

CEMIS Annual Report 2019



CEMIS

Centre for Measurement and Information Systems

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Chairmen's review

Modern society relies on management by information. No decisions can be made without measured, quality-assured, precise and properly processed supporting information. Researched, verified and validated information remains the firmest guarantee of both individual and corporate success, and the resilience of society in making difficult decisions. Developing new technologies, deploying them in production and creating expertise are essential for our wellbeing.

Producing high-quality information through measurement requires a genuine multidisciplinary approach and expertise. It relies on the research, development and innovation work of universities and research institutes, and of businesses and corporations. The operations of CEMIS arose with a view to supporting these competencies, and to regenerating and developing the Kainuu region.

We can build more effective solutions jointly at CEMIS than we ever could working alone. Having the best regional expertise has long been insufficient for success. Solutions emerge in a global world at centres where conditions are world-class. The CEMIS partners and networks accordingly seek excellence by international standards. This also generates added in-house value for partner organisations.

CEMIS has shown its strength by assembling expertise to develop the future. It must continue its efforts to realise added value through each project in turn. Performance has been exemplary in this respect.

We look forward to an increasingly thoroughgoing odyssey of common solutions, innovations and emerging expertise in years to come!



Matti Sarén
Rector
Kajaani University of Applied Sciences



Arto Maaninen
Vice-Rector for Co-operation
University of Oulu

Introduction

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

CEMIS comprises the University of Oulu Measurements Technology Unit in Kajaani (MITY), the School of Information Systems and the mechanical and mining engineering competence area of Kajaani University of Applied Sciences (KAMK), the Kajaani branch of VTT, the Vuokatti Sports Technology Unit of the University of Jyväskylä, and the Kajaani unit of CSC – IT Center for Science (Figure 2.1).

All five of these partners are committed to the work of CEMIS, together with the City of Kajaani and the municipality of Sotkamo. CEMIS is the only innovation centre of the University of Oulu that is not based in Oulu. This university has focused its technology R&D work on CEMIS in Kainuu. KAMK views CEMIS as its principal vehicle

for co-operation between universities and research institutes, and as its most important site for development. For the University of Jyväskylä, CSC and VTT, CEMIS is a form of regional co-operation.

Collaboration between the CEMIS partners includes a joint strategy and management team, co-operation in RDI work, co-ordination of project activities, joint marketing and PR, business development, collaboration in building prototypes, and training in developing shared operating facilities, surroundings and co-operation.

CEMIS values reliability. The CEMIS partners seek to be reliable partners and contributors to their parent organisations, to one another, to their localities, to their customers and to their other partners.

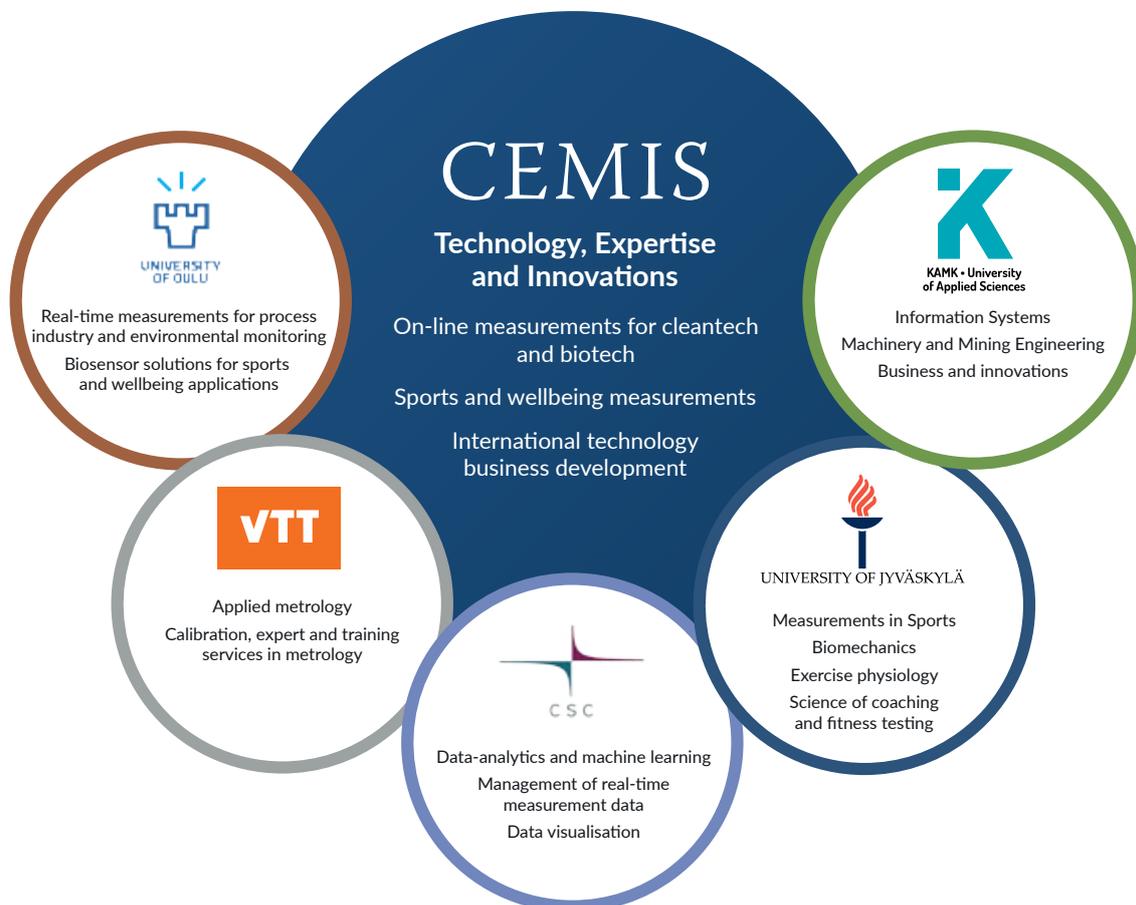


Figure 2.1. CEMIS focus areas and member organisations, with their main areas of expertise.

CEMIS also ensures the reliability of the measurement technology solutions developed by its partners, and of the measurement results that they provide.

The technological priorities of CEMIS in teaching, research and innovation are:

1. Online measurement solutions to meet the needs of process industries, particularly the bioeconomy, mining and environmental monitoring sectors (Cleantech and Bioeconomy)
2. Measurement and testing solutions for sports, wellness and healthcare applications using sensor solutions, and 3D and VR technology-based games and simulator solutions (Sports and Wellbeing)
3. Developing international technology business based on the technological expertise of CEMIS and partner enterprises (International Technology Business)

CEMIS provides reliable measuring and information system solutions and services for demanding environments in these fields, comprising cutting-edge R&D services, testing and calibration services, training and consulting, and international technology business development services. This offering applies key CEMIS technologies, including optical spectroscopy, imaging technologies, bioanalytics and biosensors, biomechanical and physiological measurements, power and torque sensors, wireless and embedded IoT sensor networks, data analytics and machine learning, virtual reality and augmented reality (VR/AR), and game technology and computer simulation.

CEMIS seeks to become a sought-after international partner in developing expertise in measurement and information system technology. With its extensive collaborative R&D services and higher education, the expertise and innovation cluster in Kainuu aims to

realise internationally significant expertise, new technology and business operations.

By providing R&D services and university-standard education in an innovative and international environment, CEMIS provides new technology, new business operations and cutting-edge expertise for businesses that are developing and applying measurement and information systems. The Centre provides an innovative and international working environment for ambitious researchers and specialists, and an inspiring learning environment for students seeking to qualify for future specialist positions.

Its mission is to make its teaching and research activities in the field of measurement and information systems increasingly attractive, competitive and effective. To achieve these aims, CEMIS has set quantitative performance targets for its operations in R&D, training and innovation, both for the Centre as a whole and for each individual partner.

The CEMIS development programme is a key tool in the work of CEMIS. It specifies measures to enhance operational co-ordination, collaboration and division of duties, use of shared resources and visibility.

The fifth two-year CEMIS development programme period began in 2019 with an annual budget of approximately EUR 1.77 million financed mainly through ESF and ERDF programmes for Northern and Eastern Finland. The total annual funding of CEMIS is more than EUR 12.6 million, consisting of self-financing by the partners, regional development funding (including the CEMIS development programme), and competitively tendered external financing. CEMIS employs nearly 100 specialists in measurement and information systems.

Operational priorities of CEMIS



CLEANTECH & BIOECONOMY

Measurement solutions for the process and mining industries, and for the bioeconomy



SPORTS & WELLBEING

Measurement and testing solutions for sports, wellness and healthcare applications



INTERNATIONAL TECHNOLOGY BUSINESS

Development of international technology business operations

Director's review

The ninth full operating year of CEMIS in 2019 largely continued in line with previous strategy and operations. The action plan for 2019-2020 was updated in relation to performance targets, and to reflect the Centre's new two-year development programme. Both funding applications and other forms of collaboration continued to stress globalisation. The first ever directly financed European Union project of Kajaani University of Applied Sciences under the EU Horizon 2020 research programme may be highlighted as a particular success in funding applications. A very important advance for the Kajaani research and business community was achieved when the LUMI consortium led by CSC – IT Center for Science secured Kajaani as a location for one of three high-speed supercomputers to be built in Europe.

CEMIS pursues and develops its work in accordance with the performance objectives specified in the Centre's operating plan, assessing outcomes in three categories: education, R&D and innovation. CEMIS realised these outcomes with a staff of nearly 100 people in 2019.

The publishing rate at CEMIS remained strong over the year, with the release of a record 38 peer-reviewed scientific articles and 35 conference and professional publications in 2019. Two doctoral degrees, seven Master's degrees, nine university of applied sciences Master's degrees and 85 university of applied sciences Bachelor's degrees were conferred at CEMIS in 2019.

The Centre supported an average of about 68 ongoing R&D projects during the year, with more than 90 projects ongoing over the year as a whole. The fifth two-year CEMIS development programme for 2019-2020 began with five projects. The more detailed content of the programme, its operations and outcomes will be described later in a separate section of this annual report. CEMIS was also

involved in 14 international projects with a funding share of nearly EUR 0.5 million. Regional project funding from the Regional Council of Kainuu or the ELY, Centre for Economic Development, Transport and the Environment was EUR 3.4 million. The aims of these projects included developing new solutions for water treatment, finding ways of monitoring metal concentrations in industrial effluent, developing process analysers for manufacturing bioethanol, recycling and repurposing industrial sidestreams, using natural raw ingredients in food supplements and the food industry, athlete testing and coaching, measurement solutions for the biathlon, biosensors for healthcare, data analytic solutions for enterprises, applying VR/AR technology for digitising the mining industry, 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 new businesses have been established due to the Centre's work. Two new commercially applied inventions were developed and two new companies were founded within CEMIS in 2019.



The Measurements Technology Unit of the University of Oulu (MITY) continued its strong trend of scientific and conference publishing. International co-operation grew in strength, especially in the direction of Estonia, which has also attracted interest at European level. One technology was also commercialised on the basis of the Unit's research.



