

CEMIS Annual Report 2020



CEMIS

Centre for Measurement and Information Systems

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Chairmen's review

The corona crisis year 2020 has highlighted the role of high quality, validated data in daily life of the whole society. Reliable information enables timely and successful decisions. New measurement methods create basis for identifying previously invisible cause-effect relationships and real-time information management and information processing enable rapid impact of actions that are based on observations.

We CEMIS actors have continued our research and development work both in fields of sensors, human & environmental measurements and assuring measuring accuracy & managing measurement information. The special strength of our centre is the expertise on measurement methods and measuring accuracy, biological and sport physiological knowhow as well as visualization of results through simulations and augmented reality.

One of the most important investments in 2020 was the start of the LUMI supercomputer construction work and building the ecosystem around the supercomputer. Computational science

and artificial intelligence (AI) provide also CEMIS with new opportunities.

An exceptional year resulted in challenges for traditional collaboration. Despite the challenging times, our projects gained larger attention internationally. This enables increasing the impact of our operations, widening the competence network as well as increasing the effectiveness of our work results.

The research and competences enable development of companies and improvement of competitive edge. Increased number of projects and deeper collaboration seem to create confidence in building the future among CEMIS industry partners.

In the future, competences and how to apply them collaboratively help us to solve even more significant challenges. This is our focus in CEMIS also in the following years.



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

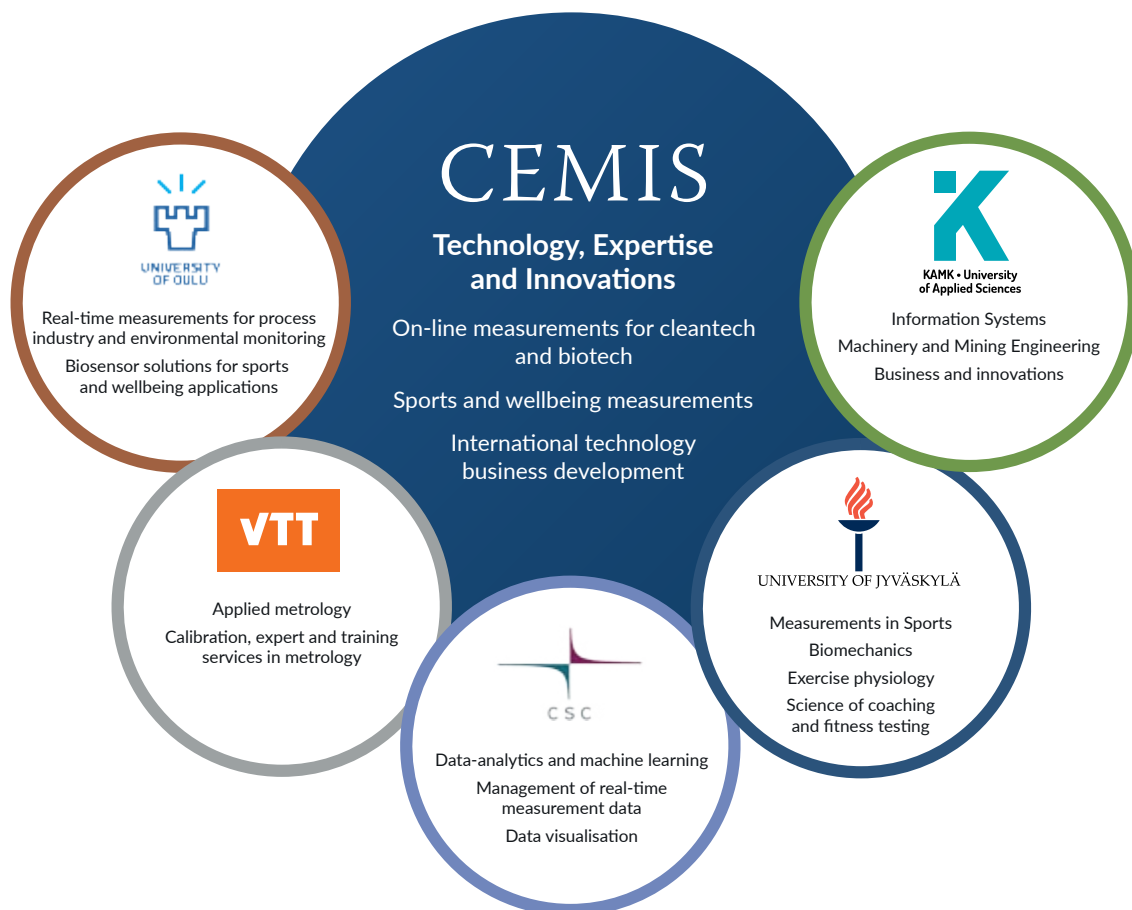


Figure 2.1. CEMIS focus areas and member organisations, with their main areas of expertise.

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 ended in 2020 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 90 specialists in measurement and information systems.



Figure 2.2. Main actors of CEMIS centre are located both in Kajaani and Vuokatti, Sotkamo and RDI operations are performed widely in Kainuu region.

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 tenth operational year of CEMIS continued according to the defined strategy and the operational plan. In March 2020, CEMIS researchers jumped into a digital work mode due to the world-wide COVID-19 pandemic. It had impact on both the services and working methods of the centre. We transitioned successfully from physical meetings and workshops to digital communication channels and many of us still continue working in a hybrid work mode. In 2020, CEMIS succeeded in strengthening the project portfolio and creating new RDI openings that established the basis for applied research of data analytics, artificial intelligence and high performance computing.

At this point, I would like to thank our previous director Mikko Kerttula for great work in leading CEMIS. Mikko jumped into new work challenges in spring 2020. I am very inspired by CEMIS research and filling Mikko's shoes. I would like to thank him also for sharing valuable information on CEMIS operations in 2020.

CEMIS operates and improves its work in accordance with the performance objectives specified in the Centre's operating plan. Outcomes of the centre are assessed in three categories: education, R&D and innovation activities. CEMIS realised these outcomes with around 85 employees in 2020 (some employees worked also for other projects partially).

In 2020, CEMIS operations resulted in 27 peer-reviewed scientific articles and 30 conference and professional publications, six Diploma/Master's degrees, fifteen university of applied sciences Master's degrees and 106 university of applied sciences Bachelor's degrees.

