation between parties and the division of labour, the use of joint resources and actions for increasing visibility is a key tool of CEMIS operations. Implemented with an annual budget of some EUR 1.7 million and funded mainly by ESF and ERDF programs in Northern and Eastern Finland, a fourth two-year development programme was launched at the beginning of 2017. Total annual funding of CEMIS is more than EUR 11 million, comprising self-financing by members, regional development funds (including the CEMIS Development Programme) and tendered external funding. CEMIS employs about 100 specialists in measurement and information systems.

CEMIS focuses on the following areas of education, research and innovation:

-  Online measurement solutions for the process industry, in particular for the bioeconomy and mining sectors, and for environmental monitoring (Cleantech)
-  Measurement and testing solutions for sports, wellness and healthcare applications using sensor solutions, and game and simulator solutions (Sports and Wellbeing)
-  Developing international technology business operations based on CEMIS technological expertise and partner companies (International Technology Business)

Director's Review

2017 has been an interesting year in the history of CEMIS. Our founder and long-time Director Risto Oikari, D.Sc. moved on to new challenges, bestowing on me responsibility for leading a well-maintained and healthy research and education centre. I would like to convey heartfelt thanks to Risto for a job well done! CEMIS has been further invigorated with a new member: CSC - IT Centre for Science Ltd. A strong competence base, excellent results and the general economic revival that began in 2017 are now all combining to give CEMIS an excellent foundation for fresh endeavours in the coming years.

The strategy of CEMIS, its operating plan and joint collaboration agreement were updated at the end of 2016, and the centre's fourth development programme for 2017-2018 was also finalised at this time. These results have clarified and guided the centre's operations throughout 2017 and facilitated my own start as Director of CEMIS.

I began my term by getting to know the CEMIS member organisations and their key staff, and I also met with the principal regional and national actors and partners from the point of view of CEMIS. This included the most important partner companies. Even at this stage, it was pleasing to find that the achievements and results of CEMIS

are of the highest quality, even by international standards, and that Kainuu enjoys a unique status as a hub of metrology expertise.

CEMIS operates and develops its functions according to the productivity targets assigned in its operating plan, assessing results in the three categories of R&D, education, and innovation activity. A staff of nearly 100 people worked to achieve these goals at CEMIS in 2017.

The publishing rate of CEMIS remained strong over the year, with the release of 26 peer-reviewed scientific articles and 28 conference



I have gladly learned that the achievements and the results of CEMIS are at top-level, even with international scale, and that the Kainuu region has a unique role as a center of excellence for measurement technology.

and professional publications. One Doctoral degree, ten Master's degrees, eight university of applied sciences Master's degrees and 85 university of applied sciences Bachelor's degrees were conferred at CEMIS in 2017.

CEMIS operated approximately 40 R&D projects in 2017. The fourth biannual CEMIS development program kicked off with four new projects at the start of the year. The content of the program, its operations and the results achieved so far will be described later in a separate section of this report. CEMIS was also engaged in eight international projects with funding increased to EUR 0.5 million. Regional funding (through the Regional Council of Kainuu or ELY - the Centre for Economic Development, Transport and the Environment) was EUR 3.2 million. The aims of these projects included developing new solutions for water treatment, analysing metal concentrations in industrial wastewater, developing process analysers for bioethanol production, recycling and repurposing industrial sidestreams (e.g. using geopolymers in roadmending), using natural raw ingredients in the food supplements and food industry, athlete testing and coaching, measurement solutions for biathlon, biosensors for the healthcare sector, solutions for recognising symptoms related to ocular diseases, learning environments applying VR/AR technology (e.g. a VR-based car mechanic tutorial), methods for torque measurement standards and metrology for multiphase flows.

The impact of CEMIS is primarily assessed in terms of new commercially viable technology and by noting how many businesses have been established due to the centre's operations. Two commercially applied inventions were developed and five new companies were founded within CEMIS in 2017.



The Measurement Technology Unit of the University of Oulu (MITY) continued its strong trend of scientific and conference publishing. One technology solution was also commercialised on the basis of the unit's research, and one company was founded to operate in the international Cleantech market.



Kajaani University of Applied Sciences strengthened its operations in international research and development. Funding of international projects increased, with a significant boost in preparing new projects under the EU Horizon 2020 research programme. Nearly 100 students graduated from programmes operated under CEMIS. Service business operations also grew significantly. Demand for VR and 3D skills remains high. One technology solution was also

commercialised and one student founded a new company in the games industry.



The Vuokatti Sports Technology unit of the University of Jyväskylä expanded its research staffing considerably by hiring three new employees, and also continued its strong publishing trend. Three new companies founded by students began operating.



VTT's Kajaani unit comprises two research teams, one of which works under MIKES Metrology, the National Metrology Institute of Finland. The overall operations of the unit have begun growing compared to the previous year, while the level of service sales to industry has remained stable. Active participation in international research also continued through EU Horizon 2020 EMPIR projects (European Metrology Program for Innovation and Research).



CSC - IT Centre for Science joined CEMIS at the end of 2016, and has brought significant added value to CEMIS, the CEMIS Development Program and regional companies in 2017 with its expertise in data management, data analysis and artificial intelligence. The Finnish government confirmed investment funds in April totalling EUR 33 million for developing data management and high performance computing. A significant portion of this has been allocated to updating the CSC datacentre in Kajaani.

Total funding for the centre in 2017 was EUR 11.4 million (-1%) divided as follows: international funding EUR 0.5 million (+ 18%), national funding EUR 1.1 million (- 50%), industry funding EUR 1.0 million (+ 10%), regional funding EUR 3.2 million (+25%) and self-financing EUR 5.6 million (+ 4%). The centre is seeking to increase international funding to EUR 1.1 million, national funding to EUR 1.6 million and industry funding to EUR 1.2 million by 2018.

The main assigned objectives of CEMIS for 2017-2018 are to generate new technology business operations and significant growth in international R&D co-operation and funding. New business was directly created in 2017 through a record number of five new companies founded by CEMIS employees and students. The service business of several CEMIS members also began to grow over the year.

CEMIS is now primed to boost international funding by activating EU funding opportunities and other sources. CEMIS members have formed a new EU project team with a view to preparing at least ten project applications every year for the EU Horizon 2020 research program over the last program period in 2018-2020. As part of EU Smart Specialisation Platforms (<http://s3platform.jrc.ec.europa.eu>), CEMIS has also joined in the planning work of the ClusSport initiative for the sport sector.

Active international co-operation has continued for CEMIS both at European level and in a broader global context. In Europe CEMIS has co-operated with the Universities of Salzburg, Ljubljana and Turin. It has also continued or initiated co-operation in South America (Peru, Chile and Brazil) and in Kazakhstan, China (Beijing Sport University and Chinese Ski Federation) and Vietnam.

In line with its strategy, CEMIS will continue operating as a research and training hub specialising in measurement and information systems, with the main objective of boosting economic growth and existing businesses in Kainuu by bringing new technology, business and specialists to the region. While CEMIS retains a strong regional operating policy focus, its objectives and outcomes can only be achieved through international excellence, drawing on international co-operation and the market. CEMIS will accordingly further strengthen its international operating efforts in future years.

The three focus areas of CEMIS – Cleantech, Sports&Wellbeing, and developing the international technology business – also give the organisation promising opportunities for exploiting its expertise internationally. There is a globally growing need for expertise related to water reserves, such as water monitoring, treatment and protection. Increasing investment in new solutions for healthcare and wellbeing is also visible not only for ageing Western and Japanese populations, but also in rapidly growing economies such as China and India. CEMIS has realistic prospects of selling its own competencies and those of its partners internationally, and thereby also strengthening and generating new technology expertise in Kainuu.

The operations of CEMIS in 2017 have been boosted by general economic growth in Finland and Europe. This has continued in a promising manner into 2018, with a good outlook for operating conditions in coming years as well. Operations in 2018 will progress according to the current strategy, operating plans and development programme, and will probably continue to be mainly based on the current strategy and operating plan in 2019-2020. More significant changes in the operating conditions of CEMIS are expected after 2020 when Finland's regional development policy changes with the planned regional reform. The EU research programme will also transition into the new 9th Framework Programme at the end of Horizon 2020. These changes will have a significant impact on CEMIS operations. The precise details have not yet been released this stage, and we can only remain prepared for them and for the future by continuously reinforcing our operations and improving our performance while increasing our impact both regionally and internationally.

CEMIS in figures



COMPANIES
FOUNDED



INVENTIONS
COMMERCIALY
APPLIED



INTERNATIONAL
PROJECTS



EUR 0.4 MILLION IN
R&D SERVICES



PEER-REVIEWED
PUBLICATIONS



CONFERENCE
PUBLICATIONS

TOTAL CENTRE
FUNDING OF EUR

11.4
MILLION

-1%

INTERNATIONAL
FUNDING OF EUR

0.5
MILLION

+18%

NATIONAL
FUNDING OF EUR

1.1
MILLION

-50%

INDUSTRY
FUNDING OF EUR

1.0
MILLION

+10%

REGIONAL
FUNDING OF EUR

3.2
MILLION

+25%

SELF-FINANCING
OF EUR

5.6
MILLION

+4%

CEMIS Development Programme 2017-2018

CEMIS Development Programmes are the key instruments for achieving the centre's goals and implementing CEMIS co-operation. The fourth two-year development programme was launched at the beginning of 2017 after joint preparation together with CEMIS members, regional companies and regional development financiers. The development programme seeks to ensure realisation of the centre's qualitative aims of increasing the attractiveness, competitiveness and impact of research and education in the field of measurement and information systems.

Compared to the outcome of the previous programme, the quantitative targets of the new programme are to double international funding of the centre and increase corporate funding by about 30%. A further aim is to establish at least six new companies and commercialise at least four technologies developed at CEMIS. The impact goals of the programme recognise national strategies, including key Finnish government projects, the programmes of EU Regional Development Funds, and the Implementation Plan for the Kainuu Regional Program (TOPSU 2017-2018). The objectives of the current CEMIS programme are as follows:

- Reducing carbon dioxide emissions by developing bioenergy generating solutions and improving efficiency in the mining industry
- Reducing environmental pollution from industry by developing water management solutions for the process and mining industries
- Establishing new spin-off companies and generating new business for existing companies
- Increasing international business opportunities for technology companies in the Kainuu region
- Maintaining the status of Kajaani as a centre of expertise in measurement technology
- Strengthening the status of Vuokatti as an international training, coaching and research centre for skiing sports
- Reinforcing the role of Kajaani and Sotkamo as an expertise cluster in the field of wellbeing measurement technology

The programme implements joint technology development projects

in engineering and application fields that provide key support for local business, and develops joint operations for implementing device solutions. It also implements marketing and communication functions and promotes commercial exploitation of research and development project outcomes. The two-year programme mainly relies on funding from the East and North Finland ERDF program, with a total budget of nearly EUR 3.4 million. A steering group comprising representatives of CEMIS members, financiers and companies guides the programme and its projects. The programme is divided into three development packages: new technologies for sustainable biofuels and mining, new technologies and services for sports and wellness, and international R&D, technology transfer services and technology demonstrations. Development of educational activities also continued in 2017 through the three-year Simulator and Game Competence in Educational Development project (SIMPPELI) launched under the previous development programme.

Four new development programme projects were launched in 2017, with one project also completed from the previous development programme:

1. *New Processes and Measurements for the Bioeconomy and Mining Industry (BIOMIT)*

The BIOMIT project seeks to reduce industrial carbon dioxide emissions by developing measurement solutions for optimising bioenergy generating and mining processes. It also seeks to reduce environmental impacts by developing solutions for water management in the process and mining industries, and new methods for efficiently using biomass and sidestreams in Kainuu according to the principles of a circular economy.

The project was carefully prepared with the largest companies operating in Kainuu (Terrafame Ltd., St1 Group, Valmet Automation Ltd., KaiCell Fibers Ltd.) and a notable regional SME group (Aquaminerals Ltd., Prometec Ltd., Teollisuustaito Ltd., Meoline Ltd., Sotkamo Silver Ltd., Mondo Minerals B.V. Branch Finland, Nordic Biorefinery Ltd., Koneistamo Alm Ltd., Kuhmo Ltd., Kajaaniwood Ltd., Infraserwing Ltd., EHP Environment Ltd., Otanmäki Mine Ltd., Tieto-Oskari Ltd.). These companies are also committed to funding the project and serving as technology testers for innovations developed during the project.

The project activities are divided into four work packages:

1. Reinforcing and developing digital modelling and simulation skills
2. Real-time monitoring and competence development
3. Piloting measurement solutions
4. Predictive measurement solutions, and control of measurement data and its reliability
5. Administration, communication and preparation for commercialisation

The most important goal of the project is to develop and pilot some four to five technologies that will enable companies to create new industrial processes for the Kainuu bioeconomy. The measurement technology will also be used to streamline existing industrial processes, thereby boosting the emergence of less carbon-intensive processes in industry.

The total project budget of EUR 924,531 is mainly channelled through the Regional Council of Kainuu (ERDF funding). The project leader is the Measurements Technology Unit MITY at the University of Oulu, and the other participants are VTT and CSC.

2. *Novel Environmental Measurements for Mining and other Industry Effluent (KAIMIT)*

KAIMIT seeks to implement new measurement solutions for monitoring sulfate and phosphate concentrations in wastewater from industrial plants. There are currently no cost-effective and reliable methods for small sulfate and phosphate concentrations on the market. This project is developing approaches based on electrochemical and optical methods, and demonstration equipment for field measurements that will be piloted at industrial sites. The project also seeks to increase communication between equipment manufacturers, system integrators, end-customers and public authorities concerning the prospects for real-time measurements.