Kajaani University of Applied Sciences strengthened its international operations, with a significant boost in preparing international projects, particularly under the EU Horizon 2020 and Karelia CBC research programmes. A record 120 students graduated from programmes in fields of expertise involved in CEMIS operations. Demand for VR and 3D skills in particular remains high in the service business sector. One new technology solution was also commercialised. The Kajaani HPC cluster also continued to grow with new projects and infrastructure development.



This was an active research publishing year for the **Vuokatti Sports Technology Unit of the University of Jyväskylä**, including the publication of 17 articles and two doctoral dissertations. The Unit also arranged an international ski congress in March attracting participants from 16 countries. Project work included applying Business Finland funding to incorporate smart textiles into the network. Development work at CEMIS focused strongly on elite sports coaching and testing methods. Alongside the Master's program in sports technology, a sports technology training path for athletes was launched in association with KAMK as a new teaching initiative.



Service sales of the **VTT Kajaani unit** to industry remained stable. The annual clientèle has remained steady at about 250 clients per year, with over 95 per cent based outside the Kainuu region. The Kajaani research team has been actively involved in the work of the European Association of National Metrology Institutes (EURAMET), including participation in meetings of its technical committees.



Led by CSC – IT Center for Science, the LUMI consortium participated in the EuroHPC programme competition, securing the selection of Kajaani as one of three locations for European supercomputers. The consortium's co-investment in an EU-supported LUMI supercomputer will amount to more than EUR 200 million and, as one of the world's most powerful supercomputers, the new installation will bring significant added value to both Finnish and pan-European research, employment and competitiveness, and also especially to Kajaani as an attractive data centre location.

Total funding for the Centre in 2019 amounted to EUR 12.6 million (0 %) divided as follows: international funding of EUR 0.5 million (+85 %), national funding of EUR 1.3 million (-15 %), private enterprise funding of EUR 1.1 million (+19 %), regional funding of EUR 3.4 million (-7 %) and self-financing of EUR 6.3 million (+2 %). The Centre is seeking to increase international funding to EUR 1.15 million, reduce regional funding to EUR 3.0 million and boost business funding to EUR 1.2 million by the year 2021.

The qualitative goals of CEMIS for 2019-2020 were to generate new technology business operations and achieve a clear increase in international R&D co-operation and funding. New business was directly created in 2019 through the foregoing two new enterprises founded by staff and students of CEMIS operators.

Active international co-operation has continued for CEMIS both at European level and in a broader global context. Co-operation in Europe included work with the Universities of Salzburg, Ljubljana, Gothenburg and Turin. Co-operation has also been pursued with two Estonian EIP projects (European Innovation Partnership). CEMIS has also continued or initiated co-operation in South America (Peru, Chile and Brazil) and in Kazakhstan, China (Beijing Sport University and the Chinese Ski Federation) and Vietnam. As a significant new initiative, KAMK arranged an international mining industry summer school involving nearly 30 of our international students, mostly from China. The summer school was arranged in partnership with Lapland University of Applied Sciences and the University of Oulu.

In the context of EU co-operation, CEMIS helped to implement the EU Smart Specialisation Platform (<http://s3platform.jrc.ec.europa.eu>) within the ClusSport consortium, which works under a smart specialisation strategy on the thematic field of sport (<https://s3platform.jrc.ec.europa.eu/sport>). The Centre has also been involved in regionally crafting the measures and objectives of the smart specialisation strategy with the Regional Council of Kainuu. CEMIS has served in an expert role in the Regions in industrial transition pilot project (ELMO) financed by the European Commission, in which the County authorities of Eastern and Northern Savonia are seeking new inter-regional approaches to harnessing business growth potential in the region.

Work to explore the prospects for further international co-operation continued, especially with China. The most common packages for marketing to China are the possibilities offered by the Vuokatti winter sports centre, the Kajaani data centre ecosystem, and the Arctic Link submarine data cable designed to pass through the Arctic Ocean. Concrete measures to enhance co-operation focused on such areas as educational exports, winter sports coaching solutions, water treatment and monitoring, VR applications, and healthcare and elderly care. CEMIS also helped its partner businesses in opening or expanding the Chinese market.

CEMIS arranged a Chinese delegation visit to Vuokatti and Kajaani in association with the China-Europe Health & Sports Council (CEHSC) in April 2019. Visitors included the management of the Chinese Winter Olympics city Zhangjiakou, representatives of a State-owned

investment company and private investors. Representatives of the city of Kajaani, Sotkamo municipality and KAMK management made a reciprocal visit to Zhangjiakou, Beijing and Nanjing at the end of June. The trip included opportunities to meet representatives of the Chinese Ministry of Industry and Information Technology (MIIT) and a visit to Beijing Sport University (BSU, see Figure 3.1). A further 2-3 significant trips to China were planned towards the end of the year with a view to marketing the Arctic Link cable and the Kajaani data ecosystem, and planning a major sports and wellness conference in Vuokatti together with the China Association of Rehabilitation Technology Transformation & Promotion (CARTTP). Unfortunately, these trips had to be cancelled due to the COVID-19 pandemic that began in early 2020.

CEMIS also participated in the Digital solutions and business concepts in ensuring extensive safety of dam reservoirs and dams (DCDAMS) project financed by the Finnish Ministry of Agriculture and Forestry (MMM), which brought together Finnish water and dam safety specialists, and established collaboration channels and supply to China. The initiative was a leading Finnish government project under the MMM Blue Bioeconomy Development Plan.

In line with its strategy, CEMIS will continue to operate as a research and education centre specialising in measurement and information systems, with the main objective of supporting the Kainuu business community and its businesses by bringing new technology, business operations and new specialists to the region. Even though operations have a strong regional policy focus, the objectives and results of the Centre can only be achieved through international standards of excellence and with the aid of international co-operation and markets. CEMIS will accordingly continue to invest strongly in international

operations in coming years.

Besides its regional mission, CEMIS is also responsible for ensuring the vitality and finances of its partners. CEMIS will accordingly also focus on strengthening the finances of its partners by developing and commercialising service business operations and research findings. The three focus areas of CEMIS – Cleantech and Bioeconomy, Sports & Wellbeing, and developing international technology business – also give the organisation promising opportunities for exploiting its expertise internationally. CEMIS also has realistic prospects of selling its own competencies and those of its partners internationally, thereby further strengthening the vitality and technological expertise of the Kainuu Region.

Operating conditions for CEMIS in coming years seem favourable, even though the coronavirus epidemic that started in early 2020 will foster economic uncertainty, disrupting the functioning of society and people's lives more generally for a long time. With the LUMI EuroHPC supercomputer investment confirmed in 2019, Kajaani has a great opportunity to develop into an international data centre location. The status of Vuokatti as a national training centre for snow sports has also been further strengthened. CEMIS will not only seek to benefit from these favourable developments in the region, but also to continue reinforcing them.

The fifth CEMIS development programme for 2019-2020 has started as planned and in accordance with the Centre's current strategy and action plan. Settling and approving the budget for the new EU funding period from 2021-2027 seems to be a drawn out process, which will also delay the start of the next nationally administered EU regional development funding and the new EU research framework



Figure 3.1. CEMIS arranged a trip to China in June 2020, visiting Beijing, Nanjing and Zhangjiakou, the venue for the upcoming 2020 Winter Olympic skiing events. The trip included a visit to Beijing Sport University (BSU). The Kainuu delegation included Juha Kauppinen of CSE Entertainment (1st on left), Kajaani City Executive Board Chairman Teuvo Hatva (3rd from left), CEMIS Director Mikko Kerttula (5th from left), Sotkamo Municipal Manager Mika Kilpeläinen (6th from left) and KAMK Rector Matti Sarén (8th from left).

programme (Horizon Europe) in 2021. This delay between funding periods may cause operational problems for many RDI organisations, and also for the CEMIS partners if concrete planning of the next CEMIS development programme cannot begin until 2021.

The CEMIS strategy and action plan will be more extensively updated in 2020.

"CEMIS globalisation investments began to pay off in 2019, with a substantial rise in international funding and significant openings made in service sales and education exports."

Mikko Kerttula, Director, CEMIS



CEMIS 2019 in figures

2

NEW START-UPS

2

COMMERCIALY
APPLIED INVENTIONS

10

INTERNATIONAL
PROJECTS

0.3

EUR 0.3 MILLION IN
SERVICE BUSINESS
SALES

38

PEER-REVIEWED
SCIENTIFIC
PUBLICATIONS

2

DOCTORAL DEGREES
AWARDED

TOTAL FUNDING
OF THE CENTRE

12.6
MILLION EUR

0%

INTERNATIONAL
FUNDING

0.5
MILLION EUR

+85%

NATIONAL
FUNDING

1.3
MILLION EUR

-15%

PRIVATE ENTERPRISE
FUNDING

1.1
MILLION EUR

+19%

REGIONAL FUNDING

3.4
MILLION EUR

-7%

SELF-FINANCING

6.3
MILLION EUR

+2%

PERCENTAGES INDICATE YEAR-ON-YEAR CHANGE
COMPARED TO 2018

CEMIS Development Programme 2019-2020

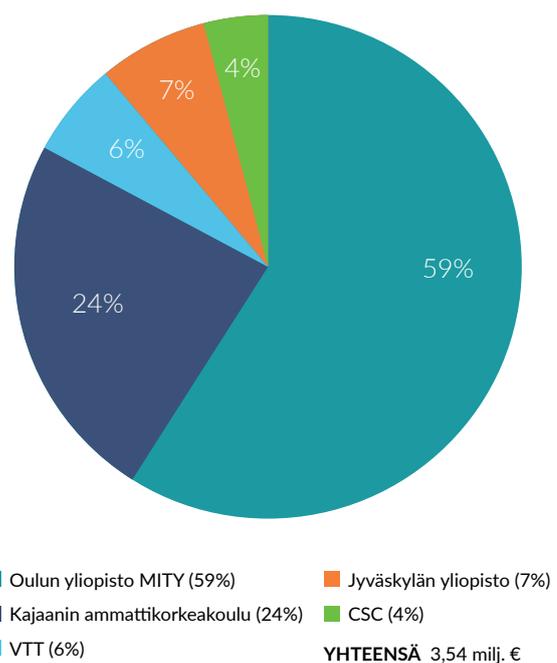
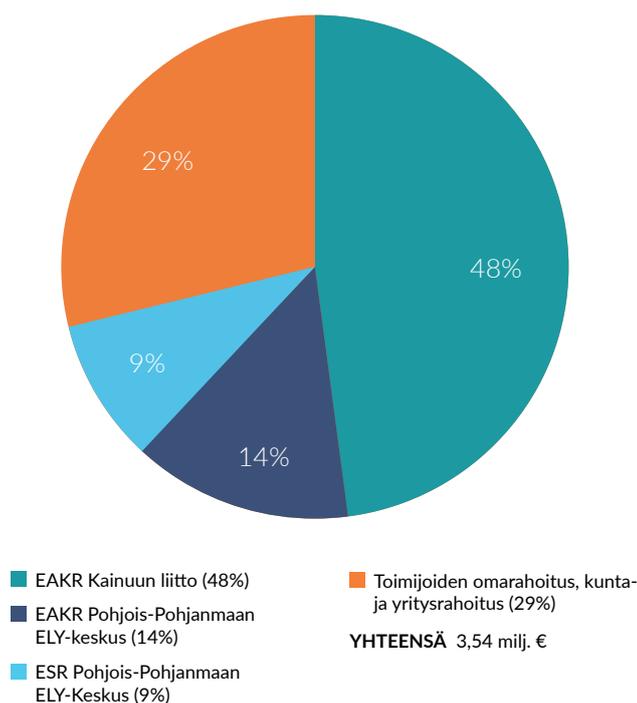
CEMIS Development Programmes are a key operational tool for achieving the Centre's objectives and realising co-operation between the CEMIS partners. The fifth two-year development programme was launched at the beginning of 2019 after joint preparation by the CEMIS partners, regional businesses and regional development financiers.