Regarding research & development activities, there were around 50 active projects running in 2020. The fifth two-year CEMIS Development Programme for 2019-2020 ended in 2020. The content of the programme is described in more detail later in this report. There were 15 international projects with a funding share of EUR 0.9 million. Regional funding from the Regional Council of Kainuu or the ELY, Centre for Economic Development, Transport and the Environment was EUR 3.23 million.

In 2020, the RDI operations of CEMIS centre in the field

of wellbeing, healthcare and sports focused on developing innovation environments (top-level sports, sports tourism) and international-level technology competences as well as increasing the competitive edge in Kainuu region. The research was performed in close collaboration with Finnish Olympic Committee, sport associations and companies by applying sensor technology to cross country skiing and biathlon as well as implementing 3D- and VR-based simulation and visualization solutions for modeling ski routes of professional-level sport events.

In the field of Cleantech and bioeconomy, CEMIS centre continued development of research methods and technologies for analyzing water quality.

Additionally, our centre continued improving companies' competences on industrial maintenance solutions and provided companies with data analytics tools for processing industrial data.

The impact of CEMIS is primarily assessed in terms of new commercially viable technology and by noting how many businesses have been established due to the centre's operations. Two commercially applied inventions were developed and two new companies were established within CEMIS in 2020.



The Measurement Technology Unit of the University of Oulu (MITY) developed measurement solutions for optimizing bioenergy production and mining industry processes as well as exploiting industrial sidestreams (for example, new usage scenarios for lignin). Additionally, the unit prepared a project for launching operations for Arctic Biovalley and performed collaborative research in CEMIS projects such as HYTELI for developing biosensors.



Kajaani University of Applied Sciences invested heavily in developing RDI operations and improving education. KUAS managed to expand its education offering both in the field of social care (received permission to provide socionom education) and in the field of sports where a flexible sports technology education (enables double career) path for top athletes was established together with University of Jyväskylä. The project operations of KUAS remained strong also in 2020. CEMIS Business Development Unit continued the strong research on technology startup companies and performed technology commercialization activities with CEMIS actors.



The Vuokatti Sports Technology Unit of the University of Jyväskylä focused on developing advanced innovation platforms and innovation environments for top-level sports and sports tourism. In CEMIS collaboration, the unit developed measurement technologies and simulation methods (3D, VR) for visualizing cross-country skiing competition tracks. These simulation methods enable also visualization of areas and facilities.



VTT Kajaani unit continued strong international metrology development in EURATOM:s bodies and in several EMPIR-funded projects such as Comprehensive Traceability for Force Metrology Services (ComTraForce) that focuses on studying static, continuous and dynamic force measurements.



CSC - IT Centre for Science CSC operations at CEMIS in 2020 focused on HYTELI and TÄRY projects. Additionally, the collaboration with Kajaani University of Applied Sciences (KUAS) in Data-analytiikan kiihdyttämö project that ended at the end of the year belongs to CEMIS operations. These projects have enabled CSC to work with significant challenges of machine learning and machine vision and gain experience on lifecycle of analytics projects based on companies' needs, together with experience on communicating results.

Total funding for the Centre in 2020 reached EUR 12.6 million (almost same than previous year) divided as follows: international funding of EUR 0.96 million (2019: EUR 0.46 million), national funding of EUR 1.25 million (2019: EUR 1.31 million), private enterprise funding of EUR 0.96 million (2019: EUR 1.12 million), regional funding of EUR 3.23 million (2019: EUR 3.41 million), and self-financing of EUR 6.16 million (2019: EUR 6.31 million).

The next CEMIS development programme aims at increasing the international and national RDI operations and related funding in relation to the regional funding as well as focusing on developing innovation ecosystems (Innovation ecosystem contract of the Kajaani region, Arctic Data Intelligence and Supercomputing Ecosystem AIKA) to increase the impact of CEMIS actions.

The qualitative objectives of CEMIS for the period 2019-2020 included generating new technology business operations and achieve a clear increase in international R&D co-operation and funding. CEMIS contributed to these objectives by generating 2 new startup companies by CEMIS employees and students.

Despite the COVID-19-pandemic, the CEMIS centre performed active international research collaboration in 2020. The CEMIS actor VTT continues strong metrology research in EU EMPIR (European Metrology Programme for Innovation and Research)-funded projects. International collaboration was continued

actively also in the field of European-level high performance computing research infrastructures (EuroHPC). The HPC-investment LUMI supercomputer, targeted at Kajaani was the centerpiece of international HPC collaboration. The city of Kajaani together with Kajaani University of Applied Sciences and CSC shall invest significantly in developing the datacenter ecosystem of Kainuu and attracting new players to the ecosystem.

The researchers of CEMIS centre have participated in dozens of international conferences (reference information is visible later in this annual report, see Publications) and clusters of EU smart specialization strategy (ClusSport, European Water Cluster). The university actors of CEMIS have provided excellent research facilities for international PhD students such as University of Jyväskylä, Sports Technology researcher Jonathan McPhail. His neuromuscular-related research helps coaches to make better informed decisions for their athletes with regards to physical training prescription and overall training load.

Aligned 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. In order to survive in increasing competition, CEMIS

needs to invest heavier in international research and training. CEMIS continues to focus on three core areas also in the future: Cleantech & Biotech, Sports & Wellbeing, and developing the international technology business.

The new CEMIS development programme shall highlight the role of AI, intelligence and analytics to support above mentioned core focus areas. The opportunities and services provided by LUMI EuroHPC supercomputer shall be identified actively. Additionally, CEMIS shall continuously support the position and brand of Vuokatti and Sotkamo as internationally recognized training center of wintersports.

We have designed and prepared the sixth CEMIS development programme (2021-2023) during 2020 and it is starting aligned with the strategy and operational plan but with a small delay due to the change in EU structural fund programme.

CEMIS has done excellent work in establishing RDI ecosystems and research infrastructure and these provide CEMIS actors and Kainuu region with significant competitive edge and opportunities to create new, innovative research openings.