Project implementation involves five work packages:

1. Real-time monitoring and competence development
2. Piloting measurement solutions at fixed measurement points
3. Piloting measurement solutions on a waterborne vessel
4. Preparing the commercialisation of developed measuring devices, measuring solutions and modified sensors
5. Administration and communication

The project will yield new technological solutions for subsequent commercialisation through corporate R&D projects. Some 2 to 3 technologies will be developed and piloted for real-time measurement of sulfate and phosphate in industrial effluent. These technologies may be used to build systems for efficiently monitoring environmental conditions, optimising cleaning processes and preventing environmental pollution.

The total project budget of EUR 399,707 is mainly ERDF funding channelled through the Centre for Economic Development, Transport and the Environment for Northern Ostrobothnia (ELY Centre), with the Measurements Technology Unit MITY at the University of Oulu responsible for implementation.

3. *New Sport and Wellbeing Technologies and Services (LIKUTPA)*

LIKUTPA seeks to produce measurement solutions that will allow people to self-monitor their health and wellbeing, facilitating the evolution of public health care towards remote and self-diagnostics, and boosting top-level sport in Finland through testing services, improved training facilities and new sport technology business operations. Using sensor and simulator solutions, the project applies measurement and testing approaches in sports, wellness and health care applications. The main project goals are to develop and pilot modern demand-driven applications, and to create a knowledge base and capacities that will enable commercialisation of developed technologies and boost international co-operation.

The project work packages are:

1. Sports technology (intelligent ski sport equipment) and advanced athlete testing environments
2. Non-invasive sensors and measurements of wellbeing: smart homecare, self-monitoring of wellbeing, sport applications and sensitive health data
3. Serious games and virtual environments: real video as part of virtual environment training and big data analytics
4. Business development, project and company co-operation
5. Co-ordination, management and communication

The project is integrating at least one sensor solution into sports equipment as a prototype, implementing a sensor solution for testing biathlon shooting performance, and creating a virtual training environment containing one top-level ski track from the Pyeongchang 2018 Olympic Games developed using either real-time video, 3D modelling or a combination of these approaches. In the field of health care, the project is piloting an intelligent homecare system demonstration in realistic operating environments. The quantitative goals of the project are to establish two new sports or health technology spin-off companies, create two new commercialised technologies for existing businesses, and publish four scientific articles and one doctoral dissertation. The project also aims to prepare two new international projects on sports, health or wellbeing measurements, and set up 2 to 3 health and wellbeing measurement projects and one follow-on project for virtual reality technology.

These projects will seek funding of EUR 2.7 million.

The total project budget of EUR 1,431,000 is mainly channelled through the Regional Council of Kainuu (ERDF funding), with the University of Jyväskylä serving as project co-ordinator and implementation involving all other CEMIS participants: MITY, KAMK, VTT and CSC. The project is strongly linked to a KAMK International Technology Business project, particularly in work package 4.

4. *International Technology Business (KANTELI)*

KANTELI is developing an operating format that can effectively promote the emergence of international business primarily in Kainuu and also in North Ostrobothnia. The project seeks to create new spin-offs, connect start-ups with existing companies, and increase international business opportunities for early stage technology businesses. Implemented by KAMK, it supports all CEMIS participants through parallel CEMIS development projects (BIOMIT, KAIMIT and LIKUTPA).

The project comprises two parts, the first of which brings together a group of specialists focused on developing international technology business operations at KAMK based on the expertise of the current CEMIS Business Development (CBD) team and specialists from Measurepolis Development Ltd. that merged with KAMK in 2017. The group supports the overall development of KAMK and CEMIS international operations, commercialisation of CEMIS R&D results, and the international business operations of start-up companies operating in the region.

The second part of the project will implement two technology demonstrations to test and promote the potential of the international technology business. The first of these demonstrations is a cost-effective, environmentally friendly solution for removing arsenic from water, and the second concerns nutrient removal and recovery from water. The demonstrations are based on technologies with commercialisation potential for CEMIS operators and on the expertise of newly started companies and new spin-off ventures established

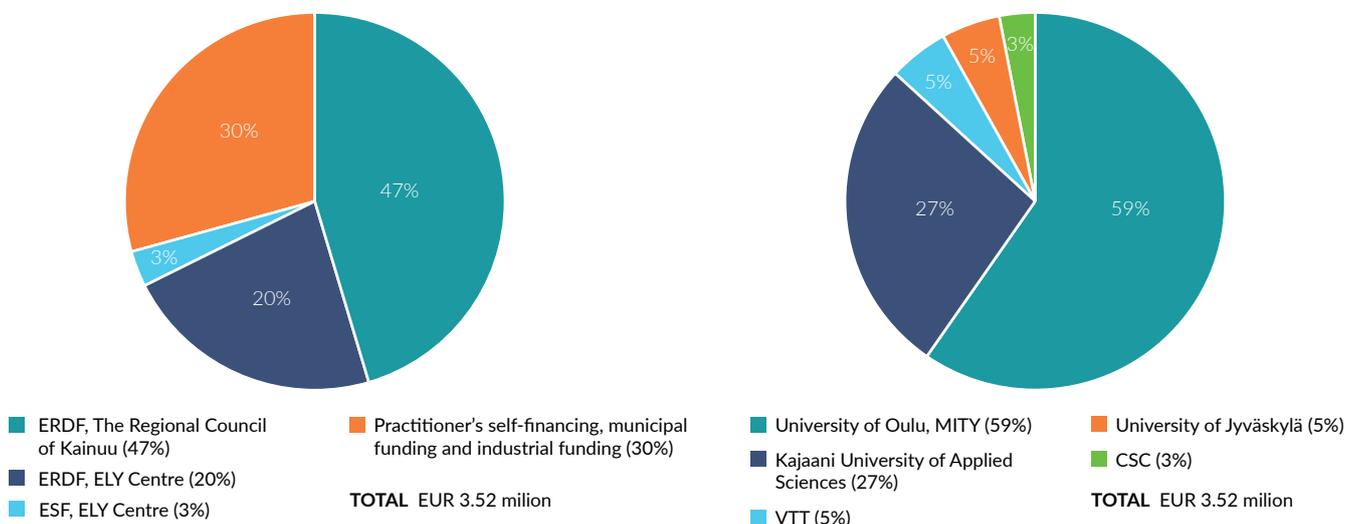
during the project, complemented by solutions from other companies in the business field. The demonstrations will be implemented in an international operating environment.

The quantitative goals of KANTELI are to identify at least ten technologies with commercialisation potential from CEMIS operators and their networks, to establish at least four new spin-off companies, and to commercialise at least four technologies for business use. A further aim is to facilitate the globalisation of CEMIS members and partners by jointly exhibiting at selected international fairs, by producing printed and digital marketing materials, and by participating in international technology business events.

The total project budget is EUR 550,860 channelled mainly through the Centre for Economic Development, Transport and the Environment for Northern Ostrobothnia (ELY Centre) with ERDF funding. The project will be implemented by KAMK, and involves separate investment in the KAMK laboratory granulation apparatus used for technology demonstrations.

5. *Simulator and Game Expertise Application in Teaching (SIMPPELI)*

In addition to the four new projects launched in 2017, the SIMPPELI project (Simulator and Game Expertise Application in Teaching) continued from the previous CEMIS Development Programme, seeking to respond to the evolving need for skills in the Kainuu region by developing new teaching content for the KAMK Smart Systems curriculum. This involves using simulator and virtual environments and gamified assignments more effectively in teaching, and developing Master's level courses in game education. Project activities reinforce the skills of teaching staff and improve the work-related skills of students by increasing the project aspect of their study programs. The project measures also seek to strengthen collaboration between R&D staff, teachers and KAMK stakeholders. Funding for the SIMPPELI project totalled about EUR 155,000 in 2017, mainly channelled through the Centre for Economic Development, Transport and the Environment for Northern Ostrobothnia (ELY Centre) from ESF sources.



ELY Centre: The Centre for Economic Development, Transport and the Environment for Northern Ostrobothnia

Figure: Breakdown of 2017-2018 CEMIS Development Program by participant and funding source.

Results of the Development Programme in 2017

The results of the CEMIS Development Programme will be reviewed in accordance with CEMIS focus areas and development sectors:

1. Measurement solutions for the process industry, bioeconomy and mining (Cleantech)
2. Measurement and testing solutions for sports, wellness and healthcare applications (Sports and Wellbeing)
3. Development of international technology business operations
4. Developing teaching with new technology solutions.

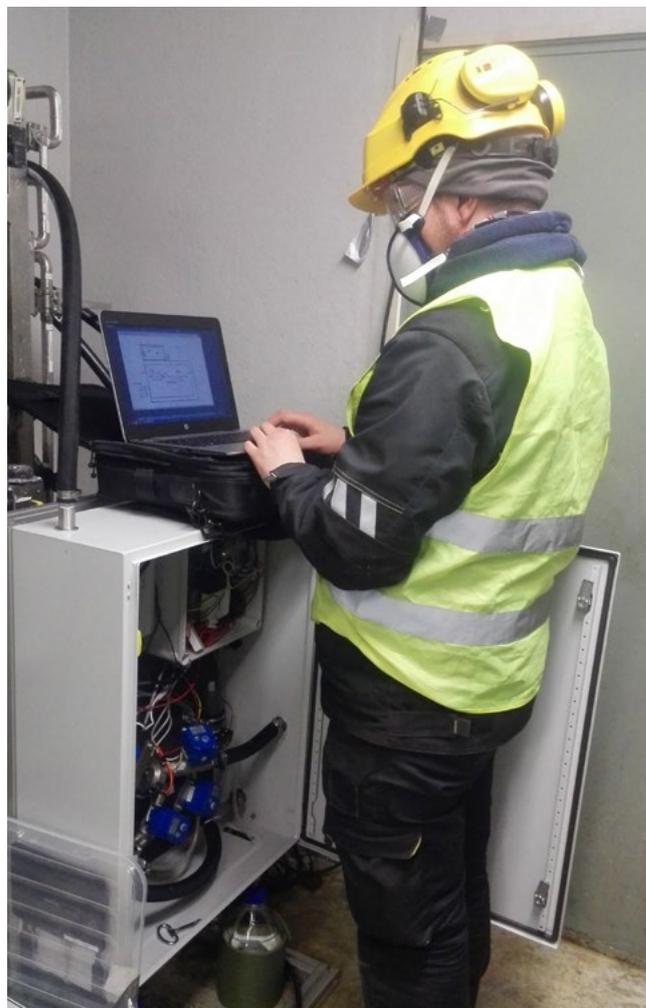
Measurement Solutions for the Process Industry, Bioeconomy and Mining

The BIOMIT and KAIMIT projects have continued to develop new measurement solutions for the process and mining industries. MITY and VTT have further enhanced their expertise in modelling and simulating complex systems and phenomena using COMSOL Multiphysics and OpenFOAM software, and this expertise will be applied in such fields as sensor studies of electrical conductivity and electrochemistry, and in determining mass characteristics from flows.

In the field of optical measurements for the process industry, direct real-time continuous spectrum measurement was developed using NIR technology (Near-Infrared) with industrial samples in a laboratory environment. A new type of NIR probe was also designed, built and tested for difficult samples and tough conditions. A new, independently operating and continuous NIR measuring instrument was built into the process sidestream based on the laboratory tests. This instrument performed successfully in field measurement cycles in the paper, pulp and mining industries, in demanding process conditions, and almost completely under remote control (Figures 4.1 and 4.2).



Picture 4.1. The real-time NIR measuring device developed by MITY in the industrial pilot test.



Picture 4.2. Mikko-Petteri Pikkarainen adjusts NIR measuring equipment in an industrial pilot test.

The BIOMIT project developed electrochemical measurements for arsenic using various buffer liquids such as phosphate, acetate, potassium nitrate and hydrochloric acid. Sensor surfaces were also developed to enhance measuring sensitivity. Measurements were made in the laboratory using arsenic reference samples. See Figure 4.3.

Supercritical fluid extraction (SFE) has been developed and tested for use in processing wood sidestream samples. Analytical methods were further developed for off-flow samples in the sidestream using gas chromatography techniques (GC-MSD and GC-FID). It was concluded that SFE is a promising technology for processing sidestreams in the forest industry, providing a basis for analysing and further developing the analysis of raw material extractives. The results formed the basis for planning a follow-on project that will use the results already obtained and pilot the extraction on a larger scale at Tekes (now Business Finland) in an ERDF call with six companies. The project received a positive financing decision.

The KAIMIT project initiated tests for reference measurements of aqueous sulfate concentrations by capillary electrophoresis (CE). The sulfate samples were subsequently measured in the laboratory using a wide range of optical and electrical methods, including refractive index, electron conductivity and UV spectrum. Measurements were made on factory samples with interfering agents added. The

measurement data were analysed using the multi-measuring principle with promising results.

Technical implementation of the BIOMIT and KAIMIT projects has been accompanied by preparations for various new project applications that will be submitted to Business Finland, the EU Horizon 2020 programme and other funding sources. Active co-operation and dissemination has also continued with businesses. Several offers for contract research and innovation commercialisations have been prepared under the BIOMIT project. The projects and its results have been presented at several events, including Environmental Monitoring Day in Helsinki and a seminar on Environmental Protection in Mining in Oulu.

Measurement and Testing Solutions for Sports, Wellness and Healthcare Applications

The results of this development area have been implemented in the LIIKUTPA project in four work packages (WP).

SPORT TECHNOLOGY & ADVANCED TEST ENVIRONMENTS (WP1)

This work package focused on developing new types of measurement solutions for integration into sports equipment in partnership with VTT, KAMK and JYU. A new version of the force sensor for a ski pole was developed to meet the needs of athlete testing and skiing research. The requirement specifications were compiled on this basis over the year, with the most suitable sensor technology selected for continuation. The work also involved designing and testing small preamplifier cards in the laboratory. Preamplifier card design work was also involved in the sensor assembly applied in developing roller ski force measurements. Sports equipment manufacturers may be expected to use this measurement solution in future. On completing the sensor specification for the biathlon shooting test, a preamplifier card was designed and installed to measure the shoulder pressure of the rifle. The goal is to apply sensors and measurement to support the development of biathlon shooting involved in the (ERDF-funded) JYU "New feedback systems for biathlon" project.