The development programme seeks to ensure that the Centre attains its qualitative goals of making teaching and research in the field of measurement and information systems more attractive, competitive and effective. The impact goals of the programme recognise national strategies, for example through Finnish government flagship projects, the programmes of EU Regional Development Funds, and the Implementation Plan for the Kainuu Regional Programme (TOPSU 2019-2020).

The two-year programme is mainly funded through the ERDF programme for Eastern and Northern Finland, with a total budget of approximately EUR 3.54 million. A steering group comprising representatives of CEMIS partners, financiers and businesses guides the programme and its projects. The programme implements joint technology development projects in technology and application fields that are crucial to the business development of local enterprises, develops co-operation in realising hardware solutions, implements marketing and PR measures related to programme outcomes, and promotes commercial exploitation of R&D project findings.

The specified general impact goals of the development programme are as follows:

- To reduce industrial CO2 emissions by developing solutions that enhance bioenergy generating and the mining industry
- To reduce environmental pollution by improving water management in process industries and mining
- To enable cost savings in social and health care by developing solutions for remote health care and independent monitoring of health and wellbeing by members of the public
- To increase national and international RDI funding and corporate funding for CEMIS and the Kainuu region
- To maintain the status of Kajaani as a centre of expertise in measurement technology
- To support the development of Vuokatti into a world-class destination for Nordic skiing



Kuva 4.1. CEMIS-kehittämisohjelman 2019-2020 rahoituksen jakautuminen toimijoittain ja rahoituslähteittäin.

- To give rise to new technology-based spinoff businesses in the operating region
- To improve international business opportunities for technology start-up enterprises in the operating region
- To increase the volume of service research by the CEMIS partners and enhance the commercialisation of research findings
- To increase national and international R&D funding and corporate funding in CEMIS and the Kainuu region
- To match training more effectively to the needs of growth enterprises

The programme seeks a further increase in corporate and international funding of the Centre compared to the previous 2017-2018 programme. Another objective is to establish at least six new enterprises and commercialise at least five technologies developed at CEMIS. The aim in teaching is to award seven doctoral degrees and release more than 40 peer-reviewed academic publications. The programme will seek co-operation with nearly 50 businesses.

The development programme comprises five projects whose content is described below. The KAIMIT project initiated during the previous 2017-2018 development programme was also continued in early 2019.

1. New, innovative and high-quality measurements and processes as part of the biorefinery and mining value chain (INNOBIO)

The INNOBIO project develops measurement solutions for bio, mining and process industries and environmental monitoring in the Kainuu region. This project seeks to reduce industrial carbon dioxide emissions by developing measurement solutions for optimising bioenergy generating and mining industry processes.

INNOBIO also works to develop fermentation expertise (bioethanol production) and to modernise associated existing pilot-scale apparatus. One concrete goal is to adopt artificial intelligence and machine learning environments to appreciate the nature of the data and how it should be processed with a view to realising the desired operation. Another study will investigate how measurement uncertainty can be verified when applying artificial intelligence or machine learning. The project was prepared in close partnership with key Kainuu-based businesses (including Valmet Automation Ltd., St1 Group, Elementis Finland and Terrafame Ltd.), and accommodates their needs.

The project measures are divided into five work packages:

1. Strengthening modelling skills for business needs
2. New innovations in the bioproducts industry
3. Process measurements for the bioproducts and extractive resources industry
4. Development of measurement analytics and quality assurance

5. Commercialisation and communication

The total project budget of EUR 940,062 was mainly channelled through the Regional Council of Kainuu (ERDF funding). The project leader is the Measurements Technology Unit (MITY) at the University of Oulu, with the Technical Research Centre of Finland (VTT) as an accompanying participant.

Project results

The project developed an electrochemical toxicity sensor prototype that will be subject to industrial field testing in 2020. The previous MITY fermentation test environment has been updated to meet the needs of the business community, with simultaneous updating of fermentation expertise. This will enable MITY to pursue further business co-operation in the region.



Figure 4.1. INNOBIO project researcher Tuomas Niskanen conducts fermentation trials.

2. Miniaturised measuring instrumentation solutions for monitoring industrial process and the environment (MINIME)

The project seeks to strengthen expertise in designing, implementing and piloting small measuring devices. It applies expertise in designing and building a small measuring device suitable for measuring lactate when monitoring a fermentation process, and a miniature (portable, drone-mounted) measuring solution for measuring low nickel concentrations. The project will yield new technological solutions for post-project commercialisation through corporate R&D projects. Growth in expertise will also enable further application of findings in other fields, such as health technology.

A further goal is to increase the information exchanges between real-time instrument manufacturers, industrial automation system suppliers, end customers and public authorities. The measurement techniques applied in the project are linked to long-term measurement expertise at MITY and to the use of international networks. Growing expertise, technology transfer and field testing will enable swifter post-project commercialisation of developed technologies for the region's businesses. Another aim is to accompany CEMIS partners to international cleantech trade fairs, where their expertise and

technology are marketed and partners are sought for further collaboration and commercialisation.

The total project budget of EUR 278,859 mainly comprises ERDF funding channelled through the Northern Ostrobothnia Centre for Economic Development, Transport and the Environment (ELY Centre). The Measurements Technology Unit (MITY) at the University of Oulu is responsible for implementing the project.

Project results

The MINIME project developed a device for measuring low nickel concentrations and an associated selective sensor. The measurement concept was tested by laboratory measurement and the device will be piloted with field measurements during 2020 and 2021.



Figure 4.2. Miniature nickel measuring device and selective sensor developed in the MINIME project.

3. Business Co-operation for Industrial Intelligent Solutions (TÄRY)

This project seeks to make businesses more competitive by supplementing KAMK expertise and training in operational maintenance solutions for industry and supplying this expertise to businesses during the project. Broader and more diverse operational maintenance training for industry will continue after the project ends as part of normal KAMK degree programmes and in-service training. The project will develop training for implementation in close partnership with enterprises. Besides improving the availability of enterprise labour and the standard of employee skills in target businesses, the project aims to improve the energy efficiency of enterprise production processes in line with the goals of sustainable development. The project also strengthens the profile of KAMK as a developer of intelligent solutions for industry and establishes a form of higher education in Finland that is currently rare but for which the need is evidently growing.

KAMK bears primary responsibility for implementing the project, and will do so in partnership with CSC – IT Center for Science, which will take charge of developing operational maintenance measurement data analytics. Project implementation will be supported by other CEMIS partners, with the Measurements Technology Unit (MITY)

at the University of Oulu responsible for developing process measurements and the Technical Research Centre of Finland (VTT) working to develop flow modelling. The total project budget of EUR 437,088 is mainly ERDF funding channelled through the Northern Ostrobothnia Centre for Economic Development, Transport and the Environment (ELY Centre).

Project results

Development of KAMK maintenance training on the TÄRY project during 2019. The Mechanical Engineering syllabus was revised to incorporate the development needs of maintenance training, defining these needs in partnership with the businesses involved in the project. The competence of maintenance teaching staff was strengthened by participating in several special training events in the field and studying the associated tools for modelling and processing measurement data. All previous maintenance training courses were revised and a few new courses were planned complete with additional course materials. Some courses were piloted during 2019 and some will be piloted in 2020 and later.

Besides improved training, another important goal of the TÄRY project is processing modern measurements and measurement data and developing presentation technologies. Newly acquired ACOEM condition monitoring measurement equipment was deployed for teaching and R&D during 2019, with discussions initiated to improve processing of maintenance measurement data using modern data analytics and machine learning systems.

The first student projects were implemented as the third set of project measures in 2019, with a student group seeking a solution to the maintenance challenges of enterprise partners. The first student projects were implemented for Normaint Oy and KAMK.

The activities, goals and results of the project were presented in the local press, at the spring meeting of the national PSK standardisation association, in the KAMK publication series, and by entering a separate booth at the Technology 2019 trade fair (Figure 4.3).



Figure 4.3. The TÄRY project was presented at the Technology 2019 trade fair in Helsinki on 5-7 November 2019.

4. Innovation platforms for wellbeing, health care and sport (HYTELI)

The goal of the HYTELI project is to develop technologically advanced innovation platforms and environments, and to increase associated global standard technological expertise and competitiveness in Kainuu. The starting point of the project is to apply the interdisciplinary expertise base of the regional CEMIS consortium to themes or sites that are important for regional business, such as preventative health care (health technology, nutritional health, intelligent home care) and the Vuokatti elite sports environment and sports tourism.

The themes are relevant to enhancing measurement technology expertise in Kainuu, increasing the standard and competitiveness of international RDI and developing the wellbeing and tourism industries, and they are also of national and international importance. The development of innovation platforms and environments will promote technological capacity and the stock of expertise, providing a basis for reacting swiftly to the needs of businesses and thereby increasing service business operations and creating new jobs.

Innovation platforms developed in the project will be applied both through commercialising innovations (including proof-of-concept), by partnering with businesses and other stakeholders to develop service business operations in innovation environments, and by investing in achieving high-quality and comparable measurement results. The project includes significant high-quality new initiatives and global standard special expertise, such as malnutrition among the elderly and an initiative on nutritional supplements: the use of wood industry side streams to promote health and wellbeing - whose economic importance to Kainuu will be considerable in an optimal scenario. The project also seeks co-operation in the field of social services and health care, for which an interdisciplinary project consortium may be able to generate solutions for the future. Data analytics, artificial intelligence and machine learning are new methods in application development of intelligent home care and elite sports testing, and now is the right time to adopt them in Kainuu. The project will also benefit from the unprecedented interest of the international and Asian winter sports community in Vuokatti, with further rounds of interest to arise.

The project task packages are:

TP1 Health technology innovation platforms: a) Nutritional health of an ageing population (e.g. use of wood sidestreams to promote wellbeing and health, b) Unlabelled biosensor measurements and other new rapid measurement technologies, c) Quality assurance of health technology innovations, d) Intelligent home care systems.

TP2 Sports technology innovation platforms - from laboratory to field: a) Trials of miniature solutions in sensor technologies for skiing and biathlon, including printable sensors, b) Measurement technology: including determination of the propulsion component in skiing, simulations of elite competition tracks, c) Reaction to needs of the field: Finnish Olympic Committee and sports federation partnership and business co-operation.