Marko Jäntti, Director, CEMIS

Marko Jäntti



CEMIS 2020 in numbers

2

NEW SPINOFF
COMPANIES

2

COMMERCIALY
APPLIED INVENTIONS

15

INTERNATIONAL
PROJECTS

0,5

MILLION EUR IN R&D
SERVICE SALE

27

PEER-REVIEWED
SCIENTIFIC
PUBLICATIONS

5

MASTER'S / DIPLOMA
THESES

TOTAL FUNDING
OF THE CENTRE, EUR
12,63
MILLION

INTERNATIONAL
FUNDING, EUR
0,96
MILLION

NATIONAL FUNDING, EUR
1,31
MILLION

INDUSTRY FUNDING, EUR
0,96
MILLION

REGIONAL FUNDING, EUR
3,23
MILLION

SELF-FINANCING, EUR
6,16
MILLION

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 ended at the end of 2020. The programme was implemented in collaboration between 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 recognised 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).

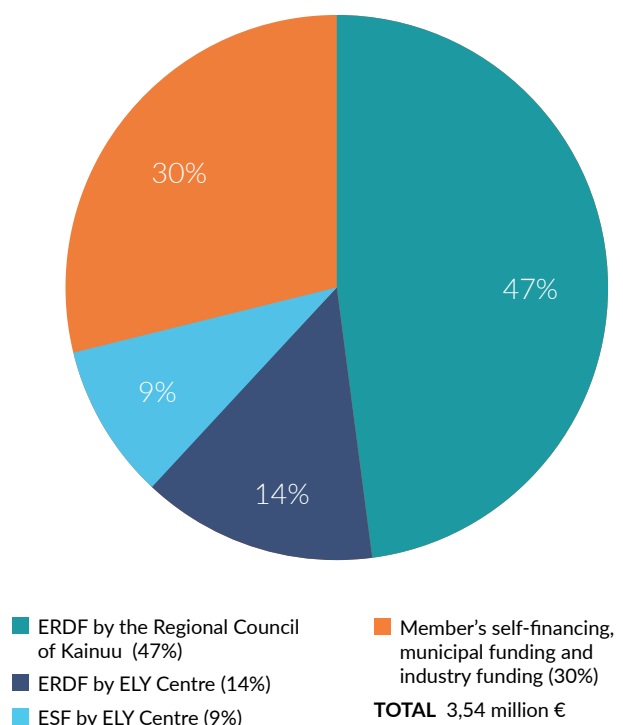
The two-year programme was mainly funded through the ERDF programme for Eastern and Northern Finland, with a total budget of approximately EUR 3.54 million. A steering group comprising representatives of CEMIS partners, financiers and businesses guided the programme and its projects. The programme implemented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

The specified general impact goals of the development programme were 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
- 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 CEMIS development programme comprised five projects. The content of those projects is described below.



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

Figure 4.1. Distribution of CEMIS Development Programme financing in 2019-2020 by funding sources.

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

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

INNOBIO also worked to develop fermentation expertise (bioethanol production) and to modernise associated existing pilot-scale apparatus. One concrete goal was 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 investigated 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, St1, Elementis Finland and Terrafame), and accommodates their needs.

The project measures were 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

WP1. Strengthening modelling skills for business needs

Research efforts of WP1 focused on modelling water flow and utilized OpenFOAM application. The computing model used an AMI solution to simulate rotating objects. During the study, we also explored how different geometries affect the flow and whether computing clusters from CSC could be used in modelling. This is possible in the following year when research groups can request computing (AI) resources from Business Finland for public research.

WP2. New innovations in the bioproducts industry

In WP2, healthy ingredients (betulin, lupeol, betulinic acid) of birchbark were studied. By using ethanol extraction, we researched whether the number of betulin compounds varies between birch trees of different ages and bark types. Our findings

showed that largest number of betulin compounds existed in surface bark of young birch trees.



Figure 4.2. INNOBIO project results show that highest number of betulin compounds exist in surface bark of young birch trees.

WP3. Process measurements for the bioproducts and extractive resources industry

Xanthates are chemicals that mining industry uses in flotation. In 2020, calibration runs for process samples of xanthate measurements were started to prepare the online device. Measurements were performed until end of July and in August, the process device without software was constructed.

WP4. Development of measurement analytics and quality assurance

Regarding measurement-related analytics and quality assurance, the project organized collaboration meetings but due to COVID-19 experimental testing was delayed.

WP5. Commercialisation and communication

The work at Workpackage 5 has resulted in three project funding applications (1 international, 2 national applications), newspaper articles and a biosensor-related invention disclosure.

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

The project aimed at strengthening expertise in designing, implementing and piloting small measuring devices. It applied 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 yielded new technological solutions for post-project commercialisation through corporate R&D projects. Growth in expertise enabled further application of findings in other fields, such as health technology.

A further goal was 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 were linked to long-term measurement expertise at MITY and to the use of

international networks. Growing expertise, technology transfer and field testing enabled swifter post-project commercialisation of developed technologies for the region's businesses. Another aim was to accompany CEMIS partners to international cleantech trade fairs, where their expertise and technology were marketed and partners were sought for further collaboration and commercialisation.

The total project budget of EUR 278,859 mainly comprised 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

In Workpackage 1, microchannel fluid flows and components have been studied as well as their simulation examples. The work in Workpackage 2 focused in 2020 on developing a small-size device solution for nickel measurements. The reliability and repeatability of measurement methods were tested by performing nickel measurements with a mixture including interfering components. In previous measurements, the mixture interfered measurements especially with small contents. Additionally, preservation testing for modified electrodes was started (some electrodes were stored in refridgerator and others in room temperature). In Workpackage 3, we put efforts on measuring lactate in the bioethanol production. Here, we used the same device than in nickel measurements.

The Workpackage 4 included nickel measurements from mining waters and natural waters. Matrix effects were studied measuring both an industrial water sample and a water sample with natural water. Additionally, a measurement device was developed for nickel measurement. The development work consisted of mechanical design, design and acquisition of circuit board, software development and testing. In Workpackage 5, the field testing was performed. The HPLC device of MITY was used as a reference method for the measurement method. Workpackage 6 covered project management, commercialization and dissemination activities. In 2020, we have created an invention disclosure together with INNOBIO project. Additionally, this workpackage has resulted in discussions with companies on commercialization possibilities, design and implementation of a promotion video as well as regional newspaper articles.



Figure 4.3. A measurement device for nickel measurement was developed in MINIME project.