To determine the propulsion component of skiers, a computer vision application for automatically calculating the pole angle was developed at CSC to requirements specified by JYU. Automatic calculation enables more precise but flexible analysis of skiing technique. A plausible ambition is to integrate the developed application into the Coachtech coaching feedback system developed by JYU in Vuokatti. Automated calculation also supports sports research, as already applied by JYU in a 2017 international ski slipstreaming wind tunnel study in Sweden (Figure 4.4). Other targets have also been identified for this application, with work on these to continue over the following year.

The focus in skiing equipment testing development was to improve the measurement signal of the ski tester and design modifications to the testing frame at VTT and JYU. The tester was presented to a large number of international teams over the year, especially from the Far

East.

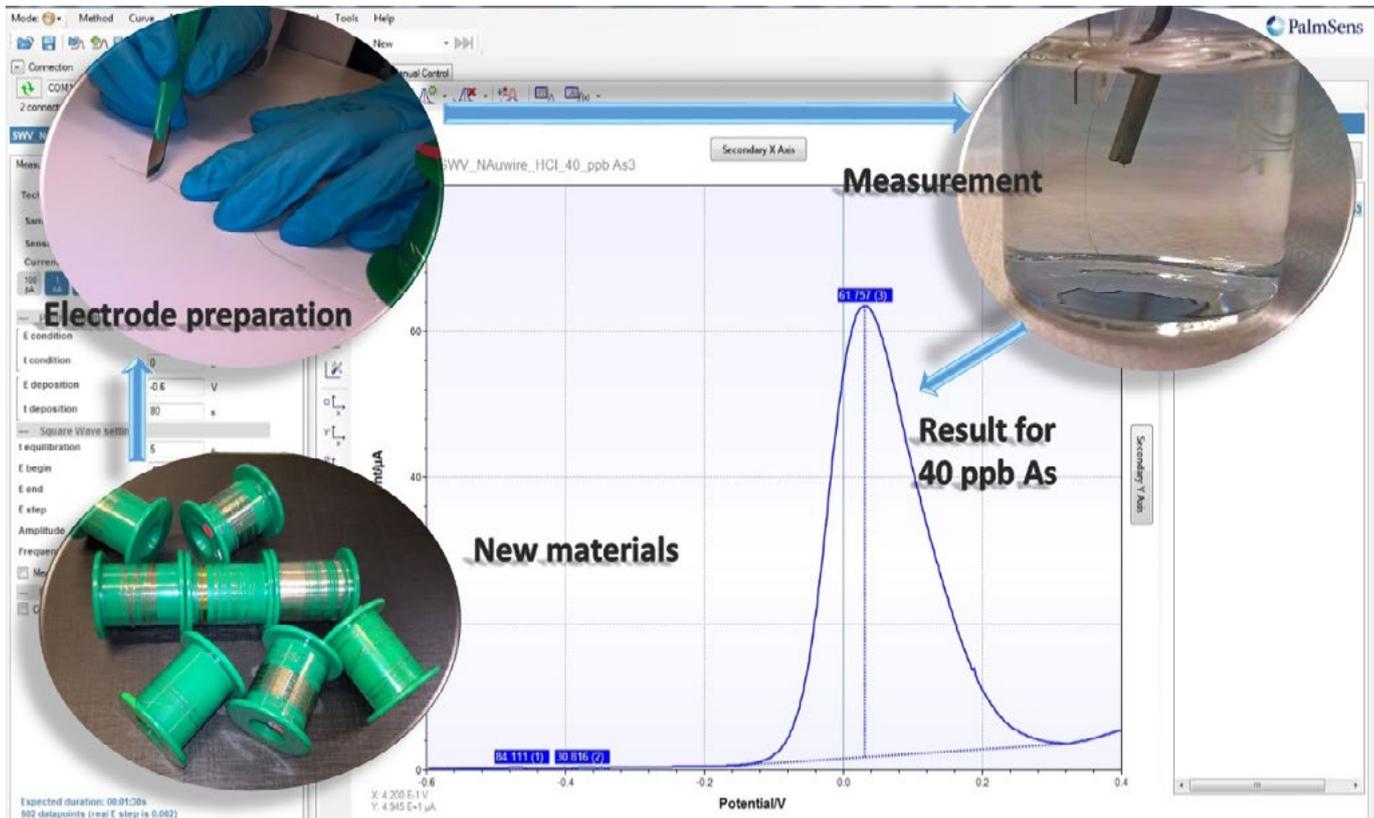
NON-INVASIVE SENSORS & WELLBEING MEASUREMENTS (WP2)

The clear aim in developing biosensors that measure nutrition and stress markers from saliva was to bring insulin measurement development work to the stage of industrial manufacturing trials and piloting. Measurement sensitivity increased over the year, and is now sufficient for quantitative (i.e. low-high) measurement of physiological insulin concentrations. Determining high and medium concentrations is most essential for health monitoring in practice. Some work was done with cortisol and lactate measurements in the field of developing stress/workload marker assays. Basic research methods were deployed for developing a wearable lactate sensor, with a view to working with a partner to produce a better sensor material for this purpose. Cortisol sensor development work compared the performance of various types of immunoassay (competitive and non-competitive, direct and indirect) in a rapid-test biosensor.

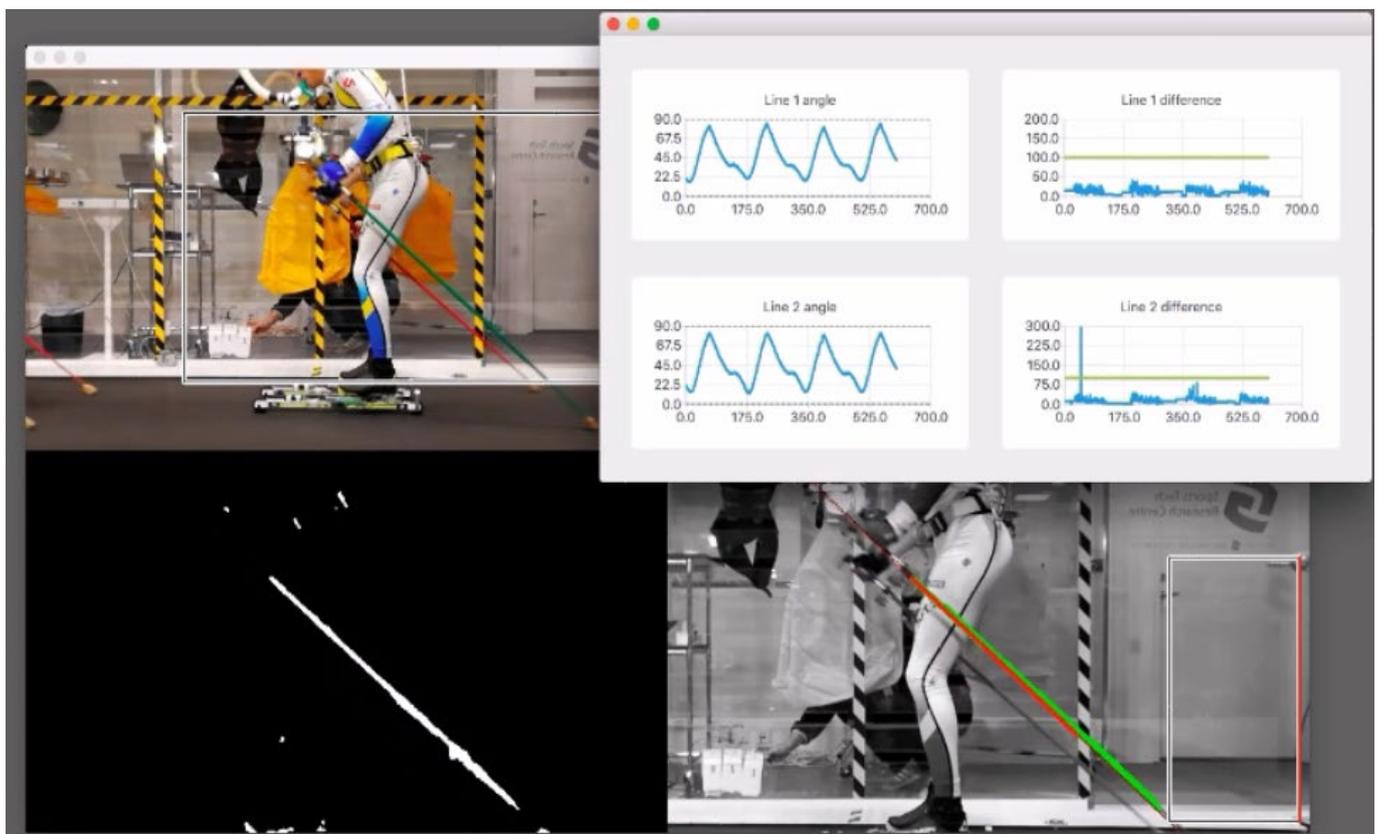
Two new initiatives arose in commercial collaboration, one of which resulted in concluding a significant supply contract with a new customer. Academic collaboration was strengthened with the Faculty of Information and Electrical Engineering and the Faculty of Medicine at the University of Oulu. The university approved separate proof-of-concept funding for initiating co-operation with researchers in the Circuits and Systems (CAS) unit of the Faculty of Information and Electrical Engineering. Significant efforts were made to prepare follow-up projects benefiting from the groundwork done in the development programmes, with four national and two international research funding applications prepared during the year, two of which secured funding (a third successful application had already been prepared in the previous year). New partners played a significant role in preparing these applications, and particularly in the field of international co-operation, project preparations launched in partnership with the National Public Health System (NHS) in Scotland may provide interesting opportunities for using and commercialising expertise from Kainuu.

Digitisation of the metrics for the National Early Warning Score (NEWS) was selected as a development target for a demonstration system implementing the theme of intelligent homecare. NEWS is a scientifically validated method used in many countries for predicting the need for care, and its use is also gradually increasing in Finland. The metrics provide an estimate of the need for treatment based on six parameters: body temperature, heart rate, blood oxygenation, respiratory rate, blood pressure and level of consciousness (subjective assessment). The development of the NEWS system proceeded consistently from technology study and architecture design to the implementation of various system components. KAMK took charge of this work.

Work on sensitive data processing was launched in December when CSC organised a seminar for project organisations and regional business partners. Some 30 people attended the seminar, which was addressed by speakers from CSC, MITY and KAMK.



Picture 4.3. Development work for real-time measurement of arsenic.



Picture 4.4. Machine vision application for calculating the ski pole angle.

SERIOUS GAMES & VIRTUAL ENVIRONMENTS (WP3)

Simulation of a real environment in athletic testing: a simulation environment of the sprint track from the Pyeongchang 2018 Olympics was completed in summer 2017. The operating principle relies on a video-based virtual environment that operates synchronously with the control of the treadmill-based ski simulator, adapting to the speed of the skier on the treadmill. The first tests of the environment were performed with six sprint skiers from the Finnish national team, who also participated in a usability survey for the environment. Feedback was mainly positive, with valuable ideas obtained for improvements and further development. JYU was responsible for developing the simulation environment in partnership with the Finnish Research Institute for Olympic Sports (KIHU), with KAMK arranging the usability survey.

Accelerating the design of virtual route modelling: This segment sought out and tested new instruments for 3D modelling of sports routes and event areas. The work drew on the expertise of KAMK, CSC and JYU. It began by studying the photogrammetry method, which creates 3D models from digital photographs. KAMK then licensed commercial photogrammetry software and acquired a professional remote control camera drone, conducting several test runs on sports routes and event areas in the latter half of 2017. Computational experiments began at this time with a view to creating 3D models from aerial photographs using photogrammetry. The prospects for high-speed 3D modelling appear promising in various fields of application.

Presenting real-time data in athlete testing: LIIKUTPA continued developing a testing system for athletes, following on from promising results achieved in the previous CEMIS programme. Development of the skiing wall system focused on improving functions and user friendliness, and on diversifying the athlete testing process. The usability testing period for the system ended in summer 2017, with further development incorporating feedback from users.

BUSINESS DEVELOPMENT AND PROJECT AND COMPANY CO-OPERATION (WP4)

Both national and international R&D co-operation on project themes were promoted as a part of the work package through co-operation negotiations and project preparation, with two co-operation agreements accordingly concluded with Fennogate Oy (Kuopio) and Sartorius Biohit Liquid Handling Oy (Kajaani). MITY served as the CEMIS partner in these agreements. Four favourable decisions emerged on national project funding (one for KAMK, three for MITY) and one service sales project agreement based on IoT solutions was concluded for KAMK with a local company. In partnership with the KAMK KANTELI project, the Coachtech coaching feedback system was selected as the JYU technology promising the greatest commercialisation potential. Coachtech has already been tested for several sports in Finland, and has also attracted interest from abroad. KAMK completed a commercialisation study of Coachtech and some marketing materials development work was also outsourced. Responding to the challenge of stimulating new business in the Kainuu region, JYU and the KANTELI project jointly launched the

design of a business skills course for inclusion as an optional course in the JYU Sports Technology Master's degree programme in 2018.

International Technology Business Development

The international technology business of CEMIS has mainly developed through the work of the CEMIS Business Development Unit (CBD) under the KANTELI project. This project completed several commercialisation studies of CEMIS technologies in 2017 (5 extensive studies and some smaller investigations) to promote the development of KAMK virtual (VR) and augmented reality (AR) solutions, and commercial development of JYU sports and wellness technology.

Networking, sharing information and marketing the technologies of CEMIS members and partners have played a significant role in international operations. The most noteworthy international events included the Perumin 2017 fair and the Ecotech 2017 event (Kazakhstan) for the cleantech and mining sector, and a presentation of CEMIS water expertise at the China Europe Water Platform (CEWP) ministerial level conference in Turku, Finland. The CEWP event was an initial step for CEMIS towards the Chinese market and contacts, and this work will continue in 2018.