TP3 Data analytics, artificial intelligence and machine learning: a) Increasing the skills of project organisations, b) Pilots: Intelligent home care, dynamic balance, propulsion component in skiing, c) Application of data fusion methods: Visualization and design tool for area or space based on 3D modelling.

TP4 Application of findings: Preparation of national and international projects based on project findings, communication, networking and publishing activities.

The targeted project outcomes are two commercialised health technology products, two service analytics products and four new service business jobs, and one spinoff enterprise or product in the field of sports technology. The project will also increase the volume of service business for project partners, and seek EUR 1.7 million in national project funding and EUR 1 million in international funding.

The total project budget of EUR 1,452,000 is mainly ERDF funding channelled through the Regional Council of Kainuu. The project is co-ordinated by the University of Jyväskylä, with all of the other CEMIS partners involved in its implementation, i.e. the Measurements Technology Unit (MITY) at the University of Oulu, KAMK, the Technical Research Centre of Finland (VTT) and CSC - IT Center for Science. The project has a strong collaborative link to the KAMK CBD team BUZTECH project.

Project results

TP1: Health technology innovation platforms

Nutritional health of an ageing population; functional food components in wood: The first isolation tests of pectin found that more pectin is obtained from spruce bark than pine bark.

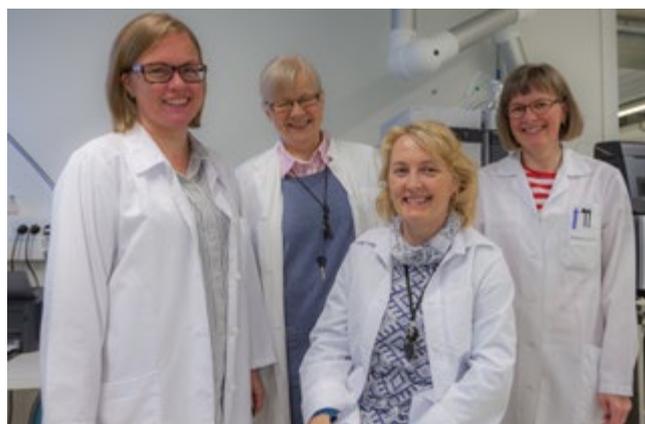


Figure 4.4. Natural raw materials and compounds that have an impact on health are a familiar field to this Measurements Technology Unit quartet. From left to right: Marianne Mäki, Hanna-Liisa Malinen, Mari Jaakkola and Riitta Lotvonen. Long-term Unit employee Hanna-Liisa Malinen retired shortly after this photograph was taken.

Finishing and quality specifications for health technology innovations:

Microbial analysis services were arranged and sold during the year. A DNA contamination assay was also developed and established, and commercialised through a long-term supply contract. An invention notice was written and submitted to the University of Oulu for a biosensor measurement and measuring device suitable for POC

diagnostics. The application submitted in the notice was measurement of insulin from saliva.

Smart Home Care: The first health imager prototype was completed. The goals of the method are wireless health measurements, intelligent login and control methods, interactivity, informativeness and a high degree of usability.

TP2: Innovation platforms in sports technology

Printed sensors for the biathlon rifle: The first prototype of a trigger sensor for the biathlon rifle was completed, and co-operation was also launched with Riga Technical University to develop a textile sensor for a biathlon application.

Sensors to be integrated into skiing equipment: The first prototype freestyle roller ski sensor (integration into commercial roller skis) was completed and tested by skiers in the Vuokatti ski laboratory. Some hysteresis emerging in the tests suggested the idea of an aluminium-frame test roller ski. A plan for a 3D-printed ski pole sensor with measurement electronics integrated inside the pole handle was also realised during the year.

Responding to needs of the field: The ski tester was applied by selling and implementing a ski wax testing service for a Finnish ski wax brand. The electronics of a miniaturised electromyography (EMG – muscle activity) measurement module were also completed.



Figure 4.5. Prototype of an aluminium-frame test roller ski developed under the HYTELI project to integrate force sensing into the wheel suspensions and within the frame.

TP3: Data analytics, artificial intelligence and machine learning

Building competence: CSC – IT Center for Science arranged a machine learning workshop with the participation of project staff.

Development of data fusion methods for area modelling: A virtual model of the Ruka MC sprint route suitable for race simulations and based on the data fusion method was completed in summer 2019. This was successfully brought to the Vuokatti ski laboratory environment, where skiers tested the model.

TP4: Application of findings, communication, networking, business co-operation

- 4 new national project funding decisions (connection to project activities or results)
- 7 new business partners
- 0.5 person-years of new employment (connection to project

activities or results)

- 2 publications

5. Strengthening and developing the technology business environment (BUZTECH)

The BUZTECH project will create a model to improve the early stage success prospects of an enterprise, and will test it in practice on the most promising technologies at CEMIS and in the Kainuu and Northern Ostrobothnia regions. The project will also identify and apply international business opportunities, develop and strengthen networks, and actively contribute to commercialising CEMIS technologies and service business concept development. The opportunities identified during the project will be refined through early-stage technology and market studies. This supports development of the business environment and efficient use of regional resources in important focus areas, and increases the expertise of technology business operations in the project area.

The project seeks to create new technology-based spinoff enterprises, develop a business environment for technology-based start-ups by locating and defining business opportunities, develop national and international networks, and apply developed technologies. It also aims to develop a model that improves the early-stage success prospects of a business by shortening and avoiding the death valley stage, and to develop service business concepts together with the CEMIS partners and identify demand for them in the international market.

The project is implemented by KAMK and the CEMIS Business Development Unit (CBD), and supports all of the CEMIS partners through parallel CEMIS development projects. The total project budget of EUR 299,810 mainly comprises ERDF funding channelled through the Northern Ostrobothnia Centre for Economic Development, Transport and the Environment (ELY Centre).

Project measures and results

Previous CEMIS development programmes have exposed a clear need to develop the commercialisation of innovations arising from CEMIS operations and more generally in Kainuu, and particularly the establishment and securing of new start-up enterprises during their initial operating years. From this perspective, the BUZTECH project sought to develop a model that improves the success prospects of early-stage businesses, helping them to shorten and avoid the death valley situation in which R&D funding runs out but the business operation is not yet generating sufficient cashflow to sustain and expand the enterprise. Developing the model involved interviewing more than 30 Finnish high-tech start-up enterprises nationally, many of which have a higher education background and are characterised as spinoff undertakings. The enterprises invited for interview represent similar technology sectors to those developed by CEMIS. These enterprises included businesses working in cleantech, artificial intelligence, IoT, sports, health and wellness technologies, virtual and augmented reality (VR/AR) technologies, and various industrial services and measurements, including companies listed in Industry

4.0.

This interview research was extensive, even by national standards, and produced a large volume of new material for analysing and further developing the model, publishing, and identifying the best practices of start-up enterprises in CEMIS operations. The analysis and identification of best practices was carried out in 2019 and development of the model will continue into 2020. Although processing and managing the material has been quite resource-intensive, the findings will be applied in the work of the CBD Unit, and more broadly at CEMIS in a wide variety of ways in the future. The eventual findings may not only help to promote the commercialisation of CEMIS technologies, but also support other regional and subsequently national innovations and start-up enterprises. The material will also be used in various articles and publications.

The BUZTECH project plays a broad and important role in CEMIS co-operation and networking. It is implementing measures to support the emergence of new technology businesses from CEMIS operations, together with the development of other commercial operations, such as conditions and concepts of the service business. Complemented by international activities such as trade fair participation and networking, the technology market studies carried out in the project will lay the foundations for planning and commercialising various promising CEMIS technologies. The findings of the interviews conducted in 2019 also complement the general understanding and knowledge of start-up operations and their development.

The BUZTECH project completed a total of ten technology market studies on CEMIS technologies in 2019. These studies focused on the application and potential of internationally evolving technologies with CEMIS solutions, such as artificial intelligence, natural language processing, digital twins and augmented reality. It is important to know which regional industries could benefit most from these opportunities, and equally important to determine how such technologies complement CEMIS innovations or help in developing new ones. Market studies and their analysis often already determine whether commercialisation of innovations is possible or sensible. These market studies and freedom of action studies used both publicly available sources and commercial databases acquired through project funding. To avoid infringing the intellectual property rights of another party, CEMIS technology development and its design must always allow for overall international market potential and perform freedom of action studies prior to commercial exploitation.

Project Manager Anas Al Natsheh, PhD, has directed the process of international networking, co-operation and charting of business opportunities. The CBD participated in several technology business trade fairs and in developing partnerships, especially in strategic target countries such as China, Russia and Brazil. Dr Al Natsheh visited the cities of Petrozavodsk and Kazan to study the needs and opportunities for digitalisation of Russian industry and SMEs. Co-operation continued in the direction of the Brazilian mining industry in September 2019 with a visit by CBD representatives to Belo Horizonte, where several large mining companies in South America operate. Project manager and CEMIS Director Mikko Kerttula visited

several sites in China in November, focusing on opportunities for VR/AR technologies and game technology in particular, and on opportunities for co-operation in the cleantech sector.

Regional information initiatives included CBD participation in the Big Friday event in January and the International Congress on Science and Skiing (ICSS) conference organized by the University of Jyväskylä in Vuokatti in March 2019. A great deal of CEMIS information and marketing material has been distributed to Finnish start-ups during various trips and the foregoing events, and at enterprise interviews. This work seeks to further increase the visibility of CEMIS activities and results, and to open up new opportunities for co-operation. The BUZTECH project will continue until the end of 2020. Project activities in 2019 have previously been presented in an article in the KAMK Technology competence area publications series. The Finnish language article is available at the following link: <https://www.theseus.fi/bitstream/handle/10024/268139/Teknologia%20osaamisalueen%20hankevuosi%202019%20over%201.1.pdf?sequence=2&isAllowed=y>

6. New environmental measurements for mining and other industry effluent (KAIMIT)

KAIMIT is a project from the previous CEMIS development programme (2017-2018) whose implementation was continued into 2019. The project seeks to realise effective new measurement methods for monitoring sulfate and phosphate concentrations in industrial effluent. There are currently no cost-effective and reliable methods on the market for monitoring low sulfate and phosphate concentrations. This project developed approaches based on electrochemical and optical methods, constructed demonstration devices for field measurements, and piloted them at industrial sites. It also sought to increase communication between equipment manufacturers, system integrators, end-customers and public authorities concerning the prospects for real-time measurements.

Project implementation was divided into five work packages:

1. Real-time monitoring and competence development
2. Piloting measurement solutions at fixed measuring 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 sought to implement new technological solutions for subsequent commercialisation through corporate R&D projects. This aim was supported by developing and piloting some 2-3 technologies for real-time measurement of sulfate and phosphate concentrations in industrial effluent. The aim of these technologies was to help build systems for efficiently monitoring watercourses, optimising treatment processes and preventing environmental pollution.

The total project budget of EUR 399,707 was mainly ERDF funding channelled through the Northern Ostrobothnia Centre for Economic

Development, Transport and the Environment (ELY Centre). The project was implemented by the Measurements Technology Unit (MITY) at the University of Oulu.