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

This project sought to make businesses more competitive by supplementing KUAS 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 KUAS degree programmes and in-service training. The project developed 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 aimed at improving the energy efficiency of enterprise production processes in line with the goals of sustainable development. The project also strengthened the profile of KUAS as a developer of intelligent solutions for industry and established a form of higher education in Finland that is currently rare but for which the need is evidently growing.

KUAS beared primary responsibility for implementing the project, and partnered with CSC - IT Center for Science, which was responsible for developing operational maintenance measurement data analytics. Project implementation was 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 was mainly ERDF funding channelled through the Northern Ostrobothnia Centre for Economic Development, Transport and the Environment (ELY Centre).

Project results

In TÄRY project, companies' competences on industrial maintenance were improved through organizing two maintenance-related courses (Industrial maintenance, Work design online course), maintenance-related data processing exercises were created, demonstration devices for condition monitoring were designed and introduction of ELMAS dependability modeling software was continued.

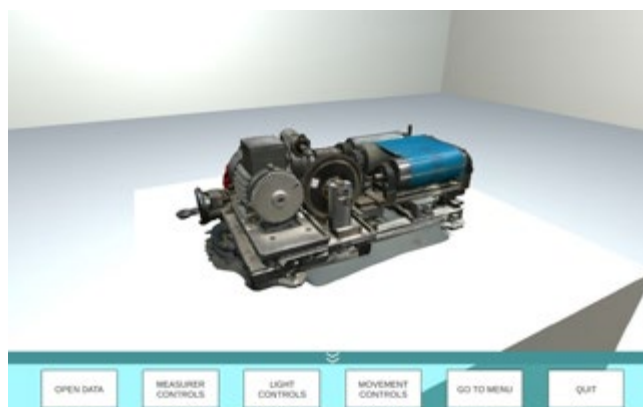


Figure 4.4. The demonstration device (a virtual bank note printing device) used in industrial maintenance training. In the application, a student practices positioning of vibration sensors and reading sensor data by using virtual glasses.

Additionally, the project team studied industrial maintenance analysis examples and data analytics tools, developed VR/AR system for visualizing maintenance data from ventilators and prepared participation in technology & industrial maintenance fairs.

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

The goal of the HYTELI project was 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 was 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 were 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 promoted 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 were 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 included 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 sought 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 were new methods in application development of intelligent home care and elite sports testing, and it was the right time to adopt them in Kainuu. The project also benefited 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 were:

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

WP1: Health technology innovation platforms

The Workpackage 1 of HYTELI has focused on studying health-promoting high-value ingredients of trees. In the research, pectine was isolated from dried and powdered bruce bark with hot water extraction & ethanol precipitation. The results of the study were compared to previous results with raw lingonberry powder. Additionally, new rapid measurement technologies have been studied in the WP1, for example measuring cortisol. The research carried out in WP1 has deepened collaboration between University of Oulu, Kajaani University of Applied Sciences and CSC related to the health technology theme.

TP2: Innovation platforms in sports technology

Regarding the Workpackage 2, Internet of Things (IoT) competences have been developed and applied to the sports technology, especially to biathlon where research efforts focused on studying trigger pressure measurement in biathlon weapons.



Figure 4.5. HYTELI project manager Anni Hakkarainen describes features of test roller skis.

Our findings showed that bringing the IoT technology to the weapon was more challenging than expected. The research work shall be continued with studying the usage of piezoresistive textile sensors for measuring the trigger pressure.

Furthermore, in the Workpackage 2, integrating sensors to ski equipment was studied, for example, sensors in ski poles enable receiving data on ski pole forces. Additionally, the measurement and structure of free style roller skis were improved (for example, use lighter and more stable material).

TP3: Data analytics, artificial intelligence and machine learning

In the Workpackage 3 (Data analytics, AI, ML) pilot design has been continued and skiing videos have been analyzed by using advanced analytics. One of the videos has been labeled and data has been prepared to an appropriate form for training. The hand labeled video has been used to train the model. Additionally, the WP3 has contributed to development of data fusion methods for modeling areas. These methods have been used to visualize and model ski routes of cross country skiing and biathlon.

The work in Workpackage 3 has provided CEMIS, Kajaani University of Applied Sciences with a new service concept / operating model for modeling virtual environments leading to two new service sales projects in strong collaboration with HYTELI.

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

Regarding Workpackage 4, exploitation and dissemination of HYTELI results continued in 2020 as well as networking in regional working groups (collaboration working group of KUAS-Kainuu Vocational College-Kainuu Social Welfare and Health Care Joint Authority) and international cluster networks (ClusSport, European Platform for Sport Innovation EPSI). Through these networks, such as ESPI Brokerage Table, further project ideas have been presented and new collaboration partners sought.

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

The BUZTECH project aimed at creating a model to improve the early stage success prospects of an enterprise, and testing it in practice on the most promising technologies at CEMIS and in the Kainuu and Northern Ostrobothnia regions. The project also identified and applied international business opportunities, developed and strengthened networks, and actively contributed to commercialising CEMIS technologies and service business concept development. The opportunities identified during the project were refined through early-stage technology and market studies. This supported development of the business environment and efficient use of regional resources in important focus areas, and increased the expertise of technology business operations in the project area.

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

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

Project measures and results

Regarding the Workpackage 1 of Buztech, the work in 2020 focused on finalizing the Buztech startup model (BSM). BSM is suitable for Finnish high-tech startup development including knowledge of the ecosystem, funding processes and potential problems. The model and its utilization complement existing company coaching/support systems in Finland due to the specific startup focus and analytical concept. BSM has 9 "building blocks": Team building, Technology development, Ecosystem, Collaboration, Funding, Business development, Technology management, Company building and early marketing.

The model enables entrepreneurs, business advisors, investors, and government agents to make better decision on a startup and makes people to understand needs and demands of working in and for a startup in high technology companies and to how succeed in that. In general, it helps startup companies in avoiding/reducing the valley of the death situation for the company. During the model development, over 300 articles were reviewed.