Picture 4.5. Eirich RV05 granulation equipment at KAMK.

An investment in Eirich RV05 laboratory scale granulation equipment (Figure 4.5) was completed as planned under the KANTELI project. The apparatus was installed in the new KAMK Industrial Engineering laboratory. Granulating minerals and industrial sidestreams is an important part of research at KAMK and of the operations of several KAMK partner companies. The fully commissioned apparatus has already been used in several research projects and training activities at KAMK, including KANTELI project demonstrations. It has also been available for local companies to use with their own products free of charge. Industrial use of the apparatus will continue with new companies and products.

Developing Teaching with New Technology Solutions

The three-year KAMK project SIMPPELI (Simulator and Game Expertise Application in Teaching) was completed at the end of 2017 under the general objectives of 1) improving the quality and content of KAMK teaching, 2) responding to changing skills requirements in the Kainuu region, 3) developing new technology-based teaching content, and 4) enhancing the skills of teaching staff. A further aim was to strengthen co-operation between teaching staff, laboratory staff and KAMK stakeholders.

The specific objectives derived from the general aims were 1) comprehensive use of simulation and computer game skills and environments in education, 2) development of a Smart Systems curriculum to serve the needs of the business sector, 3) systematising the development of serious games and improving their integration into teaching, and 4) developing content and implementation plans for Master's degree project courses. Project outcomes for content, operating models and educational solutions were expected to be of high quality, modern and practical, and accordingly capable of supporting a more effective transition of students from education to the world of work.

Nine demonstration implementations were developed in Work Package 1, based on computer game expertise and gaming environments. Each implementation involved the work of a teacher responsible for producing the teaching content and a game development team responsible for technical implementation. The game environments created in SIMPPELI are listed below, and are all freely available for downloading at www.cse.fi.

- Case 1: A game application for assessing the safety aspects of homes for the elderly (SIMPPELI Safety)
- Case 2: A virtual environment for enhancing nursing learning situations (SIMPPELI Visualisation)
- Case 3: 360 video imaging in teaching service design and customer space assessment (SIMPPELI Service Design, operating model)
- Case 4: An educational game for visualising physical changes in ageing (SIMPPELI Aging)

Case 5: Virtuality and gamification in language teaching (Goofy Game Guide)

Case 6: An educational game for reading comprehension and information retrieval (SIMPPELI Data Breach)

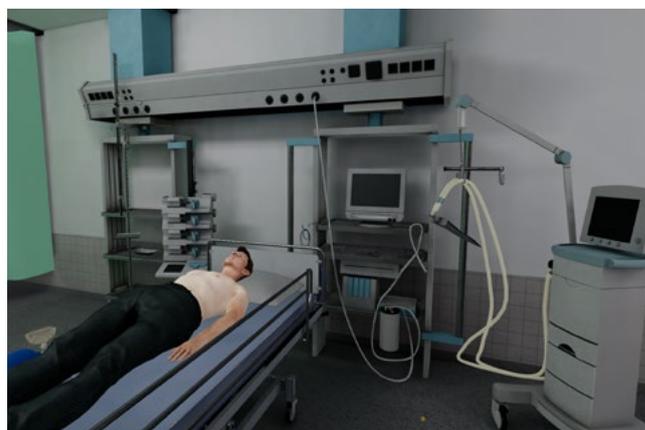
Case 7: A simulated environment for training and teaching cardiopulmonary resuscitation (SIMPPELI CPR). See Figure 4.6.

Case 8: Applying 360 videos in teaching robotics environments (SIMPPELI Robotics). See Figure 4.7.

Case 9: Motion platform and simulation technologies in game development education (course content and control interfaces for motion platforms)

Work Package 2 comprised conceiving and producing application field-specific project-based teaching packages and state-of-the-art course content for the Smart Systems curriculum. The project incorporated wishes and expectations for course content from the world of work. Development measures focused strongly on vocational and project studies: course content, exercise tasks, laboratory assignments, learning platforms, new technologies and enabling distance education. Intelligent technology, sports and gaming, intelligent environments, smart solutions for physical activity and wellbeing, and intelligent industrial measurement applications and solutions were selected as subjects for vocational studies. The content and implementation of foundation studies were also revised in parallel with vocational studies. Training for teaching and project staff was also arranged during course content implementation, focusing on key themes of the Smart Systems curriculum and on developing learning environments.

A Smart Systems learning platform was introduced and included in Smart Systems teaching from the first year of studies to demonstrate the concept of from-sensor-to-cloud. This simple, easy-access platform seeks to give students a clear understanding of the architecture, design and development of an intelligent system over the entire process from measurements to user interfaces. These measures have modernised the Smart Systems curriculum, making it better suited to the demands of the world of work. The beneficial impact of the project outcome is evident in the offering and quality



Picture 4.6. Simulated environment for training and teaching cardiopulmonary resuscitation.

of Smart Systems education, in the enhanced competence and skills of teaching staff, and in greater versatility of learning environments.

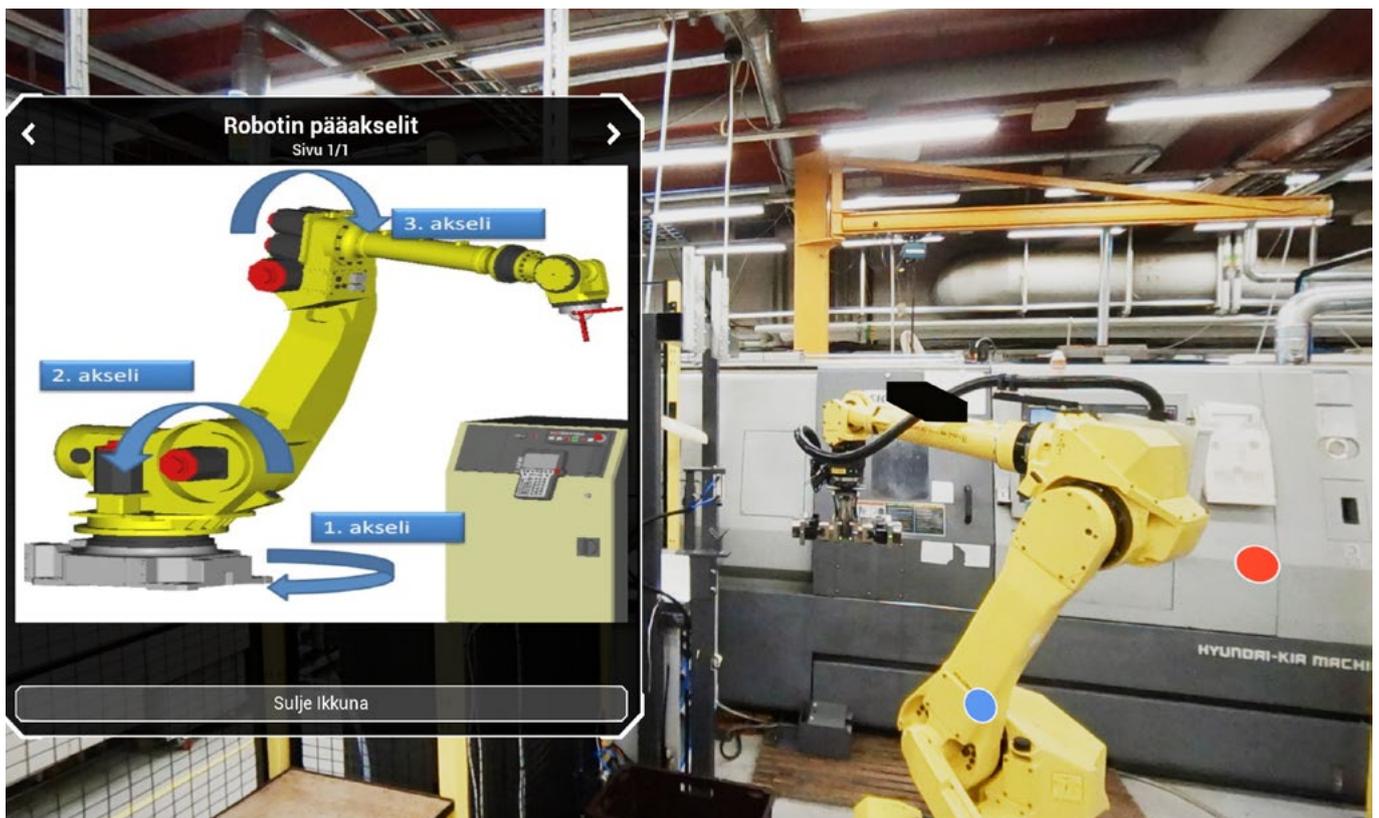
Work Package 3 developed an operating model for systematically processing serious game ideas and pursuing their development in student projects. A serious game is one primarily designed for purposes other than entertainment. The SIMPELI project involved implementing about 10 student projects for serious games, some of which remained as unfinished concepts while the rest were successfully completed. A couple of applications created in student projects were transferred to companies for further development. This project also increased the number of work-related serious game projects led by students.

Examples of successful implementations in the SIMPELI project include:

- A gamified resource management application: graphical user interface and database
- A simulation environment for testing and controlling industrial robots
- An instructive game for social services staff working with immigrants

Work package 4 implemented a master-level online course to expand the range of game education available at KAMK. The distributed game development project is an online course for the Moodle platform suitable for time and place-independent learning, enabling team members to be at various physical locations. The course was piloted as an in-house gaming project at KAMK and at a summer

school attended by both Finnish and foreign students. The project also led to an agreement with the University of Oulu approving game development summer school studies at KAMK for credit towards university studies in Oulu. This established conditions for gaining a Master's degree from Kajaani, encouraging leading university-educated talent to remain in the region. The distributed game development project will form part of future game development studies at KAMK, together with the international game studies that are mainly pursued at the summer school.



Picture 4.7. Applying 360 videos in teaching robotics environments.

The Operations of the University of Oulu

The Measurement Technology Research Unit, MITY, of the University of Oulu continued its work based on two research groups: Cleantech and Health and wellbeing. The unit is based in Kajaani, but also conducts project activities in Vuokatti.

The main application areas of the unit's research in 2017 were bioeconomy (renewable forest industry, bioenergy, use of forest biomass), cleantech (process and environmental applications, especially in mining) and health and wellbeing applications (development of biosensors, nutrition, and development of the Vuokatti area).

A temporary senior research fellowship in optical imaging technology continued in 2017 and was jointly financed by optoelectronics laboratory projects in Oulu and project funding from the Kajaani Unit. Both research teams included postgraduate degree students.

The total volume of unit operations was some EUR 3.5 million. A staff of 50 employees over the year accounted for some 41 person-years of work. The eleven staff members holding a doctoral degree performed 24 per cent of this total workload.



Picture 5.1. One major research field of MITY is the use and processing of Finnish natural resources. This research also studies berries and the valuable ingredients that they provide.

International Project Activities

MITY was involved in three international projects. It participated in the EUROMBR Marie Curie ITN (Initial Training Networks) project under the EU FP7 PEOPLE program with 12 partners from 8 countries. This project developed expertise in micro-bioreactors and provided resources for one foreign doctoral thesis employee. The unit also took part in the Eco-Innovation segment of the EU Entrepreneurship and

Innovation Programme (EIP) through the Envimon project studying the monitoring of metallic environmental emissions from industry.

MITY was also involved as a measurement method developer in the WATER-M project of the EU EUREKA cluster ITEA 2 programme, seeking to modify water management operating systems and services. Several companies and research institutes from Finland, France and Turkey took part in this project with a view to ensuring safe water for domestic use under all circumstances. The Finnish contribution to this project was financed by Tekes (now Business Finland) in 2014 – 2017, with MITY co-ordinating the associated work of the University of Oulu.

CEMIS co-operation

The work of CEMIS continued in 2017 with new CEMIS Development Programme projects:

- BIOMIT - New processes and novel measurements for the bioeconomy and for the mining industry: This project focuses on developing measurement and pre-treatment solutions for the bioeconomy, mining, forest and paper industries to improve efficiency and decrease toxic environmental discharges. The main outcomes of the project are developing and piloting some 4 to 5 technologies that improve industrial process control and reduce toxic discharges, enabling new private enterprise in the field of bioeconomy in the Kainuu region. The University of Oulu, VTT and CSC will implement the project.
- KAIMIT - New environmental measurements for mining and other industrial effluent. This project focuses on developing real-time measurement technology solutions for determining the sulfate and phosphate content of industrial effluent. Electrochemical sensors and optical methods (multi-parameter analysis) will be applied to develop real-time monitoring tools for measuring low sulfate and phosphate concentrations. Demonstration instruments will be constructed, with performance verified in field studies with industrial operators. The project will produce

innovative technological solutions that can be commercialised through new business R&D projects.

- LIIKUTPA - New sport and wellbeing technologies and services. This project seeks measurement and test solutions that will allow people to monitor their own wellbeing and health, improve the use of remote or self-diagnostics in public healthcare, and develop top-level sport and the sports technology business in Finland. The project is a joint endeavour of all five CEMIS member organisations.

The CEMIS Development Programme has further strengthened the region's expertise and co-operation between the Universities of Oulu (MITY) and Jyväskylä, and collaboration between the University of Oulu and VTT through Business Finland and regionally financed projects. Director Vesa Virtanen participated in the work of the CEMIS Strategy and Management Groups. The University of Oulu unit is clearly the largest single research operator in the CEMIS Development Programme.