Project results

One cornerstone of developing measurement methods and hardware is the use of benchmarking - comparing the results obtained with 'correct' results. MITY has experience from previous projects of using capillary electrophoresis (CE) technology for various compounds, including sulfate assays. The functionality of CE technology was verified for samples in the KAIMIT project. The reference measurement gives sulfate concentrations to an accuracy better than 0.01 g/L, which is sufficient for many applications. The CE method can also measure phosphate, with an optimised CE method capable of determining phosphate concentrations no smaller than 5 mg/L. This means that the sensitivity of the CE method is insufficient for determining phosphate when assessing eutrophication of environmental waters. SFS 3026 (Finnish Standards Association), a standard spectrophotometric method for determining total phosphorus, was accordingly deployed in the laboratory. This method can be used to measure phosphorus concentrations between 10 and 750 µg/L.

The project challenge for field equipment was approached using optical and electrochemical measurement methods. The optical method applied a multi-measurement approach that examines the sample in several ways. This proved effective when studying the waters of three sulfate-containing lakes in Kainuu, as well as industrial effluent. A mobile measuring platform was used for the field tests. Electrochemical resistance measurement was also able to determine sulfate, especially at low concentrations. Although the electrochemical method yielded promising results for the phosphate challenge, the apparatus could not be tested under field conditions. Use of the methods developed, the hardware and the increased expertise may continue in various future applications, and commercial studies will also continue. The established sulfate and phosphate comparison methods have broadened the range of services supplied by the implementing unit.



Figure 4.6. An optical multimeter for fluid analysis, conceived, designed and realised in the KAIMIT project. The picture shows the sample chamber disconnected from the measuring device.

Operations of the Measurements Technology Unit (MITY) at the University of Oulu

MITY was reorganised into a single research group format in September 2019, with continued operations in Cleantech and Health and wellbeing. The staff of the previous groups were wholly reassigned to the new group. The unit operates in Kajaani, but also conducts project activities in Vuokatti.

The main research application fields in 2019 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 university research fellowship in imaging measurements continued in 2019 and was jointly financed by optoelectronics laboratory projects at the University of Oulu and project funding from the Kajaani Unit. Both research teams included postgraduate degree students.

The volume of unit operations was approximately EUR 3.3 million. A staff of 42 people completed some 36 person-years of work over the year. The ten staff members holding a doctoral degree performed 26 per cent of this total workload.

One new initiative in 2019 was a professorship in biorefinery measurements based at MITY premises, launched with co-financing from the City of Kajaani, the Kainuu Association, St1 Oy, the University of Oulu and the Faculty of Technology of the University of Oulu. The start-up phase for the first three years includes establishing a research group in Kajaani and Oulu, and arranging teaching and research in the field. Mika Ruusunen, PhD, from the University of Oulu, was appointed professor. The professorship will focus on developing automated optimisation of measurements and production efficiency of bio-based raw materials, their refining processes and the resulting sidestreams. The research team will accordingly work on MITY premises in Kajaani.

International project work

A study of co-channel interference due to electromagnetic scattering by raindrops at the THz frequencies used by future 5G/6G applications was completed in partnership with the Center for Wireless Communications (CWC) of the University of Oulu as part of the Terranova EU project. The findings of this work were presented at an international flagship conference on communications (IEEE ICC 2019).

An Interreg Nord project "Ice Proof Arctic - Innovations for ice and snow management" validates and develops new ice and snow management solutions for eliminating ice loads on power lines, optimising the efficiency and safety of renewable electric power

generating, and monitoring snow loads on roofs.

The EIP-AGRI SMART FEED project financed by the Finnish Agency for Rural Affairs is collaborating with two Estonian EIP projects (European Innovation Partnership). The Estonian projects are co-ordinated by the Estonian Dairy Cluster and the Estonian University of Life Sciences. This collaboration has attracted interest at European level.

CEMIS co-operation

The work of CEMIS continued in 2019 with CEMIS Development Programme projects (INNOBIO, MINIME, KAIMIT and HYTELI):

- INNOBIO - New, innovative, high-standard measurements and processes in the biorefining and mining value chain: This project seeks to develop measurement solutions with a view to lower-carbon industrial processes and more efficient wastewater monitoring, reducing the risk of water pollution. A further aim is to exploit bioeconomy sidestreams developed by new process technology solutions, and to enhance fermentation expertise and modernise existing equipment. The fermentation apparatus was upgraded in 2019, with steps taken to develop a real-time measurement system for flotation chemicals used in the mining industry.
- MINIME - Miniaturised measuring instrument solutions for monitoring industrial processes and the environment: Financed by the Northern Ostrobothnia ELY centre, this project is developing small measuring instrument solutions for measuring lactate in various industrial applications and nickel in watercourses near mining operations (Figure 5.1). Research in 2019 focused on nickel measurement and equipment solution design. MITY will be able to conduct the associated field tests in summer 2020.
- KAIMIT - Novel environmental measurements for mining and other industry effluent: This project focuses on developing new measuring methods for monitoring industrial effluent, with particular reference to sulfate and phosphate assays lacking reliable and cost-effective commercial field measurement solutions. The implementing unit is applying its cutting-edge expertise in electrochemistry and optics/photonics to this research challenge. Methodological progress will also apply the

principle of multimeasurement, combining signals from several modes of measurement. Promising results have been achieved, particularly in (field) measurement of sulfate. MITY and VTT have continued applying computer simulation for understanding processes and phenomena in research and hardware development, with simulations performed especially for fluid flows and electrochemistry. The project will end in early 2020.

- HYTELI - Innovation platforms for wellbeing, health care and sport: a project co-ordinated by the University of Jyväskylä. MITY is developing measurement of nutritional markers, completing the biosensor measurement of salivary insulin, isolating and studying health-affecting compounds in wood, setting up various quality assays to supply as service analytics to Kainuu businesses, and conducting trials of new technology in the fields of POC diagnostics and health and wellness. The first new quality specification was commercialised in 2019. Previous CEMIS projects applied expertise developed in the field of wellbeing and health measurement by selling external services and in designing a ground-breaking project on the health impacts of timber construction, for which a funding decision was issued in the autumn.

The CEMIS Development Programme has again combined expertise in the field with collaboration between Jyväskylä and MITY, and between MITY and VTT. Research co-operation with the University of Jyväskylä and VTT was also reinforced through Business Finland projects. Director Vesa Virtanen was involved 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 had 3 ongoing projects funded by Business Finland.

1. The DentSaver project (Tools for low-threshold oral health care, Business Finland, TUTLI funding) developed an oral health screening and care guidance service for health kiosks for assessing oral health outside of dental clinics.
2. The CRYSTAL project (Challenge Finland funding from Business Finland) seeks to improve the ophthalmic healthcare chain by providing a new computer-aided solution for detecting symptoms of ocular disease. The outcome of this project is an application that collects and analyses information on various tests and measurements related to ocular health (visual acuity, intraocular pressure, retinal image, field of view). The application analyses the retinal image, combining the results of all tests into an observation report and reporting the risk of disease in the light of the observations.
3. The EXTREAM project (Extraction of valuable compounds from bioeconomy industry sidestreams) is linked to an existing industrial ecosystem. This project applies environmentally friendly extraction technology (supercritical carbon dioxide extraction) to sidestreams from the mechanical forest industry and forestry residues to produce fat-soluble biochemicals, and develops a real-time method for measuring the size of wood chips. The first piloting period of the extraction technology was conducted in Austria in June 2018, with the second period in February 2019. These piloting trials used a five-litre apparatus with various forest industry sidestreams. A third pilot trial was conducted in Austria using an 80-litre supercritical fluid extraction (SFE) apparatus that is scalable to factory dimensions. The findings also enable profitability calculations. Real-time measurement of piece size was piloted in an MITY in-house environment.

Besides its CEMIS Development Programme and Business Finland projects, MITY had ten other ongoing initiatives, pursuing industrial collaboration with dozens of enterprises in the Kainuu region and nationally.



Figure 5.1. The MINIME project has developed a field measuring device and sensor for low nickel concentrations.

The unit is involved in a project funded by the Academy of Finland entitled Single-photon detector array for simultaneous label-free Raman and fluorescence lifetime spectroscopy. This involves developing combined Raman/fluorescence lifetime hardware.

Funded by the Finnish Agency for Rural Affairs, the PALKO 2 and PALKO 3 projects entitled Improving the Quality and Safety of Natural Products focused on enhancing research in the field of natural products based on the needs of business. PALKO 2 conducted extraction trials, using them to formulate training packages, and also developed analytics for studying the activity of cosmetics based on cell culture testing. Responsibility for training course development was outsourced to Kainuu Vocational College (KAO) as a subcontractor, with the foregoing measures implemented in other respects by MITY as project co-ordinator. PALKO 3 used various enterprise samples to optimise and finalise the development of analytics. Ten natural product industry businesses were involved in this project. The PALKO 2 and 3 projects ended in December 2019. The projects led to the establishment of three new natural product businesses in Kainuu and initiated development of Arktinen Biolaakso, an enterprise-driven natural product network. The projects also generated research expertise that assisted in planning collaboration to prepare a joint international application on natural products and cosmetics with an Irish partner.

Financed by the European Social Fund, the ELY Centre KOS project seeks to supply training for the needs of the growth and structural change sectors. Systematic collaboration between research institutes and universities and the world of work will also be strengthened, enhancing research and development. The project develops business in a wide range of operating fields, such as biomass refining, digitisation of healthcare, the nutritional health of the elderly, and cleantech measurements. It was involved in arranging a national

research seminar in the natural products sector held in Kajaani in November 2019. This seminar attracted more than 100 people from business and research organisations throughout Finland.

The KryoMikro project studies the suitability of two untapped technologies in the Finnish process industry – cryoconcentration and microwave processing – for processing food and natural products, and for treating fractions recovered from wastewater streams. This project has made Finnish operators aware of technologies that are gaining ground globally, and able to use them in improving the viability, productivity and competitiveness of their operations. Project work in 2019 included a microwave drying pilot in Italy using nettles from Kainuu. The KryoMikro project will end in April 2020.

Financed by the Finnish Agency for Rural Affairs, the national “smart measurements in cattle feeding and healthcare” project (ÄLYREHU) is one of eight Finnish EIP projects in agriculture (European Innovation Partnership). It works with farmers and specialists to improve on-farm measurements and data communication applications that monitor fodder quality and the welfare of livestock.

Co-funded by the European Maritime and Fisheries Fund (EMFF) and co-ordinated by Natural Resources Institute Finland (Luke), a large-scale project entitled Successful fish releases assigns MITY to discharge a proof-of-concept (PoC) segment, with a view to developing field-capable measurement of cortisol stress hormone suitable for use in fish farm basins.

MITY has also been involved in three proof-of-concept projects funded by the University of Oulu Innovation Unit. The findings of one project were used as preliminary tests in support of a Good for Livestock EIP (European Innovation Partnership) project application. Another project trialled a wide range of methods for measuring polyamines in urine samples. Polyamines could be significant in future



Figure 5.2. A supercritical fluid extractor moved from Oulu to Kajaani in 2019. Researchers from the MITY and Biorefinery Measurements research group are now examining its use.

as a general marker for cancer. The Dent AI PoC sub-project of the CHT DigiHealth HUB dental data collection project was also ongoing.