In the Workpackage 2, five market and technology trend studies were performed by the project team in 2020:

- Real time sulphate measurements-technology and market study,
- Betulin from birch bark-market evaluation study
- Bilberry leaves-market products study
- Muscle acidity – market need and technology potential
- Hattrick Industrial Collaboration Solution – business and market development

The work efforts of Workpackage 3 were allocated in piloting the BUZTECH process model with three CEMIS prestartup cases. In 2020, BUZTECH team performed the startup model analysis including 3-4- key block recommendations and delivered analyses and recommendations to the case companies. The work in WP3 also contributed to concept development of KUAS VIS industrial VR/AR/XR services by identifying international market potential implemented and national market companies and sectors as well as identifying appropriate marketing activities to be used in the selected market segment.

Workpackage 4 involved dissemination activities such as planning webinars, updating the description of CBD to the CEMIS website as well preparations of a literature review article on BUZTECH project findings. The article was published in 2021 as a conference article (15th International Technology, Education and Development Conference): The causes of valley of death: a literature review.

Operations of the Measurements Technology Unit (MITY) at the University of Oulu and biorefinery measurements professorship

Measurements Technology Unit continued its operations according to one research group structure in two core research areas: cleantech and wellbeing/health. The unit had research operations in Kajaani and RDI project operations also in Vuokatti.

The main application areas of the unit's research were in 2020: bioeconomy, (renewable forest industry, bioenergy, use of forest biomass), cleantech, (process and environmental applications, especially for mining industry) and health and wellbeing applications (development of biosensors, nutrition, development of Vuokatti area).

A temporary university research fellowship in imaging measurements continued in 2020 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 3.65 million. A staff of 45 people completed some 37 person-years of work over the year. The ten staff members holding a doctoral degree performed 26 per cent of this total workload.

The professorship in Biorefinery measurements, that started in 2019, continued at MITY's facilities. The professorship is co-financed with City of Kajaani, Regional Council of Kainuu, St1 Oy, University of Oulu, and the Faculty of Technology of University of Oulu. Mika Ruusunen is the appointed professor. The professorship aims at developing bio-based raw materials, their refinery processes, measurements of their sidestreams, and automated optimizing of production efficiency. In Kajaani, the research group operates in facilities of MITY and an industry partner.

International project work

The Interreg Nord project "Ice Proof Arctic – Innovations for ice and snow management" continued in 2020. The project aims at validating and developing new ice & snow management solutions for eliminating ice loads of electricity lines, optimizing efficiency and safety of renewable electricity production and monitoring snow loads on roofs.

The EIP-AGRI project financed by the Finnish Agency for Rural Affairs collaborates with two Estonian EIP projects (EIP, European Innovation Partnership). Those Estonian projects are co-coordinated by Estonian Dairy cluster and Estonian University of Life Sciences. This project collaboration has attracted interest

also on European level.

BioSPRINT (EU-H2020): Improve biorefinery operations through process intensification and new end products.

OXILATE (Operational eXcellence by Integrating Learned information into AcTionable Expertise) is an ITEA project (partners from Belgium, Spain and Finland). OXILATE focuses on flexible development of smart analytics innovations and service innovations and integrating those into complex systems of industrial customer's operating environments.

CEMIS co-operation

Co-operation in CEMIS centre continued in 2020 according to CEMIS development 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. In 2020, fermentation equipment was upgraded and development of real time measurement system for flotation chemicals used by 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. In 2020, research focused on nickel measurement and designing the measurement device. MITY performed field tests in summer 2020.
- KAIMIT - Novel environmental measurements for mining and other industry effluent: KAIMIT project ended in the beginning of 2020. This project developed new measuring methods for monitoring industrial effluent, with the particular

reference to sulfate and phosphate assays lacking reliable and cost-effective commercial field measurement solutions. This research challenge was approached with the research unit's cutting-edge expertise in electrochemistry and optics/ photonics. In the methodological progress, principles of multimeasurement were applied, combining signals from several modes of measurement. Promising results have been achieved, particularly in laboratory measurement of sulfate and phosphate. The optical sulfate method was deployed into the field device version and it was successfully tested with sulfate water that runs into Nuasjärvi. For both substances, accurate reference specifications were defined. There have been plans and discussions for commercializing the developed methods.

- 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 of the new quality specifications was commercialized in 2020. The expertise developed in previous CEMIS projects was utilized in service sales and in the preparation of Health impacts of timber construction project for which a funding decision was issued in the autumn.

Director Vesa Virtanen was involved in the work of the CEMIS Strategy and Management Groups. Professor Mika Ruusunen has participated in the work of the CEMIS management group.

The University of Oulu unit is clearly the largest single research operator in the CEMIS Development Programme.

The BIOSFE (Utilization of sidestreams in biocircular economy - demonstration of continuous supercritical carbon dioxide extraction) project of professor Ruusunen was combined to the steering group of other projects in the CEMIS development programme according to the feedback from a funding agency. The project aims demonstrating continuous supercritical carbon dioxide extraction with the device that is developed during the project and developing the automation of the device.

Other project activities

The CEMIS-related operations of University of Oulu included four projects funded by Business Finland:

- BF co-creation, Testing Spindec-x technology-based battery charging device and building a project consortium, coordinated by University of Oulu and Oulu Mining School 1.1.2020 – 31.12.2020
- BF COVID Co-Creation Pocket size deactivator of lethal microorganisms based on a unique concept of non-hazardous UV light - DEACUV coordinated by University of Oulu and CAS together with University of Oulu / Diseases Networks and Aalto/Electronics and Nanoengineering 1.6.2020 – 30.11.2020.
- APASSI (Autonomous Processes Facilitated by Artificial Sensing Intelligence) that aims at taking a step towards autonomic industrial processes by improving reliability and scope of measurement technology and looking into machine learning applications. BF Co-innovation 1.5.2019 -30.4.2021
- HOPE- Highly Optimized Energy Systems project focuses



Figure 5.1. Three reader devices were developed and manufactured in CEMIS project (HYTELI-> Bioreader, INNOBIO->Toxic reader, MINIME->Metalreader)

on developing solutions for improving energy efficiency in energy networks and collaboration on energy domain. In the project, tools and solutions for multi-objective optimization are developed. BF co-innovation 1/08/20 → 31/07/22

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

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.

City of Kuhmo and MITY implement a ground breaking research in Health impacts of timber construction project. It is financed by regional agricultural fund (Kainuu ELY centre) and Finnish Forest Foundation. In the project, physical, chemical and microbiological features of school buildings are monitored during three seasons as well as stress and absence of pupils. The monitoring targets are Tuupala school (of timber) in Kuhmo and Vaalan yhtenäiskoulu as a reference target.