Other Project Activities

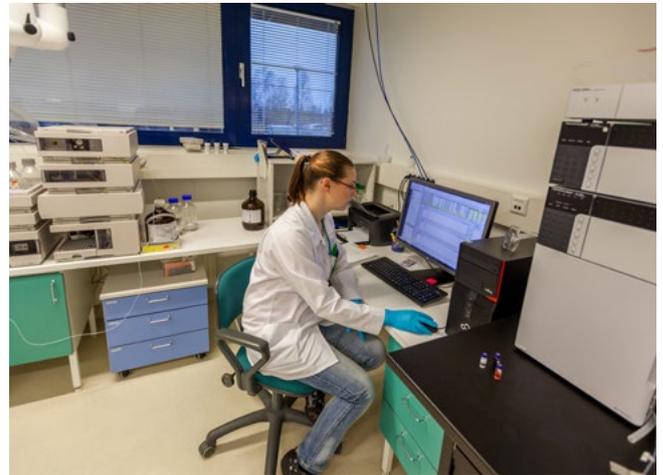
MITY was involved in seven projects funded by Tekes (now Business Finland) in 2017.

1. MPA (Business Finland TUTLI funding): optimising bioethanol production with a versatile process analyser
 2. ICEMET (Business Finland TUTLI funding): Icing condition management in generating wind energy
 3. Water-M (ITEA2 EUREKA cluster Programme): developing an intelligent water supply system
 4. PULU (Business Finland TUTLI funding): Refining high value lingonberry compounds for a global market
 5. CRYSTAL (Challenge Finland funding from Business Finland): New computer-aided solutions for detecting symptoms of ocular disease
 6. SIMP(DIMECC programme): Systems Integrated Metal Processes
 7. Extream (Business Finland regional funding): extracting valuable compounds from industrial sidestreams in the bioeconomy
- In addition to the CEMIS development program and the Tekes projects, MITY had 19 other projects in progress. There was cooperation with both the Kainuu region and with more than ten companies in the country.

Besides the CEMIS Development Programme and Tekes projects, MITY operated 19 other ongoing projects, pursuing industrial collaboration with dozens of companies in the Kainuu region and nationally.

The Kajaani Lab project sought to create a laboratory learning environment to enhance staff skills, increase the number of specialists and the scope and quality of research services, and improve the use of infrastructure through additional staff training. Expertise was gained in health technology, in using various printing methods for biosensor surface materials, and in sensor surface materials and

readers (see Figure 3) A further aim was to manage the widespread use of new modelling software. The training also provided staff with new biotechnical tools and a better capacity to apply and optimise pilot implementations and proof-of-concept stages. The project improved the ability of MITY to support the development projects and competitiveness of micro-enterprises and SMEs, supporting the start-up and development of biorefinery, bioenergy and mining industry ventures in Kainuu.



Picture 5.2. MITY has versatile laboratory equipment and specialised staff, whose expertise has been further enhanced through the Kajaani Lab project.

A project seeking to improve coaching at the Vuokatti-Ruka Sports Academy aims to build a simple and robust system for improved monitoring of physical strain, development and technique. The required testing blocks and evaluation feedback for this solution are also being developed for endurance sports athletes at Vuokatti and for alpine sport athletes in Ruka, together with instruments to support the work of coaches. The project involves collaboration between the University of Jyväskylä and Vuokatti-Ruka Sport Academy.

Analytical Services and Profitability of Biogas Production in the Kainuu Region (BITES 1 and BITES 2) is a project implemented in partnership with specialists from Measurepolis Development Ltd., which merged with KAMK in 2017. The aim is to boost biogas production in Kainuu with a broader raw material base, process competence and optimisation; to support the development of biogas business models and services in Kainuu focusing on the analysis of various types of biogas reactors; and to produce and acquire new information on biogas process operation and optimisation. The projects have developed analytics for monitoring the biogas process and the methods developed will be field-tested at a biogas plant in 2018.

A project entitled Management and Rehabilitation of Surface Water Bodies Receiving Mine Waters (KaiHali) seeks to develop expertise and business opportunities in managing mine effluent discharges to surface waters. This project is enhancing the forecasting and modelling of mine effluent mixing and dilution, and the resulting ecological and stratification effects in recipient surface waters. The project also addresses the accumulation of loading in aquatic sediments, the resulting changes in sediment geochemistry, and

the increased cost-effectiveness of sediment survey methodology. Use of an autonomous measurement vessel (remotely operated underwater vehicle, ROV) will be evaluated in this context. Project implementation is the responsibility of the Finnish Environment Institute (SYKE) serving as co-ordinator, together with the Geological Survey of Finland (GTK), KAMK and MITY.

The Drones in Water Monitoring and Sampling (DROMINÄ) project studies the use of Unmanned Aerial Vehicles (UAVs or drones) for water quality monitoring and sampling (see Figure 2) It studies new measurement and sampling strategies suitable for drones, and demonstrates their performance in measuring and sampling water quality and process water quality. The project was launched in spring and will be implemented through a partnership with the Finnish Environment Institute (SYKE) and the Geological Survey of Finland (GTK). Project financing comes from the Northern Ostrobothnia ELY Center (ERDF), Sotkamon Silver Ltd., Infrasuunnittelu Ltd., WND Solutions Ltd., Savo-Karjalan Ympäristötutkimus Ltd., and other participants.



Picture 5.3. MITY is studying the use of drones (Unmanned Aerial Vehicles, UAVs) in environmental measurement.

A project using CFD (Computational Fluid Dynamics) to model the dispersal of oil and metal discharges from mines and harbours (JaMit) is developing a continuous measurement method for simultaneously measuring discharges of oil, nickel and mercury. The project involves collaboration with the Environmental and the Chemical Engineering group (ECE) of the University of Oulu and Lappia Vocational College.

MITY and Kainuu Vocational College (KAO) are implementing projects under the heading of Improving the Quality and Safety of Natural Products (PALKO 1 and PALKO 2). These projects are developing new methods and gathering information to improve the quality and safety of the natural products that are used especially in the cosmetics sector. Selected quality control parameters are based on stricter legislation governing cosmetic compounds. This safety information is required before enterprises may release their products onto the market. PALKO 2 is also developing methods based on cell culture testing to study the activity of cosmetics. The PALKO 3 project at MITY will optimise these methods using various samples from business enterprises. The project includes ten natural product companies.

Funded by the Oulujärvi Leader association, the PAJU project is a small MITY study in which the Finnish Forest Centre serves as a consultant. This project is studying the use of young trees (willow, alder and birch) as a raw material for valuable compounds. The project findings will be applied in the unit's biomass-related research.

The KryoMikro project began in August 2017, seeking to study the prospects for applying two processing technologies, freeze concentration and microwave processing, which have not yet been used for industrial processing in Finland. The project studies freeze concentration and microwave processing using industrial samples, with the quality of the end product analysed in the laboratory. The costs of the equipment and processing will also be evaluated, meaning that enterprises will obtain comprehensive information on the commercial use of these processes.

A project entitled Applying smart specialisation in improving industrial competitiveness seeks to support local businesses in their development projects and to improve competitiveness by enhancing productivity, innovation and R&D.

The unit has also been involved in two proof-of-concept (PoC) projects funded by the Innovation office of the University of Oulu. The first of these concerns filtration and detection of microplastics, and the second relates to early detection of pancreatic cancer using a hybrid sensor.

Research Collaboration and Publications

Research collaboration with the School of Pharmacy at the Kuopio campus of the University of Eastern Finland (UEF) continued with a study of the dissolution process of medicines, resulting in a joint publication in the International Journal of Pharmaceutics. MITY has also worked with the Physics Department on the Joensuu campus of UEF. One recent co-operation theme has been optical identification of adulterated fuels. The findings of the study have been reported in a refereed paper with one writer, Boniphace Kanyathare, earning the Master's thesis of the Year award from TEK (Academic Engineers and Architects in Finland) and MAOL (The Finnish Association for Teachers of Mathematics, Physics, Chemistry and Informatics).

International researcher exchanges amounted to 42 person-months as planned. Active international co-operation targeted more than ten research institutions from countries including Italy, Denmark, Russia, the USA and the United Kingdom. The number of scientific articles produced was encouraging, with 13 refereed international scientific articles and 14 conference and other publications or presentations. Unit staff participated in international and national evaluation assignments (scientific magazine publications, pre-evaluation of Ph.D. theses, and assessment of international project applications). One commercialised invention was developed and two companies were established based on MITY research work.

The Operations of Kajaani University of Applied Sciences

Globalisation was a clear strength of Kajaani University of Applied Sciences (KAMK) in 2017. This is evident from the number of international project applications submitted, and from projects ongoing, direct contacts established, and a growing international profile. Growth in the service business was also significant in schools participating in CEMIS operations. Demand focused especially on industrial 3D simulations and virtual reality (VR) applications, in which KAMK was able to provide strong expertise due to its long history of game development education.

KAMK operations at CEMIS involved 3 areas of expertise in 2017: Information Systems, Mechanical and Mining Engineering, and CEMIS Business Development (CBD). CEMIS operations were also effectively linked to KAMK research, development and innovation operations (RDI) in the joint preparation of project applications. A significant change in the organisation of KAMK occurred at the end of the year when Rector Turo Kilpeläinen announced his move to a new position and was replaced by Matti Sarén, Ph.D.

School of Information Systems - Expertise from Sensor to Cloud

The School of Information Systems is a unit with 64 teachers and project workers and 574 students. The unit educates information and communication technology degree students (Bachelor of Business Administration) and information technology engineers (Bachelor of Engineering). There are three subject groups: Games and Game Technology (Games), Data Centres (DC) and Intelligent Systems (IS).



Picture 6.1. Demand for virtual reality (VR) applications in industry is growing. The KAMK School of Information Systems exploits strong game development expertise in VR application development.

The School is a highly successful unit even by international standards (attractiveness, study performance, impact, projects), achieving prominence and reputation especially through the successes of games students in various competitions. Key figures for 2017 were 47 university of applied sciences bachelor's degrees, 8 master's degrees, 8 publications, and external RDI funding totalling some EUR 850,000.

Information Systems continued its solid work of previous years on the project front. The sources of funding were ESF, ERDF, Tekes (now Business Finland) and Erasmus+. National projects included SIMPELI and LIIKUTPA under the CEMIS Development Programme, and ESports Center (ESR), electronic sports player testing and analysis services (Tekes, TUTLI), building the eUrho Electronic Sports Learning Environment (ERDF) and the Finland Education Centre in Vietnam (Tekes, BEAM). CEMIS member organisations, universities, colleges and companies were involved in these projects. This active collaboration with various bodies illustrates success in implementing regional development and co-operation with the world of work. The key development themes of projects conducted by Information Systems were VR/AR applications, 3D photogrammetry, serious games, education, technological solutions for sports and exercise, and laboratory services.

Information Systems staff were also involved in work to prepare international projects (H2020, NPA, Erasmus +, Interreg BSR) on the foregoing themes. In relation to the game industry, the School was invited to join an international consortium seeking to develop games to support tourism. International operations also draw support from eSports projects, for which the School received substantial funding in partnership with the Vuokatti-Ruka Sports Academy. These projects and their outcomes will bring a significant number of international visitors and customers to the Kainuu region. In the course of these projects, the School organised the first Nordic eSports Academy training in Finland, gaining more than 1,000 academic study credits and significant publicity value. The international NGS conference (Northern Game Summit, www.northerngamesummit.org) was also once again held in Kajaani on a larger scale than ever before, with more than 1,100 participants and visitors from 16 countries.

The Information Systems strategy process included updating the RDI and education roadmaps for the School in partnership with RDI and education services. The strategy work found that when developing the strengths of the School, gaming and measurement system expertise are naturally linked to data centre expertise, which forms the basic service for all School operations. The long tradition of measurement technology in teaching and business in the region combines with the integration of sensors, cloud services and games to yield innovations that create new opportunities for the region. Students will also be able to practice working in real-life specialist teams, thereby gaining much better skills for the world of work and a broader perspective on the settings in which they will subsequently pursue their careers. The overall core competencies of the School enable the implementation of advanced applications across various domains, including intelligent homecare, activity tourism, manufacturing technology and industry, and the service sector. There are countless opportunities for applying

game-like, gamified user interfaces that retrieve, analyse and control real-time cloud data inputs from various measuring devices and sensors.

The School of Information Systems was involved in promoting exports for several regional companies, with export promotion visits made to countries such as Ireland, Germany and Japan. The School also supported the planning and establishment of several start-up companies. In the field of service sales, Information Systems secured some EUR 24,000 in sales of testing services (weather, vibration, EMC) and some EUR 380,000 in software and hardware development services. Investments in hardware, software and environments totalled nearly EUR 80,000. Several key staff were recruited for the School in 2017. Three employees are completing doctoral degrees and bringing new knowledge and expertise to the entire School through their research.

The most significant new initiatives for the School in 2017 were eSports projects, innovations and application development in human biometrics, and acquisition of the Bull supercomputer from CSC at the end of the year.

Stronger International Project Expertise in Mechanics and Mining

The Mechanical and Mining Engineering competence area continued as a part of the education, research and service operations of the School of Engineering. The school awards degrees in Mechanical and Mining Engineering and in Construction and Civil Engineering. Its particular field of expertise is production systems. Key figures in 2017 included 38 graduates, 5 publications (3 of which were peer reviewed and scientific publications) and some EUR 800,000 in external RDI funding. An average of 32 staff members were divided roughly equally between teaching and RDI operations.

The competence area was involved in seven EU Horizon 2020 applications and some other international project preparations (ERA-



Picture 6.2. The Mechanical and Mining Engineering competence area at KAMK specialises in geopolymers and their novel applications, such as water treatment.

MIN and ERA-NET Cofunds) between 2015 and 2017. The Tekes-funded ERA-NET project BioFegg was launched in December 2017 with KAMK serving as co-ordinator and project partners including higher education institutions such as the University of Natural Resources and Life Sciences, Vienna (BOKU) and Luleå University of Technology, together with various industrial partners. The total project volume is EUR 1.2 million.