Research collaboration and publications

Fruitful co-operation continued with the Joensuu campus of the University of Eastern Finland. This was enlarged to include research on microplastics in watercourses and their detection, with a view to developing a measuring device for attachment to vessels that will detect the presence of microplastic particles in real time. The research work produced a publication and two manuscripts in 2019.

MITY is involved (between 2018 and 2020) as an academic mentor in Bioeconomy specialisation training, a joint educational project of the University of Eastern Finland (Kuopio and Joensuu campuses) and the Savonia and Karelia universities of applied sciences. Besides mentoring, the MITY laboratories and their equipment have been available for academic thesis work.

International researcher exchanges amounted to some 21 person months. Active international co-operation involved more than ten research institutions from countries including Italy, Denmark and the United Kingdom. A healthy number of academic articles were released, with 6 refereed international scientific articles and 16 conference publications. Unit staff participated in national and international evaluation assignments (peer reviews for academic journals, and assessing international project applications).

Operations of Kajaani University of Applied Sciences

Kajaani University of Applied Sciences continued stable operations in 2019 with some reorganisation and other reforms. These findings were also reflected in several key R&D figures. Some 72 development projects were ongoing over the year, including ten international projects. The total volume of projects was over EUR 4 million. The launch of three new Karelia CBC programme projects was particularly gratifying, and the first international summer school in the mining industry was also successfully organised.

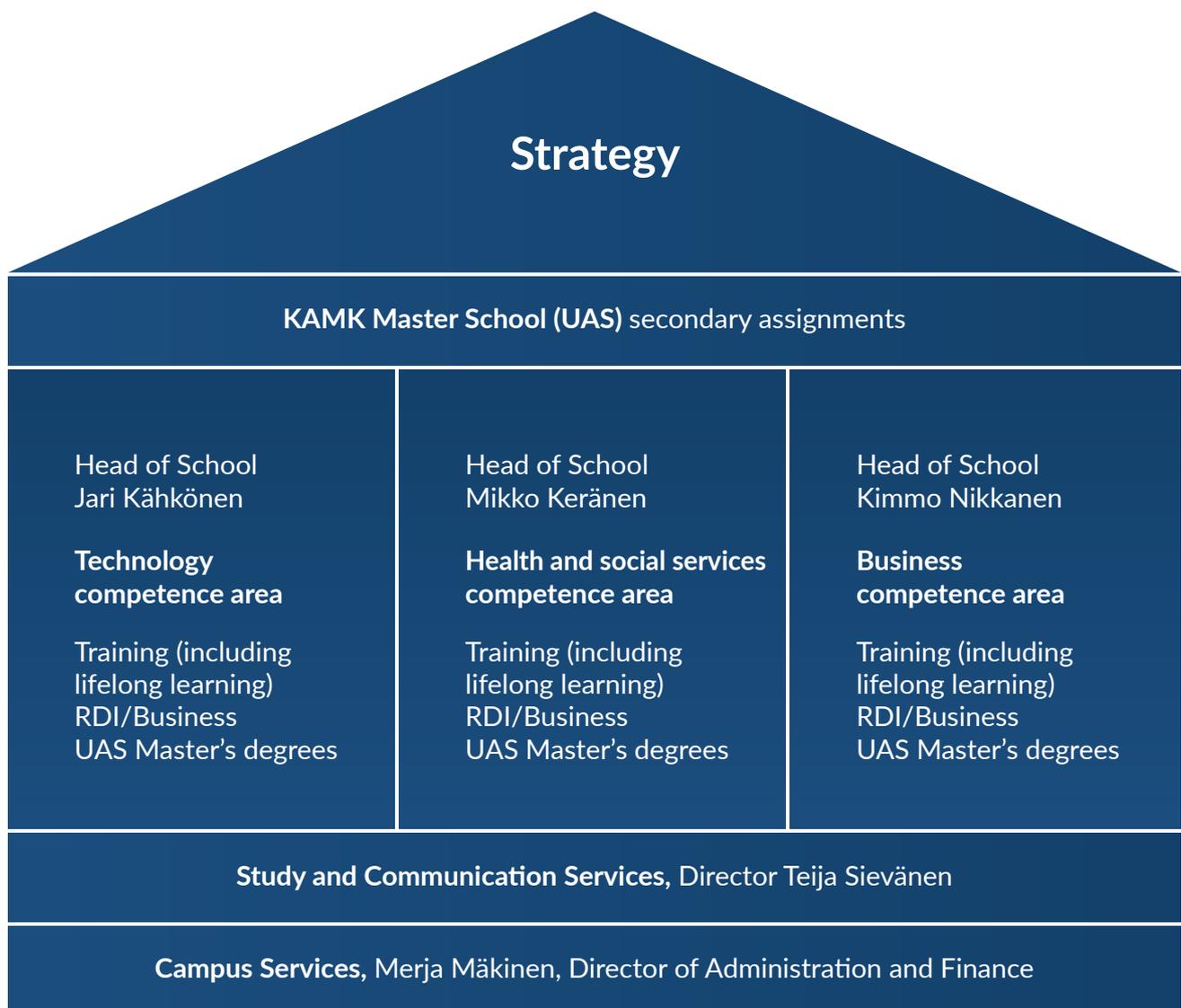


Figure 6.1. Reformed organisation of Kajaani University of Applied Sciences as of 1 April 2019.

Work to formulate a new strategy began at Kajaani University of Applied Sciences in 2018 under the leadership of the Board, with a restructured organisation launched on 1 April 2019. The most visible change for CEMIS was a merger of the Information Systems and Mechanical and Mining Technology areas into a new Technology competence area that also includes the CEMIS Business Development (CBD) Unit and its staff.

KAMK also expanded its territorial coverage as shown on the map in Figure 6.2, exerting influence either through RDI or training, or a combination of both. This included negotiations during 2019 on new daytime training services for the Raahelä region in autumn 2020 targeting undergraduate degrees in mechanical engineering and computer science.

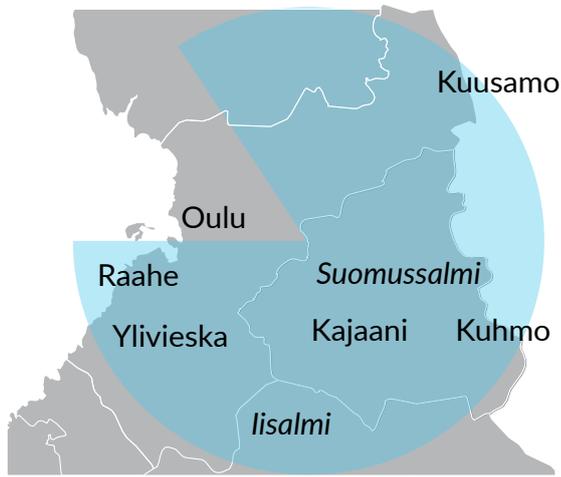


Figure 6.2. Territorial coverage of Kajaani University of Applied Sciences.

The revised competence area

We initiated vigorous development work and syllabus reform in mechanical engineering training, in which a revised study programme stressing process industry expertise will be introduced in 2020. We also launched From Data to Artificial Intelligence, a new IT training specialisation, as part of the engineering degree programme. Design of a data ecosystem has simultaneously begun in the region, including all regional operators interested in data, data processing and their commercial applications. This is also supported by our Data Processing Datacenter training as part of business administration training, and by the games industry.

Training in Intelligent Systems and games technology will also continue as part of IT engineering training.

Key figures for 2019 in this competence area were 88 completed first degrees and eight postgraduate degrees. 55 publications were released, with about 70 staff members divided roughly equally between teaching and RDI functions.

The EMC and condition laboratory services traditionally provided in-house by KAMK were contracted out to Sunit Ltd.

The technology competence area continued the still ongoing TÄRY, HYTELI and BUZTECH projects of the CEMIS development programme.

CEMIS Business Development Unit 2019 - expanding capacities

The CEMIS Business Development Unit (CBD) will implement the CEMIS development programme BUZTECH project at KAMK in 2019–2020. BUZTECH focuses on identifying and exploiting international business opportunities, strengthening national and international networks, supporting the commercialisation of CEMIS technologies, and developing service business concepts. The project seeks to generate new expertise to help early-stage technology businesses overcome typical problems during their first operating years. While the BUZTECH project formed an important part of CBD Unit operations, the unit and its staff were also involved in several

other, equally challenging and demanding technology business development projects with varying workloads. Working on various projects has also greatly increased the capabilities of the Unit. The CBD Unit is led by Dr Anas Al Natsheh and employed four business development specialists and two student interns during 2019.

The CBD Unit worked on and was responsible for the KAMK projects OredVR (financed by ERDF, the Regional Council of Kainuu and private enterprise) and Future Mine (financed by Business Finland), both of which are related to the digitalisation of mining operations using VR/AR/XR technologies and applications. The Unit is responsible for project commercialisation measures. This reflects several years of vigorous RDI work at KAMK, and particularly the partnership between the CBD Unit and the Virtual Industrial Solutions (VIS) team responsible for technical project implementation. These projects have involved engaging in substantial discussions with industry operators, conducting specialist interviews, and gathering preliminary test feedback. Background work has included competitor analyses and studies of intellectual property, together with ongoing investigations and monitoring of digitalisation in the mining industry and associated business formats. The evolving solutions and operations of both projects have secured encouraging feedback from stakeholders, and this co-operation will continue in 2020.

The DigiVision micro-project implemented under the Karelia cross-border co-operation (CBC) programme supported the creation and development of cross-border business co-operation between Russian Karelia and Kainuu. KAMK and the CBD Unit implemented this project in partnership with Petrozavodsk State University. The strengthening and developing network with Petrozavodsk has since expanded to include other projects and co-operation in which KAMK is involved. Besides these projects, CBC Unit staff have also participated in other KAMK and CEMIS projects. One common factor in these projects has been industrial digitalisation and related expertise, which accelerates and develops Finnish business internationally in various fields, such as water management.

The CBD Unit has been involved in the Biogas for Future Electric and Gas Grids (BIOFEGG) project (2018-2020). Biogas is one of the most promising forms of energy generating that has not yet been fully exploited. Financed by Business Finland, the BIOFEGG project seeks to improve the quality of biogas, test new methods in the anaerobic digestion process, and develop novel purification methods, such as removing siloxanes. Besides co-ordinating the project, the CBD Unit has been involved in implementing various work packages and measures, such as defining the customer needs and market potential of solutions and formulating a plan for exploiting results. The project will be implemented by an international consortium of four industrial partners and four research partners in Austria, Sweden and Finland. KAMK is co-ordinating the project. The experience gained in the BIOFEGG project will be important for KAMK and the CBD Unit, with efforts made to apply the acquired expertise and network in future.

Operations of VTT Technical Research Centre of Finland in Kajaani

The operations of VTT Technical Research Centre in Kajaani during 2019 continued to focus on the metrology work of VTT MIKES. The Kajaani facility of VTT MIKES is the world's northernmost measurement standard laboratory, operating from purpose-built premises at Renforsin Ranta Business Park since 2011.