The goal of KOS project, funded with ESF funding of ELY centre is to provide growth sectors and sectors experiencing structural change with need-based training. At the same time, the systematic collaboration between research institutes, higher education institutions and working life is strengthened leading to

more effective research and development activities. The project improves business operations in various domains such as refining biomasses, digitalization of health care and elderly people's nutritional health as well as cleantech measurements. In 2020, the following competences have been transferred into companies:

- regarding the competences in product development and refinery of biomasses, we have focused on SME devices targeted at industrial use: pH measurements for emulsions, scale, rotary evaporator, reverse osmosis and emulgator device. Practikum training has involved learning and introduction of new technologies and devices that can be used for making refining more effective and improving the exploitation of sidestreams.
- companies were provided "arduino-based sensing for health and environmental applications" theory and practikum trainings
- IPR training was organized.

The KryoMikro project studied 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.



Figure 5.2. MITY process hall. REMMI project testing on-going.

In 2020, the research work in the project focused especially on samples of brewery-, dairy- and cheese-related products and natural products. The project resulted in good results, for example, in concentrating berry juices, birch sap and beer through cryoconcentration and companies are interested in utilizing the technology in their operations. The microwave processing improved the quality of natural products especially in terms of preservability of active compounds and microbiological quality. Microwave drying technology was piloted successfully with nettle samples in Italy. The project continued in 2020 with studying waste water samples. KryoMikro project ended in April 2020 and the project was funded by European Regional Development Fund.

Taiga project (1/2020 – 12/2023) aims at studying health effects of arctic plants and focuses especially on obesity and low-grade inflammation and changes in metabolism that affect obesity-related sicknesses. It is known that a plant based diet includes ingredients that normalize this silent inflammation. The project seeks valuable Nordic natural ingredients that include health benefits. In the project, lingonberry and crowberry are studied in order to identify health effects and ingredients resulting in health effects. The project is coordinated by the immunopharmacology research group of University of Tampere. MITY participates as a participant and is responsible for analytics of berry powders used in the research. Due to COVID restrictions the laboratory work of the project was started with a delay in the end of 2020. The project is funded by European Regional Development Fund.

PATE project (4/2020 – 3/2022) develops innovative technological solutions based on freezing method in collaboration with companies of Eastern and Northern Finland dealing with groceries, natural products and wastewater. The purpose is to study and apply the freezing concentration to decrease amount of water and thus improve the quality of the product. The freezing concentration is based on the natural ability of water to crystallize into ice while freezing the water solution. When the ice shall be removed, other ingredients such as aromas and bioactive health ingredients remain unchanged in the concentrated solution. Thus, valuable ingredients can be captured. The project shall utilize the expertise developed in previous projects by Lappeenranta University of Technology and University of Oulu for developing demonstration devices. The needs of small companies are especially taken into account.

The cross-regional project of Lappeenranta University of Technology and University of Oulu is funded by South Savo Regional Council and Regional Council of Kainuu (European Regional Development Fund).

In ARCOS project (4/2019 – 3/2021), operations of natural cosmetics companies are developed. The goal of the project is to create new raw material and market-ready cosmetics products as well as to improve marketing of companies. This shall result in development of the natural cosmetics sector in Kainuu by helping it to reach better international customers and markets and to achieve profitable and growing business.

There are five companies in the project that is coordinated by MITY. The project is a cross-regional development project (Oulujärvi Leader and Elävä Kainuu Leader) led by a consortium of companies and financed by European Agricultural Fund for Rural Development of ELY Centre.

Pilot environment for development of natural product and technology validation in Kainuu (Tbio). Tbio project (1.12.2020-31.7.2022) supports design and implementation of Arctic Biovalley. The project focuses on increasing the degree of processing of natural ingredients in micro and SME companies. The project also produces a roadmap for future validation needs of companies. Additionally, the industrial piloting and validation of measurement devices is performed in the project.

ÄLYREHU “*Smart measurements in cattle feeding and healthcare*” is a national project financed by the Finnish Agency for Rural Affairs (European Innovation Partnership). MITY coordinates the project and other actors are ProAgria Kainuu, eight agricultural companies, two other companies and a veterinary. The project aims at improving on-farm measurements and data communication applications that monitor fodder quality and the welfare of livestock. The project collaborates with two Estonian agricultural EIP projects.

In 2019, MITY received funding for another agricultural EIP project Good for Livestock that continued in 2020. This project improves monitoring of silage heaps and agricultural applications for antimicrobial peptides. MITY also coordinates this project and thus is the first Finnish research unit that has coordinated two EIP projects. The project partners include Häme University of Applied Sciences (HAMK), Natural Resources Institute Finland (LUKE) and in the innovation group there are 5 farms, 4 companies, 2 veterinaries and ProAgria Eastern-Finland.

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.

Increased usage of plastics, inadequate recycling and waste collection systems and traffic are causing are involved in causing global environmental threats. Increased amounts of plastics are found from water areas, ground and even in the atmosphere. Small sized plastic particles end easily to micro-organisms and finally to the entire foodchain. The international research related to the problem has started including evaluation of health effects of plastics, development of replacing and environmental-friendlier materials, idea generation on waste collection techniques and applying measurement technology in monitoring and identifying plastics.

The Measurements Technology Unit (MITY) at the University of Oulu and Kajaani University of Applied Sciences (KUAS)

have started an ERDF project related to this theme. The goal of REMMI project is to develop a compact field device for real-time monitoring of microplastics. The field tests of the project shall be performed in water treatment plants.

The role of KUAS in the project is to explore the most common sources and routes of microplastics in Kainuu region and test new filtering materials for removing microplastics. The commercialization paths for the measurement system to be developed in the project shall be identified. The duration of the project is 2 years with the budget of 396.000 €.

Additionally, the unit has participated in a proof-of-concept -project funded by University of Oulu's Innovation Department. CHT DigiHealth HUB PoC project Dent AI focuses on collecting dental data.

Research collaboration and publications

Co-operation between MITY and University of Eastern Finland (School of Pharmacy, Department of Applied Physics) has been prepared regarding research on forest biomass. The research on measurement methods was continued with emeritus professor Kai Peiponen and his group from the Joensuu campus of UEF to study the global and severe research problem: microplastics in water areas. In 2020, two joint publications have been created. This research shall continue.