KAMK served as initiator in preparing several projects, and as co-ordinator for preparing initial applications, producing a significant number of application texts and assembling initial consortia members. After the preliminary stages applications have usually been assigned to a more experienced co-ordinator with better credentials. With respect to substantial contribution, the role of the Mechanical and Mining Engineering competence area in these project applications has been to develop geopolymer-based water treatment chemicals (adsorbents) for removing harmful metals and recovering nutrients and precious metals from industrial, urban and agricultural effluent (see Figure 6.2).

The competence area seeks to continue as an active international R&D operator by reinforcing its special expertise in developing geopolymer-based adsorbents for water treatment and, more broadly, by improving its in-house skills and competence in research and innovations involving geopolymer-based materials. The competence area has already identified about ten project calls for the ongoing final three-year period of the Horizon 2020 programme in which it intends to participate actively.

The volume of service business in the competence area increased substantially from the previous year to reach some EUR 90,000. Room for improvement still remains in this field, and KAMK is pursuing this together with all competence areas. For example common product cards are being prepared for services provided by KAMK to support service operations.

The most significant initiative of the competence area in 2017 was planning and marketing of education in the Raahe region, which significantly expanded the territory for student recruitment. Negotiations were initiated in January 2017 with the largest companies in the area, the City of Raahe and the Chamber of Commerce with a view to launching education in construction and civil engineering. Surveys and a needs assessment suggest a clear need to launch multiform education in January 2018. The groundwork for this was done in 2017, with KAMK receiving a record number (143) of primary course applicants through the joint application system in the autumn. The aim is to continue co-operation with this region.

The competence area celebrated new infrastructure in autumn 2017 when a renovated industrial engineering laboratory was commissioned in the KAMK Tieto2 campus building. The new laboratory will deliver services for construction and civil engineering, mining and water treatment, and measurement and machining services for mechanical engineering.

Planning and development of expertise and skills for the mining

industry continued with Lapland University of Applied Sciences and Oulu Mining School, with a view to providing a more effective training partnership for the mining industry. The aims were also specified in an agreement for the 2017-2020 period concluded between KAMK, Lapland University of Applied Sciences and the Ministry of Education and Culture. The Ministry will also allocate strategic funding for operations over the agreement period.

CEMIS Business Development (CBD) – Specialising in the International Technology Business

The CEMIS Business Development (CBD) unit comprised Senior Business Advisor Anas Al Natsheh (Ph.D.) and three business advisors in 2017. One student trainee and one international researcher secured through researcher exchange were also involved in the team for part of the year. More specialists joined the CBD team following the merger of Measurepolis Development Ltd. into KAMK in the spring. This was a valuable step in creating a broader group of specialists to develop the technology business at CEMIS. Collaboration between the various CEMIS participants in general was very close throughout the year, with various discussions on technology and research held on a weekly basis on themes from CEMIS projects.

2017 was a busy and dynamic year for CBD with operations focusing on a new International Technology Business project (KANTELI) under the CEMIS Development Programme. CBD managed and implemented the project in close partnership with other programme projects. KANTELI supports the technology development and business operations of CEMIS partners through various business research and globalisation initiatives, producing extensive reports for partners within CEMIS and in key sectors for Kainuu, such as virtual reality (VR) and augmented reality (AR) solutions, cleantech, bioeconomy, and health and sports technology. Many of these studies were applied as a background for new CEMIS development efforts. VR/AR solutions in particular are being adopted at an accelerating pace in various industries, creating new opportunities for KAMK expertise. New openings and projects in this field are expected in 2018.

CBD and CEMIS secured a significant distinction early in the year when Dr. Anas Al Natsheh was appointed to the board of the International Technology Innovation International (TII) association. The CBD unit was invited to attend the invitational event of TII in the City of Vaasa in March.

Globalisation operations of CBD were mainly implemented under the KANTELI project, and consisted of numerous events including trade fairs, conferences and networking events. The main goal was to promote CEMIS expertise and technologies, and to identify new market opportunities for CEMIS and Kainuu-based expertise and companies. Highlighted events included Traffex in Birmingham, UK; Perumin (mining, cleantech) in Arequipa, Peru; and EcoTech (cleantech) in Kazakhstan.

Attendance at Traffex fell under the KAMK GeoROAD project, which studied the technical suitability and commercial potential of using geopolymer materials for road repairs. The event proved an effective contact channel, with considerable interest shown in the GeoROAD solution. CBD gained a solid understanding of the UK road industry, the requirements of its customers and the standard of technological progress. The materials technology of GeoROAD attracted considerable interest in the UK, as the costs caused by potholes are reckoned in the billions, and new environmentally friendly and cost-effective solutions and products for tackling this problem are sought continuously.

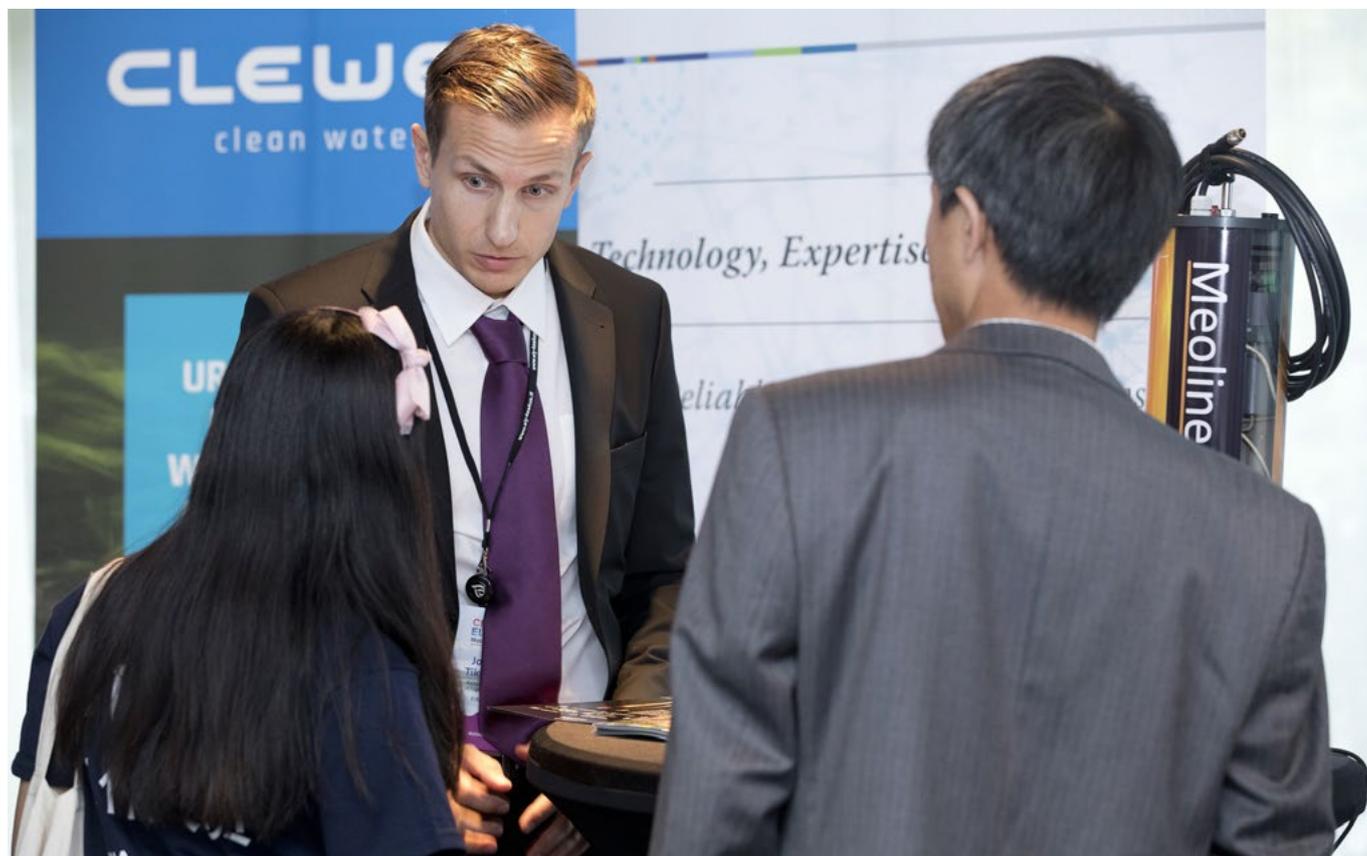
In association with the new CEMIS director Mikko Kerttula, CBD also presented CEMIS water technologies to some 200 Chinese visitors at the China Europe Water Platform (CEWP) ministerial level conference held in the City of Turku in September 2017 (see Figure 6.3). Demand for water management, treatment and measurement technology is very high in China, creating a challenge for Finnish companies and organisations in arranging sufficiently comprehensive solutions. CEWP provided an opportunity for CEMIS to take its first steps towards a more profound understanding of the Chinese market, and to establish initial contacts. Work in this new market will continue alongside the previous target markets of CBD, namely Europe, South America and the Middle East. There is also rapidly growing demand for winter sports technologies in China due to the upcoming Beijing 2022 Winter Olympics, and CBD will also continue to work on this opportunity.

A favourable funding decision was received for the Future Electric and Gas Grids project (BIOFEGG) financed under the ERA-NET

programme of the European Union. The core of RDI operations in this project concerns refining biogas for distribution networks and converting it into biomethane vehicle fuel. The project supports the regional objectives of Kainuu in the field of bioeconomy, with KAMK serving as a project co-ordinator.

Continuing from 2016, CBD participated in the MPA project co-ordinated by MITY with Tekes TUTLI funding, and in the foregoing GeoROAD project. Both of these projects were completed in 2017. GeoROAD submitted a patent application for a new road patching material. CBD also entered into a partnership looking towards Russian Karelia, with financing from the Karelia CBC programme approved for a DiGi-Vision micro-project. DiGi-Vision is set to examine how digitisation can support SME growth in remote areas such as Northern Finland and Russian Karelia, with increased co-operation across the international border.

CBD worked in close partnership with numerous units at KAMK over the year, and also with MITY, JYU, VTT and CSC. An important part of CBD work in the KANTELI-project has been to pursue development of Kainuu-based technologies and find international opportunities for them. The goal is to advise CEMIS technology developers of the latest customer demands and requirements, to provide information on markets, IPR and competitors, to initiate commercialisation of technologies with the greatest potential, and to explore financing opportunities for these initiatives. This enables technology-oriented CEMIS units to focus more on their core competencies. As international market opportunities are always larger than purely domestic options, CBD has focused considerable efforts on international market research and on identifying opportunities.



Picture 6.3. CEMIS Business Development (CBD) participated in the China Europe Water Platform (CEWP) ministerial level conference held in the City of Turku on 21-22 September 2018. Here Business Advisor Joonas Tikkanen introduces CEMIS to the Chinese conference participants.

The Operations of VTT

VTT continued its work in traceability services and research according to expectations in 2017. Over the first seven years of operation the Kajaani unit has had some 200-300 customers annually, of whom more than 95 per cent are from outside the Kainuu region. Foreign customers have outnumbered those from the Kainuu region, meaning that a location as the world's northernmost standards laboratory has not been an obstacle to demand.

The work of VTT (the Technical Research Centre of Finland Ltd.) in Kajaani continued to focus on VTT MIKES Metrology (VTT MIKES) operations in 2017. VTT MIKES became one of the VTT's research areas in 2016 with the following changes made to its management in 2017: former Vice President Dr Mikko Merimaa moved to lead VTT Knowledge Intensive Products and Services (KIPS), to be replaced by Dr Martti Heinonen, who was previously responsible for MIKES research. Two VTT research teams (BA1609 and BA1704) served as part of a total staff of 8 persons employed at the Kajaani office in 2017.

VTT MIKES Kajaani

VTT MIKES Kajaani is the northernmost National Standards Laboratory in the world. Since 2011 the unit has operated from purpose-built facilities in the Renforsin Ranta Business Park. Work at Kajaani focuses on maintaining national measurement standards of force, torque (Figure 7.1), water flow and large masses, traceability services for measuring instruments, and on participating in national and international research projects. National measurement standards for force, torque, large masses (between 20 and 2000 kg) and water flow are located in Kajaani. These standards are applied when calibrating measuring instruments to determine the error between the instrument readout and the standard. VTT MIKES Kajaani is also involved in the metrology club operations of the metrology advisory board at the Ministry of Economic Affairs and Employment, with responsibility for force and water flow metrology clubs.

The traceability services and research operations of the unit continued to evolve as expected in 2017. VTT MIKES Kajaani has served between 200 and 300 customers annually over the first seven years of its operations. Over 95 per cent of this clientele is from outside the Kainuu region. Foreign customers outnumber local customers, so the unit's geographical location has not diminished demand for its services.