VTT MIKES is a separate field of research within the VTT organisation. As Finland's National Metrology Institute (NMI), it is responsible for implementing SI measurement units in Finland and for developing, maintaining and co-ordinating the national system of measurement standards. VTT MIKES develops new methods and technologies for enterprises to realise reliable measurements and metrological traceability. VTT MIKES calibration services enable tracing of industrial measurements to the internationally approved SI system.

The work of VTT MIKES in Kajaani has focused on calibration services for force, mass, torque and fluid flows, and on industry research. The national measurement standards for force, torque, fluid flow and masses exceeding 20 kg are kept in Kajaani. They are used to calibrate measuring instruments, meaning that they are used to determine the magnitude of error displayed by the instrument being calibrated. VTT MIKES Kajaani is involved in the work of the national VTT metrology stakeholder group.

2019 was a steady operating year for VTT MIKES. There were some changes in staffing, but the impact on human resources was soon minimised with new recruitments. The Kajaani facility has a staff

of seven employees. Traceability services and research operations progressed as expected over the year. The annual clientèle has remained steady at about 250 clients per year, with over 95 per cent based outside the Kainuu region. There are more foreign than Kainuu-based clients. The location of the laboratory has proved well suited to its operations and appropriate for its clients over the years.

International co-operation

The Kajaani research team has been actively involved in the work of the European Association of National Metrology Institutes (EURAMET), including participation in its technical meetings. Kajaani staff members also represent Finland on the EURAMET Technical Committee for Flow (TC-F) and on the TC3 (Measurement of Force, Mass and Torque) technical committee of the International Measurement Confederation (IMEKO). During 2019 VTT MIKES Kajaani was involved in three projects (MultiFlowMet II, MetroWaMet and ComTraForce) of the European Metrology Programme for Innovation and Research (EMPIR), and in preparing one project related to wind power plants in which torque measurement plays an important role.



Figure 7.1. The VTT MIKES Kajaani facility in Renforsin Ranta Business Park.

Research

VTT MIKES Kajaani actively participated in implementing the CEMIS development programme joint projects INNOBIO (New, innovative and high-quality measurements and processes as part of the biorefining and mining industry value chain) and HYTELI (Innovation platforms for wellbeing, healthcare and sports).

The HYTELI project is co-ordinated by the University of Jyväskylä, with VTT providing special expertise in measurements, measurement methods and equipment for use in skiing. A design for roller skis was completed in 2019, including measurement of vertical and lateral forces as an integral element. FEM calculation was applied in the design work. Construction of a ski prototype will take place during 2020. This prototype will be force-tested using the VTT MIKES force standard apparatus, which provides important information on the reliability of empirical and computed results.

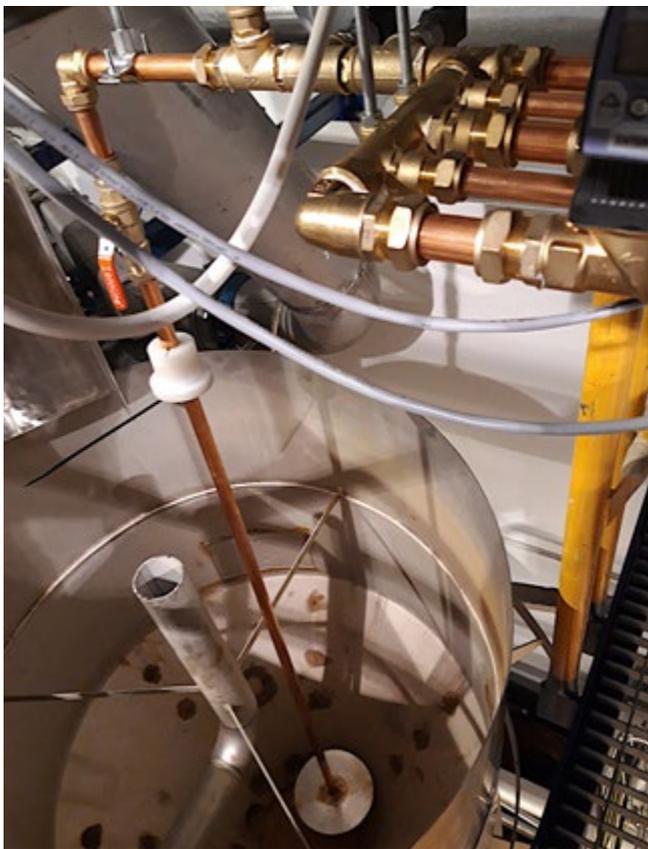


Figure 7.2. Part of the European Metrology Research Programme (EMPIR), the MetroWaMet project included designing and building a flowmeter testing apparatus suitable for small water flows. The apparatus uses valves to regulate flow, with weighing scales that serve as a reference. The flow range used is from 50 to 3,000 kg/h.

VTT MIKES Kajaani assisted in the INNOBIO project by further developing its own CFD (Computational Flow Dynamics) expertise with a view to using open source tools (such as OpenFOAM®) more effectively in CFD calculations. The challenge is to make complex models with moving parts work in a computing environment. The longer-term goal is to produce research findings on how well the results obtained from computational models correspond to empirically measured results.

VTT MIKES Kajaani has also been involved in preparing other publicly financed research projects and in customer-oriented research projects. These research questions also related to the quantity fields maintained in the unit, and to their application in various measurements.

Outlook for 2020-2021

The outlook for 2020 is promising. New research projects are under way in which metrology and its application play an important role. Collaboration with various stakeholders has continued to grow, and co-operation within VTT has also increased significantly, which brings further benefits for CEMIS.



Figure 7.3. The HYTELI project included designing and constructing a prototype freestyle roller ski with vertical and lateral force measurement.

The relevance and importance of measurement reliability has continued to grow in the business world, where reliable measurements bring quality, market value and a competitive edge. The major share of traceability services in the budget of VTT MIKES is expected to hold up in 2020. A high metrological standard will be maintained by participating in international research and benchmarking projects.

Operations of the University of Jyväskylä in Vuokatti

The emergence in 2019 of national development work on data analytics for elite sports has also helped to guide operations in Vuokatti, with CEMIS collaboration more effectively exploiting the opportunities provided by data analytics and artificial intelligence in sports technology application fields. A national decision made during the year to base the work of the Vuokatti-Ruka Olympic Coaching Center in Vuokatti will also enable increasingly smooth collaboration between R&D and coaching, and the deployment of new methods in the field.

General overview

For years the Vuokatti Sports Technology Unit of the University of Jyväskylä has specialised in developing technology for use in measuring performance and as a coaching tool for the needs of elite sports, and of Nordic skiing in particular. The developed technologies may also be guided towards promoting wellbeing, for example when developing a dynamic balance measurement method and related

research that may have future applications in monitoring physical functional capacity. A significant degree of R&D progress has been made in partnership with CEMIS organisations.

A major share of operations at the Vuokatti Sports Technology Unit comprises R&D projects implemented with national and international partners. The most important Finnish partners have been the CEMIS partners: the University of Oulu, Kajaani University of Applied



Figure 8.1. Pictured from left to right: professor Qyvind Sandback (Norway, serving as opponent to the dissertation), newly qualified sports sciences PhD Olli Ohtonen, and PhD supervisors professor Vesa Linnamo and professor Stefan Lindinger (Sweden). The dissertation was formally defended in Vuokatti on 29 June 2019.

Sciences, VTT-MIKES and CSC – IT Center for Science, Vuokatti Sports Institute (Vuokatti Sport), Vuokatti-Ruka Sports Academy, Sotkamo Municipality, the Finnish Research Institute for Olympic Sports (KIHU), the Finnish Ski and Biathlon Associations, and the Finnish Olympic Committee.

A total of 14 people worked at the Vuokatti unit in 2019, including a full-time staff of seven employees. Three staff members worked for both the University of Jyväskylä and the Finnish Ski Association, the Finnish Biathlon Association, the Finnish Olympic Committee, or the Vuokatti-Ruka Olympic Training Center. The Vuokatti unit is headed by professor Vesa Linnamo.

Teaching and research

Alongside development work and projects, the unit provides teaching for higher and doctoral degree programmes in sports sciences. Six individuals completed a Master's degree in sports sciences over the year. A total of 77 graduates had completed the Master's degree programme in sports technology by the end of 2019.

2019 was a record year for doctoral programmes, with as many as nine ongoing dissertation projects. Two of these were completed during the year: Biomechanics in cross-country skiing skating technique; measurement techniques of force production and ski properties, by Olli Ohtonen (see Figure 8.1), and Biomechanics in Paralympic Cross-Country sit-skiing; evidence-based tests for classification, by Valeria Rosson. All of the ongoing dissertations will apply measurement technologies developed in partnership with CEMIS.

2019 was also a record-breaking year in terms of releasing research findings, with 19 original academic publications emerging from the Vuokatti team, comprising two doctoral dissertations, two book chapters and fifteen peer-reviewed articles. The Unit also produced a total of 17 congress abstracts. Held in Vuokatti in March 2019, the 8th International Congress on Science and Skiing (ICSS 2019) also served as a splendid forum for presenting research findings.

Project work

The largest ongoing projects in 2019 were (principal financiers and total budget in parentheses): the CEMIS joint project Innovation platforms for wellbeing, health care and sport – HYTELI (Regional Council of Kainuu, ERDF, EUR 240,000), From an athlete test to an international product in Vuokatti (Regional Council of Kainuu, ERDF, approximately EUR 310,000), Silver economy and smart textiles (Business Finland, Co-creation, approximately EUR 95,000), and the Sports technology training path for athletes project launched at the end of the year (Northern Ostrobothnia ELY Centre, City of Kajaani, ESF, approximately EUR 390,000). One dissertation project ongoing in the Unit was also continued with a three-year grant (EUR 40,000 annually) financed by the Amer Cultural Foundation.

Unit work on the HYTELI project under the 2019-2020 CEMIS development programme focused on co-ordinating the project and improving the integration of sensors into ski equipment and biathlon rifles. The project also launched development work to take charge of

data analytics and artificial intelligence methods. Sensor integration work focused on collaborating with VTT MIKES and KAMK to measure 2D forces in a roller ski (Figure 8.2) and to build a new version of a ski pole force sensor in which the measurement electronics and wireless node are integrated within the pole handle. Automatic motion analysis based on machine vision and a pattern recognition algorithm began in partnership with the University of Jyväskylä, CSC – IT Center for Science and VTT MIKES. This work includes automatically calculating various joint angles for swifter feedback in roller skiing and dynamic balance measurement. The project also focused on determining the propulsion component in skiing, and on developing competition simulations in association with KAMK. Development work on the propulsion component was pursued in collaboration with the ongoing doctoral dissertation project of Shuang Zhao at the Unit. This work is also linked to developing sensor integration, as determining propulsion requires both force and motion analysis data.



Figure 8.2. Prototype of an aluminium-frame test roller ski developed under the HYTELI project to integrate force sensing into the wheel suspensions and within the frame.