MITY is participating (2018-2020) as an academic mentor in Bioeconomy specialization training that is a joint education project of University of Eastern Finland, Savonia University of Applied Sciences and Karelia University of Applied Sciences. In addition to mentoring, the laboratories and laboratory devices of MITY have been utilized in a thesis work of the education project.

A project manager of MITY, Mari Jaakkola participated as an expert in European Commission working group (EIP-AGRI Focus Group) that studies concrete means for reducing food losses at farm level in EU region. The first meeting of the group was organized in Nantes, France in March 2019. The group published a common report in 2020 to activate regional operative groups to participate in reducing food losses. The report was published in 2020.

MITY performed active international collaboration with ten research institutes such as in Italy, Denmark, Estonia, USA and UK. The number of scientific articles was good, total 27 refereed international scientific articles and professional / conference articles with a conference presentation. Unit staff participated in national and international review assignments (peer reviews for academic journals, and assessing international project applications).

Operations of Kajaani University of Applied Sciences

The year 2020 started at Kajaani University of Applied Sciences like other years. However, news from Asia regarding a new threat were daily topics of coffee table discussions also in Kainuu. When the pandemic had spread to Europe, it was clear that it would reach also Kajaani. In March, school facilities were closed and remote work and remote teaching started.

Luckily, at that point the studies of graduating students were in the phase where final steps of supervision and for example, completion of theses were not negatively impacted or those impacts were minimal.

The potential COVID impacts on those students who started or continued their studies in 2020 and their results shall appear later. The technology competence area of Kajaani University of Applied Sciences has organized remote teaching to multiform groups for ten years. Therefore, we had excellent acquisitions to jump into remote teaching mode with very short notice.



Figure 6.1. Characteristics of a hybrid teacher: „Wish that a hybrid teacher would be like a hybrid car with two power sources. With one source you would deal with the classroom teaching and with another the remote teaching.”

During the last two months of spring semester 2020 our operations continued following the COVID restrictions and expectations for the fall 2020 were better. In fall 2020, the semester was started in a normal mode. However, when the pandemic situation got worse, we jumped into a hybrid model where those courses not requiring mandatory classroom teaching were transitioned under



Figure 6.2. The work from home studio that enables working while standing

remote teaching. It was even possible to organize the first on campus technology competence area meeting in October.

Both staff and students addressed the lack of social contacts in virtual meetings. Despite the challenges, we launched Bachelor in mechanical engineering programme and day groups of Bachelor of Gaming Education, Information Technology programme in Raahe. The education regarding these openings was organized mostly remotely during fall 2020.

Technology competence area in the middle of the pandemic

In fall 2020, we continued with existing education except in the Bachelor in mechanical engineering programme we introduced a new study plan. The student groups became fuller and especially the attraction of multiform educations was clearly visible compared to other education programmes. In the information technology education, we launched already second „From data to artificial intelligence” education (applicable target) as part of Bachelor of Information and Communication Technology education.

At the same time, our RDI-related competences on data, data processing and collection were headed to new substance areas. This was visible for example, in Pandemic Platform project funded by Business Finland. Additionally, our project applications regarding

environment, low-carbon economy, and water treatment received also funding. One of the most significant funding decisions was Karelia CBC investment project (over 2 million euros) that aims at establishing a biopower plant in Puolanka, Kainuu.

Intelligent Systems education and Game Technology education also continue as part of Bachelor of Information and Communication Technology education.

Our key figures for 2020 were 105 first degrees and 15 postgraduate degrees completed. This can be considered as an excellent achievement and the number is biggest in several years. We issued 48 publications and we had an average of 80 staff members divided roughly equally between teaching and RDI operations. There were 6 international projects from total a total of 30 projects. We also participated first time in Academy of Finland project.

Service sales business activities included selling expertise of specialist, developing various products and also EMC laboratory services and condition laboratory services provided by Sunit Oy were launched successfully. The volume of service business increased slightly from the level of the previous year.

The technology competence area continued collaboration in TÄRY, HYTELI and BUZTECH projects of the CEMIS development programme. Project extension was applied for TÄRY and HYTELI projects.

In the new education opening, „Athlete’s career path” project by Kajaani University of Applied Sciences and University of Jyväskylä, students started their studies in Kajaani and Sotkamo. We also invested in production of international education material in selected areas of information technology in order to increase the number of international students both online and on campus in Kajaani.

The total volume the competence area including projects and education programmes was over 5 million euros.

CEMIS Business Development unit in 2020 – technology startups research

CEMIS program’s BUZTECH project continued and finalized during the year 2020. BUZTECH was implemented by the CEMIS Business Development unit (CBD) at Kajaani University of Applied Sciences (KAMK). BUZTECH was focusing particularly on researching Finnish technology startup companies and analysis of the new information for innovative, deep insights and action models. The target of the project was to create new knowhow to support early-stage technology companies/startups, so that they would succeed better through typical difficulties faced in initial years of existence. For this goal, a wide survey of over 30 Finnish high-tech startups was implemented by primary interviews and based on this, a new action model was created. One conference article has been published at this moment as result of the project (INTED2021 Conference): The Causes of Valley of Death:

A Literature Review (Al Natsheh, A., Gbadegeshin, S.A., Ghafel, K., Mohammed, O., Koskela, A., Rimpiläinen, A., Tikkanen, J. & Kuoppala, A.). In addition, at the time of writing this, another two articles are in review process at scientific publications.

In addition to the BUZTECH project activities, CBD was responsible of commercialization work in a few other extensive projects targeting certain CEMIS and KAMK technology focus areas. CBD worked and directed the commercial work packages of KAMK projects (OredVR (EAKR, Kainuun Liitto, company funding) ja Future Mine (Business Finland-funding), which were both connected to digitalization of mining operations utilizing VR/AR/XR-technologies and related software. OredVR finished towards the end of 2020 and Future Mine in early 2021. In these projects, CBD have formed vast knowhow around the mining industry and augmented as well as virtual reality technology commercialization and market requirements.