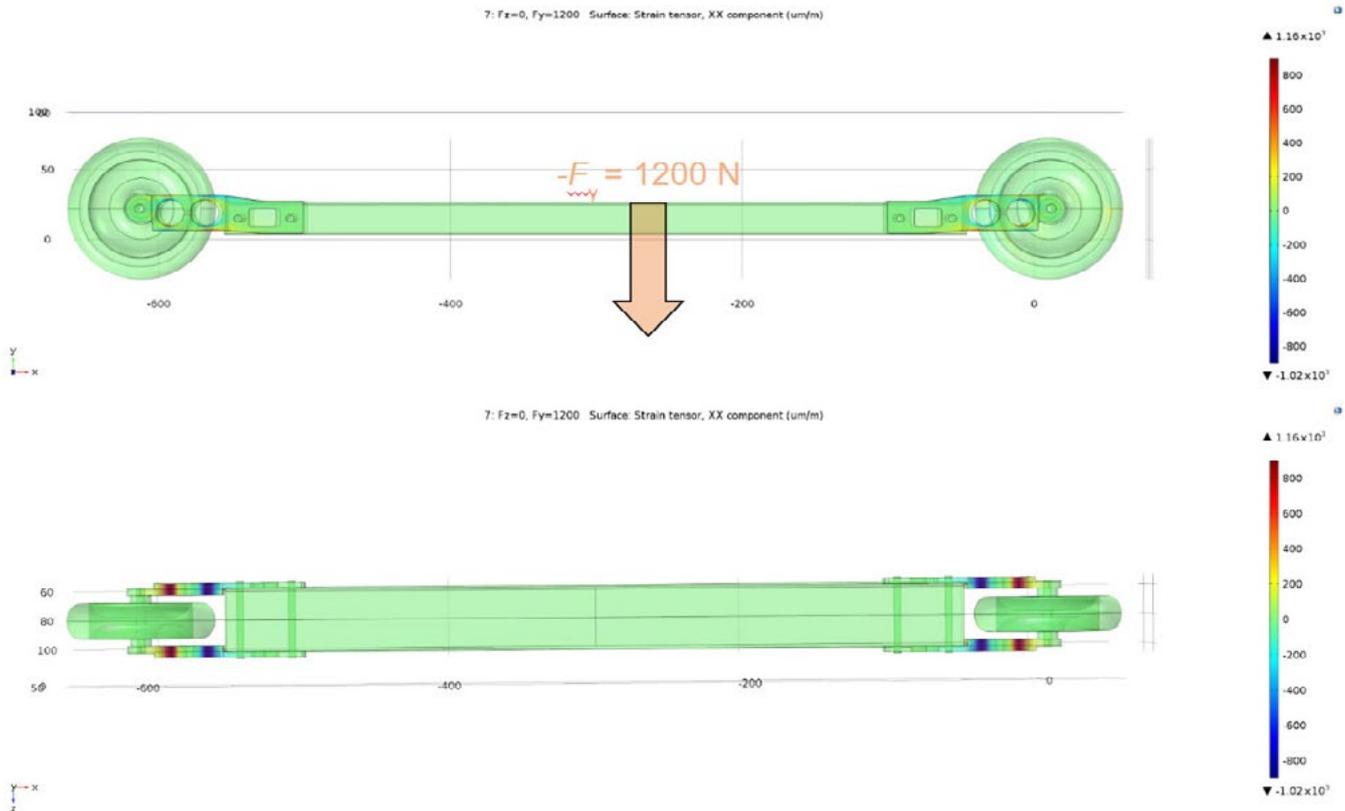
Picture 7.1. The VTT MIKES 2 kNm torque standard for calibrating torque sensors is located in Kajaani.

International Collaboration

VTT MIKES Kajaani has actively participated in the work of the European Association of National Metrology Institutes (EURAMET), including technical meetings related to the specific physical quantities for which the unit is responsible. Together with the Finnish Society of Automation, the unit was involved in organising an international meeting in Helsinki: the IMEKO TC3, TC5 and TC22 International Conference 2017. The unit has also been involved in four EURAMET EU research projects: EMRP Force has already been completed, EMPIR Torque and EMPIR MultiFlowMet II are ongoing, and EMPIR Metrowamet will begin in summer 2018. A total of 33 EU research projects are ongoing at VTT MIKES.

Research Activities

VTT MIKES Kajaani has actively participated in implementing the CEMIS Development Programme joint projects BIOMIT (New

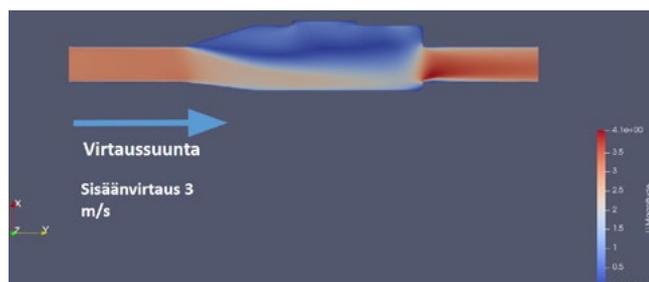


Picture 7.2. As part of the LIIKUTPA project, VTT MIKES modelled and simulated the maximum strain and elongation of roller skis. The diagram shows how the downward force is distributed at the designated sensor locations.

processes and novel measurements for bioeconomy and the mining industry) and LIIKUTPA (New sport and wellbeing technologies and services).

LIIKUTPA is co-ordinated by the University of Jyväskylä. VTT provides expertise in measurements and measurement methods for skiing equipment (Figure 7.3). The measurement methods, which also include instrument calibration, have significantly enhanced performance comparisons. Traceable calibrated SI measurement systems ensure the accuracy and reliability of measurements.

As part of the BIOMIT project, VTT MIKES Kajaani has developed expertise in CFD (Computational Flow Dynamics) for bioenergy generating and mining applications. The goal is to learn to use open source tools (e.g. OpenFOAM®) effectively in CFD (Figure 7.3). Another challenge is to study the phenomena occurring in a multiphase environment and to learn the basics of modelling individual fibres in pulp. This is a demanding undertaking that requires a great deal of computing power. The VTT computing cluster provides a significant



Picture 7.3. As part of the BIOMIT project, VTT MIKES Kajaani has strengthened its competence in computational flow dynamics (CFD). The diagram shows the flow profile of the measuring chamber calculated on water using OpenFOAM® software.

benefit in this regard, with even greater benefits available when CSC supercomputers can be used.

VTT MIKES Kajaani has also participated in other publicly funded research projects and in customer-oriented research projects studying subjects related to the quantity ranges maintained in the unit and to their application in various measurements.

Outlook for 2018 – 2019

The outlook for 2018 is promising. Some new research projects are under consideration in which metrology will play a significant role. Co-operation has increased with various stakeholders and within VTT. The role and importance of reliability in measuring has grown further in the business world, as it brings quality, market value and a competitive edge. The share of traceability services in the unit's budget is expected to remain high in 2018. The unit will continue maintaining its world-class expertise in metrology by participating in international research and benchmarking projects. VTT began developing UWB (Ultra Wide Band) impulse radar and positioning technology in Kajaani more than ten years ago. This technology has now attained a degree of sophistication that justifies high expectations of a new business base in 2018.

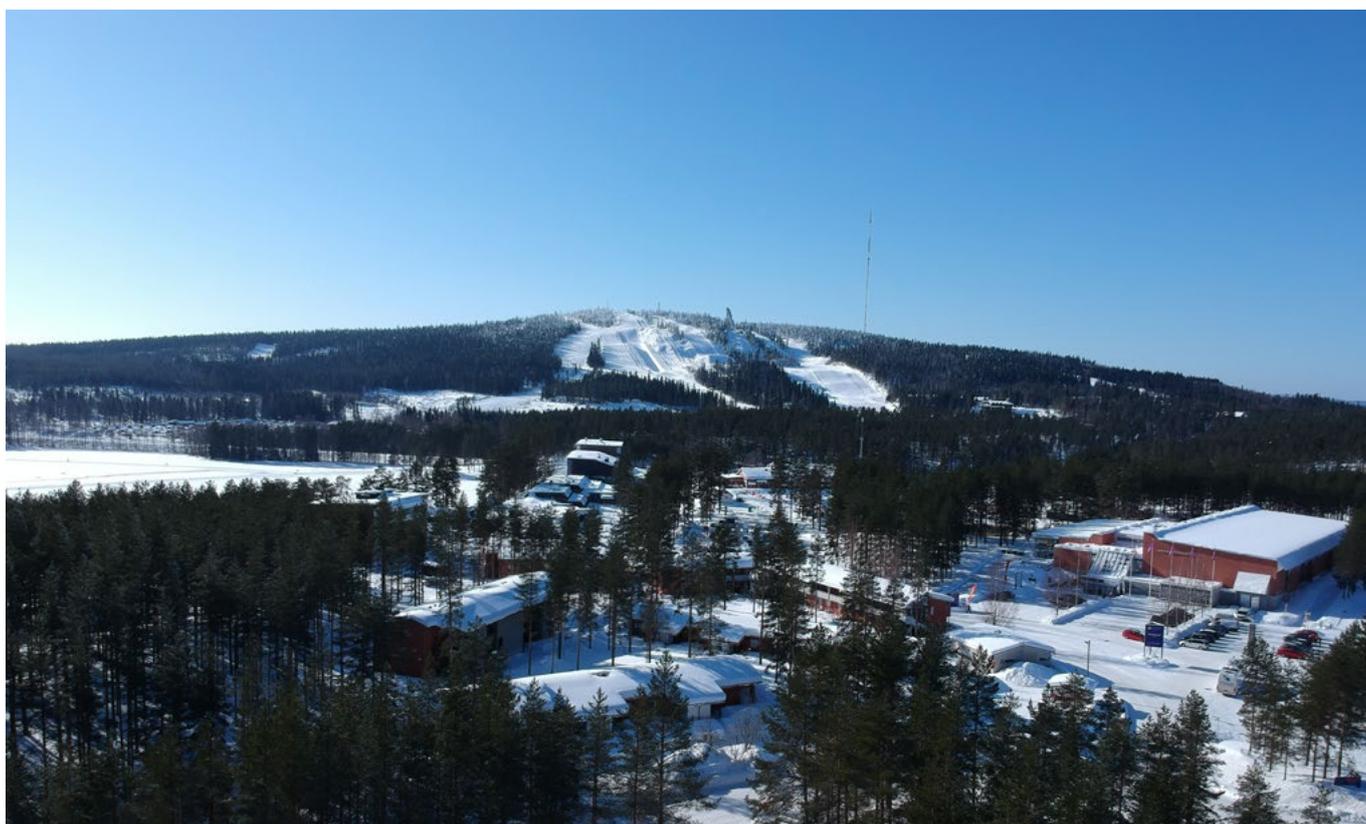
The Operations of the University of Jyväskylä

The Vuokatti unit of the University of Jyväskylä has significantly supported the growing contribution of Vuokatti Sports Institute in coaching Chinese winter sports athletes. The unit's expertise and research have also played an important role in supporting the Finnish national cross-country skiing team. One example of this is the simulated environment of the PyeongChang 2018 Olympic Skiing Sprint Route implemented at Vuokatti, which Finland's cross-country skiers used when training for the Winter Olympics.

General Overview

Vuokatti sports technology unit is part of the Faculty of Sport and Health Sciences at the University of Jyväskylä. The unit provides Master's and doctoral degree programmes in sport sciences and pursues research and development projects with national and international partners. The unit had a total staff of 12 persons in 2017, with three engaged in teaching and the remainder working on various projects. Some of the staff have been jointly engaged by the University of Jyväskylä and

the Finnish Ski Association, the Finnish Biathlon Association or the Finnish Olympic Committee. The Vuokatti unit is headed by professor Vesa Linnamo. The unit is based at premises in Snowpolis Technology Park in Vuokatti, Kainuu. The Vuokatti team published seven original academic articles, two books or book chapters and four international congress abstracts over the year. The staff also held a total of five invited presentations, four of which were international presentations.



Picture 8.1. Vuokatti Sports Center and Snowpolis.

A seminar on sports technology and winter sports was arranged in Vuokatti in June 2017, with presentations including the findings of the Vuokatti-Ruka sports academy training development project that ended in April. The seminar also presented the winter sports R&D work of the sports technology unit in recent years. As an international guest at the seminar, Professor Thomas Stöggel from the University of Salzburg discussed the topical theme of equal propulsion in cross-country skiing.

Partnerships

A significant part of the unit's operations are R&D projects implemented with national and international partners. The principal national partners have been the other CEMIS participants: the University of Oulu, KAMK, VTT, CSC, Vuokatti Sports Institute and the Municipality of Sotkamo. Under the CEMIS Development Program, the University of Jyväskylä has been responsible for coordinating the competence area of measurements for sports and wellness. Winter sport research has involved close partnerships with the Finnish Research Institute for Olympic Sports (KIHU), the Finnish Ski Association, the Finnish Biathlon Association and the Finnish Olympic Committee. International research collaboration continued both with the Austrian University of Salzburg in pursuing measurements for a study of equal propulsion at Vuokatti in March-April, and with the Mid-Sweden University in conducting cross-country skiing research measurements at the Östersund wind tunnel in March, May and October 2017. International collaboration in relation to Paralympic cross-country sit-skiing also continued with the Polytechnic University of Turin, the Universities of Gothenburg, Leuven and Warsaw, and the Freiburg Olympic Training Centre. A partnership agreement was concluded in October 2017 between the Chinese Beijing Sport University (BSU) and the Faculty of Sport and Health Sciences of the University of Jyväskylä, whereby training in winter sports research, testing and coaching will be arranged for

BSU teaching and research staff both in Jyväskylä and Vuokatti. The academic visit began in Jyväskylä in December.

Project Operations

The New sport and wellbeing technologies and services project (LIIKUTPA) was launched under the 2017–2018 CEMIS Development Programme at the beginning of 2017, with the Vuokatti unit of the University of Jyväskylä primarily responsible for implementation. The CEMIS partners assisting in implementing the project are MITY, KAMK, VTT and CSC. The two-year project seeks to develop measurement and testing solutions, both for the needs of wellness and remote healthcare and for Nordic skiing sports. One outcome of the project in 2017 is a simulation of the environment of the Ski Sprint Route at the 2018 PyeongChang Winter Olympics shown in Figure 8.2. The Sprinters of the Finnish cross-country ski team used the simulation at several training camps in Vuokatti while preparing for the Olympics in June - October.

A joint review of LIIKUTPA and KANTELI projects under the CEMIS Development Programme selected the Coachtech Coaching Feedback System (Figure 8.3) as the sports technology solution developed at Vuokatti with the strongest commercialisation potential. This work included measures to launch the Coachtech business taken with the CEMIS Business Development team at KAMK.