The project From an athlete test to an international product in Vuokatti worked with Vuokatti Sport to explore the service commercialisation prospects of technologies and athlete testing service innovations developed in previous projects. Subjects of the commercialisation project included the Coachtech coaching feedback system, a new ski laboratory environment (Figure 8.3) and biathlon tests.

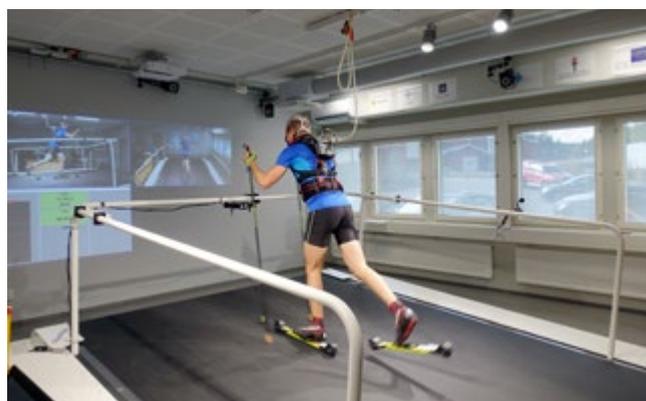


Figure 8.3. The University of Jyväskylä ski laboratory constructed at Snowpolis in Vuokatti with ERDF financing.

The Silver economy and smart textiles Co-creation project sought to determine the most relevant and advanced body measurement technologies for an ageing population and how these technologies can be applied across a wide range of wellness products and services. Project themes included body measurement technology, sport and wellness services, and wearable electronics, clothing and accessories. The project resulted in an extensive literature review of wearable technologies and smart clothing, together with a market review compiled by the Happy Textiles business. It laid a foundation for preparing a follow-up project for an application under the Business Finland Co-Innovation scheme.

The Sports technology education path for athletes ESF project was launched at the end of 2019 in partnership with KAMK. This project seeks to meet a need identified in the region to provide targeted training for athletes, including support for flexible sports careers. The approach of the envisaged training will create a dual career training path leading from secondary education to a Master's degree in sports technology. Project preparations included co-operation and a needs assessment formulated with Vuokatti-Ruka Sports Academy. The end-project goal is to mainstream a 330-credit academic programme at the University of Jyväskylä and Kajaani University of Applied Sciences requiring a joint application to both universities for admission to a university of applied sciences engineering degree and a Master's degree in sports technology.

CSC unit operations in Kajaani

CSC operations have focused on the new HYTELI and TÄRY projects launched in 2019 under the CEMIS development programme. CEMIS also continued its collaboration with KAMK in the context of the previously launched Data Analytics Accelerator project. The new projects have helped CSC to gain a broader and more profound understanding of artificial intelligence applications in sports and wellbeing, and to gain insight into the analytical challenges of operational maintenance in industry.

CSC – IT Center for Science Ltd. is a national centre for high-performance computing, data analytics and information networks that provides services to universities, research institutes, the public sector and businesses. It is a non-profit limited company owned by the Finnish government and higher education institutions, and managed by the Ministry of Education and Culture. Since joining CEMIS in August 2016, CSC has focused on applying and disseminating expertise on data analytics and artificial intelligence within the CEMIS network.

Significant upgrades and enlargements were made to the CSC Kajaani data centre in 2019. As part of the DL2021 project of the Ministry of Education and Culture, the Puhti computing cluster was installed and commissioned, including the PuhtiAI section for massive artificial intelligence applications and the Allas large data storage system (Figure 9.1). Kajaani continued to grow in the field of supercomputers when the European co-operation body EuroHPC decided a location

for future world-class hardware (<https://eurohpc-ju.europa.eu>). The LUMI consortium co-ordinated by CSC took part in the competition, and Kajaani was selected as one of three locations in Europe.

The current CSC hardware at Renforsin Ranta Business Park is located in the Warehouse building, which also houses the Kajaani office. The LUMI supercomputer will be installed in the Kone building and the office will expand to the Rata property. The increased computing capacity located in Kajaani has also led to growth in staffing at the CSC facility, and has naturally aroused significant interest and collaboration potential globally. The Finnish Ministry of Economic Affairs and Employment also contributed to national funding of EuroHPC, mandating CSC to seek extensive business use for the supercomputing environment. Preparations for business use and awareness raising began in 2019, and CEMIS has also provided an excellent channel for this work.



Figure 9.1. The national Puhti supercomputer and Allas data management environment were officially inaugurated at the CSC data centre in Kajaani on 23 September 2019. Attendees at the opening ceremony included Nash Palaniswamy (General Manager for AI and HPC Solutions at Intel), Agnès Boudot (Senior Vice President, Head of HPC & Quantum at Atos), Erja Heikkinen (Director, Division for Science Policy, Ministry of Education and Culture) and Kimmo Koski (Managing Director, CSC – IT Center for Science).

Machine vision applications for sport and exercise

The HYTELI project at CSC has focused on applying image-based human pose estimation to various needs in sports science (Figure 9.2). New neural network algorithms (such as AlphaPose) have greatly improved the reliability and accuracy of pose estimation based on video input from a standard camera or smartphone, and image-based pose estimation can now be applied for many purposes that previously required a complex and costly motion capture system.

The HYTELI project has developed pose estimation for monitoring the pose of a test subject in a dynamic balance test developed at Vuokatti. Camera-based pose estimation would enable use of a balance test much more flexibly and cost-effectively than when using a motion capture system.

Pose estimation has also been used in a ski pose application to determine the pose and movements of a skier's body. This enables calculation of such factors as a skier's centre of mass, which is an important variable in analysing the skier's power output. Pose estimation has also been used in an application developed in the previous LIKUTPA project for automatically determining a skier's pole angle.

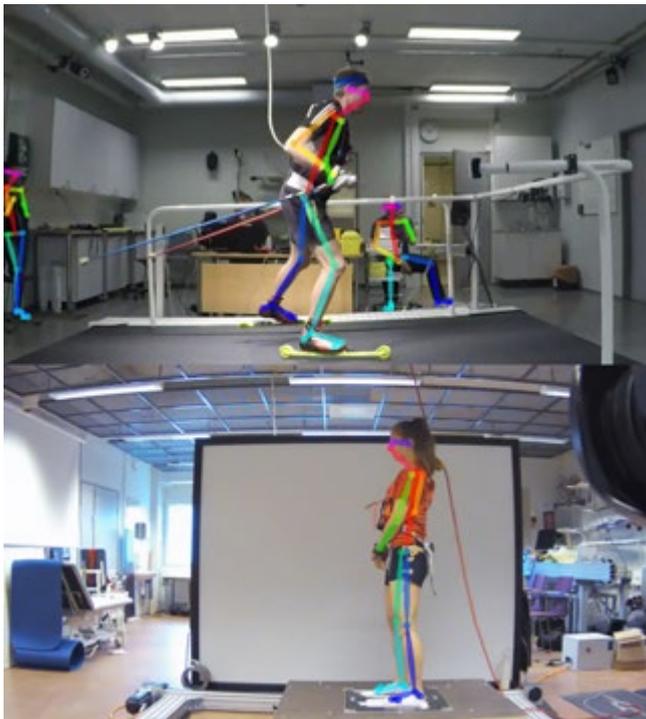


Figure 9.2. As part of the HYTELI project, CSC continued developing applications of human pose estimation in dynamic balance tests and mat skiing.

Operational maintenance in industry supported by analytics

The TÄRY project develops expertise and training in the field of operational maintenance in industry. Converting from traditional maintenance to ongoing operational maintenance is a major problem in industry, to which intelligent technology based on measurement and data analysis offers one answer.

In 2019 CSC supported KAMK staff in enhancing analytical expertise and building industrial collaboration. This undertaking implements pilot projects of increasing difficulty in analytics, helping to formulate a common understanding of the prospects for analytics in operational maintenance among teaching staff, participating companies, and ultimately students.

Accelerating the deployment of analytics in businesses

CSC co-ordinated a joint data analytics accelerator project with KAMK providing support to regional businesses in deploying analytics. 2019 was a year of active business co-operation. This included launching workshops in which businesses were introduced to the possibilities of analytics, examining the theme one step at a time. Twelve target businesses were involved in the project over the year. Pilot projects were also launched with partner enterprises, seeking to delve more deeply into the analytics challenges of one business. Particular progress was made over the year in a maintenance-related project with the power distribution company Loiste Sähköverkko (now Kajave Ltd.).

A new and unique artificial intelligence training program was also launched at KAMK in autumn 2019. The Data Analytics Accelerator project collaborated with the degree programme, seeking to network students and local businesses through such measures as identifying potential internship projects and supporting their implementation.

Publications

A total of 38 international peer-reviewed academic publications and 36 professional and conference publications were produced at CEMIS in 2019. CEMIS was also involved in the completion of two doctoral dissertations, seven Master's theses, nine University of Applied Sciences Master's degrees and 85 theses in science, engineering and business administration.

Doctoral dissertations

Ohtonen, Olli (2019) Biomechanics in cross-country skiing skating technique and measurement techniques of force production. PhD thesis. University of Jyväskylä, 76 pp. (JYU Dissertations. ISSN 2489-9003; 97) ISBN 978-951-39-7797-9 (dissertation formally presented on 29 June 2019)

Rosso, Valeria (2019) Biomechanics in Paralympic Cross-Country sit skiing: Evidence-based tests for classification. PhD thesis. Politecnico di Torino. University of Jyväskylä, 96 pp. (JYU Dissertations ISSN 2489-9003; 101) ISBN 978-951-39-7807-5 (dissertation formally presented on 22 July 2019)

Diploma and Master's theses

Natunen, Elli (2019) Effect of take-off ground contact time on jump height and lower limb joint movement range in aesthetic group gymnastics jumping. Faculty of Sports and Health Sciences, University of Jyväskylä, Master's thesis in Sport Coaching and Fitness Training. Master's thesis, 65 pp, 2 appendices.

Korhonen, Pietu E. A. (2019). Effect of upper-body maximum strength training on double poling performance of young female skiers. Faculty of Sport and Health Sciences, University of Jyväskylä, Master's thesis, 48 pp.

Timo Koskinen (2019). Decomposition of Motor Units from Differential Electromyography using Mathematical Clustering Methods. Faculty of Sport and Health Sciences, University of Jyväskylä, Biomechanics, Master's thesis, 71 pp.

Kiljunen, Topi (2019) Comparison of gliding and grip properties of various classical cross-country ski types. Faculty of Sport and Health Sciences, University of Jyväskylä, Master's thesis in Biomechanics, 92 p. 1 appendix.

Multasuo, Jukka-Pekka (2019) Use of inertial measuring device as a measure of swimming: development of method and testing of suitability in daily swim coaching. Faculty of Sports and Health Sciences, University of Jyväskylä, Master's thesis in Biomechanics, 74 pp., 7 appendices.

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CEMIS is based in Kajaani and Sotkamo in eastern Finland, far from the congestion and haste of major metropolitan centres. The region provides wonderful natural surroundings and splendid opportunities for leisure activities and hobbies as a counterweight to working. Please feel free to contact us by e-mailing info@cemis.fi if you are interested in working or studying at CEMIS.



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