The Virtual coach for healthcare and wellness professionals project financed by Tekes (now Business Finland) and the ERDF continued with the involvement of all CEMIS participants, and the Vuokatti-Ruka Sports Academy coaching development project financed by the Regional Council of Kainuu and the ERDF ended in April. An important new development and investment project entitled New feedback systems for biathlon was also launched in September with ERDF funding channelled through the Regional Council of Kainuu. This



Picture 8.2. Simulation of the environment of the Ski Sprint Route at the 2018 PyeongChang Winter Olympics at the Vuokatti sport testing station.

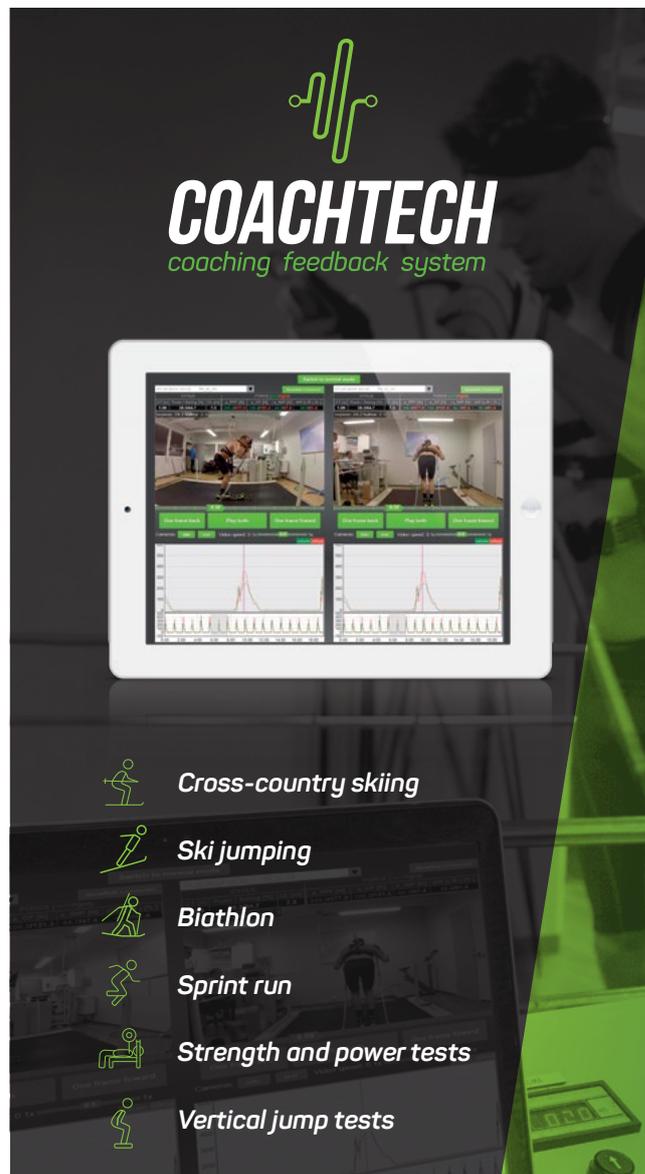
project will construct a new biathlon testing and training environment in the Snowpolis building premises of the Vuokatti unit, including the procurement of a treadmill that is more suitable for roller skiing. The University of Jyväskylä was also involved in a specialist capacity in implementing an international sports expertise business development project led by Vuokatti Sports Institute with funding from the Centre for Economic Development, Transport and the Environment and the ERDF, focusing particularly on building international networks in the Far East.

Master's Degree and Doctoral Education Programmes

Six individuals completed a Master's degree in sport sciences during 2017, bringing the all-time total number of graduates from the sports technology Master's degree programme to 70. A total of seven graduates of the programme secured employment over the year. Three graduates established enterprises of their own, one of which was based in Kajaani. The Master's degree programme in sports technology has been financed by the Faculty of Sport and Health Sciences at the University of Jyväskylä and the Municipality of Sotkamo since 2014. Preliminary discussions between these financiers regarding a new five-year programme of education for Master's and doctoral degrees were initiated in September with a review of operations in Vuokatti by Keijo Hämäläinen, the new Rector of the University of Jyväskylä.

Vuokatti provides facilities for completing Master's thesis work in high standard research projects or in partnership with private businesses. The major subjects of such theses are either biomechanics, sports physiology or coaching and testing, and may concern such topics as aids for human activity and movement, development and quality assurance of testing and training equipment for top-level sports and fitness, and processing of biosignals in the context of physical exercise.

Five theses were pending in the doctoral education programme in 2017, three of which involved a partnership with foreign universities. A thesis prepared by Caroline Göpfert, M.Sc. on the subject of Biomechanics of speed adaptation and functionality of arm swing in cross-country skiing was formally examined at Salzburg, Austria, in December 2017 (see Figure 8.4). This doctoral thesis work was completed through a partnership between the universities of Jyväskylä and Salzburg. Two pending doctoral theses are subject to partnerships with the Universities of Salzburg and Turin, and two others involve collaboration with the Finnish Research Institute for Olympic Sports (KIHU).



Picture 8.3. New visual design of Coachtech Coaching Feedback System.



Picture 8.4. Doctoral dissertation of Caroline Göpfert, M.Sc. at the University of Salzburg in December 2017. From left to right: professor Erich Müller, Dr Joseph Kröll, professor Stefan Lindinger, Dr Caroline Göpfert, professor Vesa Linnamo, professor Walter Herzog and professor Hermann Schwameder. The thesis work was supervised by professors Müller, Lindinger and Linnamo, with professor Herzog serving as opponent to the doctoral dissertation.

The Operations of CSC

CSC operations at CEMIS in 2017 focused on applications of machine vision and machine learning, and on developing the Graphics Processing Unit (GPU) environments and sensitive data processing required for machine learning. These activities have helped CSC to continue improving its own measuring technology skills and understanding of the field. The inclusion of CSC at CEMIS has given other CEMIS operators and partner enterprises new opportunities for applying data analytics and machine learning in teaching, research and business development.

CSC – IT Center for Science is a national centre for high-performance computing (HPC), data analytics and information networks that provides services to universities, research institutes, the public sector and businesses. CSC is a non-profit limited company that is owned by the Finnish government and higher education institutions and administered by the Ministry of Education and Culture.

Since joining CEMIS in August 2016, CSC has focused on applying and disseminating data analytics expertise within the CEMIS network. CSC is involved in the LIIKUTPA and BIOMIT projects, focusing on applications of machine vision and machine learning, and on developing the GPU environments and sensitive data processing that are required for machine learning. These activities have helped CSC to improve its own measuring technology skills and understanding



Picture 9.1. The CSC data centre is in the Renforsin Ranta Business Park.

of the field. Improvements in data analytics are often an outcome of achievements in measurement technology, so CSC regards CEMIS as a valuable vantage point for monitoring progress in the field. The CEMIS partners may access the powerful computation environment of CSC, particularly its IO-optimised cloud services and GPU computing.

CSC participation in CEMIS mainly focused on the LIIKUTPA project in 2017, with assignments related to data analytics, sensitive data, machine learning and machine vision. This included realising a machine vision-based method for automated ski pole angle analysis. CSC worked with other CEMIS participants to begin constructing a pilot environment for collecting and analysing confidential data.

Ski Pole Angle Analysis

CSC assisted in work to develop advanced testing environments as part of the LIIKUTPA project, responding to a need for automation in determining the angle of a ski pole used by a competition skier on an athlete testing treadmill. The angle of the ski pole in turn determines the propulsion component that drives the skier forward.

The development work relied on camera-based ski pole angle analysis and automatic recognition of the ski pole using machine vision (see Figure 9.2). The main requirements were found to be eliminating the imaging background, colour-based ski pole filtering and line tracking. The principal imaging environment requirements for reliably operating the method were related to illumination, an unobstructed field of view and colouring of the ski poles.

A prototype implementation was created for developing the ski pole angle analysis method, and this then served as a basis for designing and developing the analysis tool in a Qt development environment. Requirements for the tool included application-specific settings with an interactive graphical user interface, and a batch processing feature built into the Coachtech system. The final tool has been used for analysing varying test materials filmed with a range of cameras, for example in measurements for a study of international ski slipstreaming conducted in Sweden by researchers from the University of Jyväskylä.



Picture 9.2. Various neural network models for recognising the posture of an athlete have been trialled in the context of the LIIKUTPA project.

The prospects for other applications of the tool have also been studied, with further development for simultaneous recognition and tracking of varying colour lines. Body segment recognition, ski jumping, sit-skiing and a dynamic balance test developed at Vuokatti

have been studied as potential new applications. Project work has also been launched to investigate the broader application of machine vision in analysing skiing technique.

Sensitive Data

Processing sensitive data is a key issue in studies of health and wellness, as the details of an individual's health must be handled with particular care and with the assurance of confidentiality. On the other hand, many services related to personal health and wellness already operate on the cloud nowadays. Harmonising sensitive data and cloud services has accordingly assumed key significance in the field of health and wellness research.

CSC arranged a sensitive data seminar on this theme at KAMK on 19 December 2017, with presentations from CSC and other CEMIS participants. Some 30 CEMIS staff members and regional business partners attended the seminar. CSC has begun working with other CEMIS participants to construct a pilot environment for collecting and analysing confidential data.

Route Modelling

This project has developed faster route modelling methods for use in modelling the terrain of major sporting events. Assessments of performance, pricing, licencing conditions and suitability of software intended for photo-based 3D modelling have been compiled at KAMK.

KAMK has also secured access rights to the CSC cloud computing environment, and conducted trial calculations for photogrammetric 3D modelling in a cloud environment. CSC and KAMK worked together on the project to plan the use of data centre-based GPU computing for producing 3D models.

Other Projects

CSC served as a specialist member of the Virtual Coaching Project, contributing in particular to the design of data analytics and cloud-based production solutions. A preliminary investigation of the prospects for using mine operation measurement data for identifying sidestream metals was conducted as part of a BIOMIT subproject in 2017.

Publications

A total of 26 international peer-reviewed academic publications and 28 professional and conference publications were produced at CEMIS in 2017. CEMIS was also the background to one doctoral thesis, ten Master's theses, eight University of Applied Sciences Master's degrees and 85 theses in science, engineering and business administration.

Doctoral Dissertations

Göpfert Caroline (2017) Performance characteristics in classic and skating techniques of cross-country skiing; effects of kick double poling and arm swing. Doctoral thesis. Paris Lodron University of Salzburg and University of Jyväskylä. (dissertation formally presented on 14 December 2017)

Diploma and Master's Theses

Kostamovaara J. (2017) Development of characterization environment for silicon photomultipliers. Diploma thesis. University of Oulu.

Lassila P. (2017) Lääketieteellisen kamerainstrumentin suunnittelu. (Medical camera instrument design) Diploma thesis. University of Oulu.

Honkanen A. (2017) Fundus autofluorescence imaging. Diploma thesis. University of Oulu.

Hartikainen E. (2017) Dynaamisen tasapainotestin toistettavuus ja validointi. (Repeatability and validation of a dynamic balance test) Master's thesis. University of Jyväskylä.

Peltola J. (2017) Suoritusanalyysi painonnostossa. (Performance analysis in weightlifting) Master's thesis. University of Jyväskylä.

Haverinen M. (2017) Jalkojen voima, iskun voima ja melonnan ajoitus nuorilla ja kokeneille melojilla melontaergometrissa. (Leg power, stroke power and the timing of paddling for young and experienced canoeists in canoeing ergometrics.) Master's thesis. University of Jyväskylä.

Happonen A. (2017) Kahden tunnin lajinomaisen harjoittelun vaikutukset väsymykseen ja reaktivoimat suksislopestyessä. (Effect of two-hour sport training on fatigue and reaction forces in ski slopestyle) Master's thesis. University of Jyväskylä.

Vänskä H. (2017) HIT-harjoittelun vaikutukset VO₂max:iin, kehonkoostumukseen ja voimaan 6 viikon harjoitusjaksolla. (Effects of high-intensity training on VO₂max, body composition and power in a six-week training period) Master's thesis. University of Jyväskylä.

Allonen J. (2017) Voimaharjoittelun vaikutukset dynaamiseen ja staattiseen tasapainoon nuorilla ja ikääntyneillä. (Effects of strength training on dynamic and static balance in young and elderly people) Master's thesis. University of Jyväskylä.

Ruostekoski A. (2017) The effect of exercise intensity and exercise environment on brain-derived neurotrophic factor (BDNF) and physiologic parameters in young male skiers. Master's thesis. University of Jyväskylä.

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Dong Y., Haverinen J., Tuuttila T., Jaakkola M., Holm J., Leveque J., Lassi U. (2017) Rapid one-step solvent-free acid-catalyzed mechanical depolymerization of pine sawdust to high-yield water-soluble sugars. - *Biomass and Bioenergy* 102. pp. 23-30.

Ferancova A., Hattuniemi M., Sesay A., Rätty J., Virtanen V. (2017) Complexation of Ni(II) by Dimethylglyoxime for Rapid Removal and Monitoring of Ni(II) in Water. - *Minewater and the environment* 36 (2). pp. 273-282.

Ferancova A., Hattuniemi M., Pääkkönen S., Tervo P., Ohtonen E., Sesay, A., Rätty J., Virtanen V. (2017) Electrochemical impedance spectroscopy for monitoring of alkaline phosphatase reaction with substrate. - *Procedia Technology* 27. pp. 315-316.

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Niskanen I., Rätty J., Peiponen, K-E. (2017) On the immersion liquid evaporation method based on the dynamic sweep of magnitude of the refractive index of a binary liquid mixture: a case study on determining mineral particle light dispersion. - *Applied spectroscopy* 71 (7). pp. 1586-1592.

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Panjan P., Ohtonen E., Tervo P., Virtanen V., Sesay A. (2017) Shelf life of enzymatic electrochemical sensors. - *Procedia Technology* 27. pp. 306-308.

Panjan P., Virtanen V., Sesay A. (2017) Micro-fluidic integrated toolkit for micro-bioreactors and bio-catalytic processes. - *Procedia Technology* 27. pp. 309-311.

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