KAMK coordinated Biogas for Future Electric and Gas Grids (BIOFEGG) project in 2018-2020. This project was implemented in the ERA-NET Bioenergy program and KAMK research project within was funded by Business Finland and companies. The international joint project targeted improving the quality of biogas by testing new methods for the anaerobic digestion process, and developing new types of purification methods, e.g. to remove siloxanes. CBD studied the market potential for the developing solutions. Two CBD personnel participated to the project, one as project manager and one project worker. In its entirety, the project was implemented by an international consortium, totaling of four industrial partners and four research partners from Austria, Finland and Sweden.

An important CEMIS result of 2020 was achieved when Hatrick Technologies Oy was founded in December 2020 by CBD director, Dr. Anas Al Natsheh and his colleague, technology specialist Jonna Kalerma-Poranen (both KAMK). The company is a spinoff/startup from KAMK, based on Hatrick project outcomes (Kainuun Liitto, EAKR-funding), and its field is software design, particularly for optimizing industrial maintenance operations. The company is updating news in near future through its website: <https://www.hatricktech.com/>

Six business development experts worked in projects in the CBD 2020 for the unit director, Dr. Al Natsheh. In addition to the described projects, CBD had shares of work in several other KAMK R&D projects. In the KAMK publication series, the unit published an article about its experiences in remote work mode. Publication can be viewed at: <https://www.theseus.fi/handle/10024/356163>.

During its existence since 2011, CBD has for its part contributed to highly educated immigrants’ employment to Kainuu region as well as return moves to Kainuu for a number of highly educated persons. Through the unit’s activities, its employees have progressed into doctoral studies, positions in private companies, or fixed positions in higher education.

Operations of VTT Technical Research Center of Finland in Kajaani

The work of VTT Technical Research Centre in 2020 in Kajaani continued to focus on the metrology operations of VTT MIKES. This facility is the world's northernmost National Standards Laboratory, and has been operating since 2011 in purpose-built premises at Renforsin Ranta Business Park.

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.



Figure 7.1. Petri Koponen from VTT MIKES demonstrates fluid flow measurement equipment.

2020 was a steady operating year for VTT MIKES. 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 Collaboration

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). The national contact point of IMEKO is also located in Kajaani.

During 2020 VTT MIKES Kajaani was involved in four projects (MultiFlowMet II, MetroWaMet, ComTraForce ja WindEFCY) of the European Metrology Programme for Innovation and Research (EMPIR). Additionally, a project on fluid flow measurement was prepared. In this project, Kajaani unit's devices play a significant role.

The research team has also participated in Graphene-Based Thermal Straps -ESA (European Space Agency) project that aims at using a measurement device produced in Kajaani to measure whether graphene-based, thermal satellite straps are compliant with mechanical specifications of ESA.

The research team has actively participated in other international project preparations in various research programmes, such as Electronic Components and Systems for European Leadership (ECSEL). The research team of Kajaani has had a significant role in preparing the Nokia's leading companies project "Smart Water".

Research

VTT MIKES Kajaani participated actively in the implementation of the projects in the CEMIS development programme: INNOBIO (New, innovative and high-quality measurements and processes as part of the biorefinery and mining value chain) and HYTELI (Innovation platforms for wellbeing, health care and sport).

HYTELI is a project coordinated by University of Jyväskylä. VTT has provided HYTELI with expertise on measurement of ski equipment, measurement method and equipment itself. During 2020, a prototype of a roller ski designed in 2019, was implemented. The prototype enables measurement of horizontal and vertical forces targeting at a ski during skiing. The prototype

shall be tested with VTT MIKES's force normal device that results in important information on reliability of experimental and computational results.

In INNOBIO project, VTT MIKES Kajaani developed further its own CFD (Computational Flow Dynamics) competences in order to use open source tools such as OpenFOAM® in CFD calculations more efficiently. It is challenging to make complicated models with moving objects to work in computing environment.

The long-term objective is to produce research results on how well results from computing-based models match the empirically measured results. The project has also resulted in measurement uncertainty calculations regarding measurement methods of MITY and collaboration with TÄRY project of KUAS was also started.

VTT MIKES Kajaani has also been involved in project preparations of public research funding and customer-driven research projects. In these projects, research questions have also been related to quantity areas maintained by the unit and their application in various measurements.

Outlook for 2021-2022

The outlook for 2021 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.

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 2021. A high metrological standard will be maintained by participating in international research and benchmarking projects.

Operations of the University of Jyväskylä in Vuokatti

Overview

The Vuokatti Sports Technology Unit of University of Jyväskylä has been responsible for coordinating the Sports and Wellbeing research area since 2010. During more than 10 years of operation, the unit has focused on developing measurement technologies and applied research to serve especially Nordic skiing sports. During the operational years, the unit has established the ground for reliable measurements and variables based on validated research data. The research path has involved listening various stakeholder groups: athletes, coaches and ski equipment maintenance teams. The linkage between research and practice became stronger when National Olympic Training Center Vuokatti-Ruka started its operations in early 2019.

In general, the Sports Technology Unit aims at allocating more development efforts into high quality, reliable research data covering the whole lifecycle from data collection and data storing to the processing and analytics of data. However, in order to apply advanced data analytics and artificial intelligence for improving the performance of Finnish top-level sport, many development steps need to be taken. In this way, developed competences can be also brought into improving national wellbeing in Finland.

Vuokatti Sports Technology Unit, that specializes in applied sport sciences and developing measurement technologies, had total 15 employees (7 full time) in 2020. Professor Vesa Linnamo is the director of the unit. Three employees worked both for University of Jyväskylä and Finnish Ski Association, Finnish Biathlon Federation, Finnish Olympic Committee and National Olympic Training Center Vuokatti-Ruka.

The Sports Technology Unit published 12 scientific peer reviewed publications and 8 professional / conference publications. The director of the unit professor Vesa Linnamo was selected to lead the implementation of the national strategy for top-level sports data which also drives the future of the unit's development actions. The data strategy work consists of several organizations including Faculty of Sport Science and Faculty of Information Technology at the University of Jyväskylä, CSC - IT Center for Science, Finnish Olympic Committee and KIHU - Research Institute for Olympic Sports.

Education and project operations

The year 2020 was very active from the perspective of the sports technology education. 10 new students started their Sports Technology master studies in Vuokatti. Additionally, 15 students started to study in the education path designed for athletes (Education programme for top-level athletes by Kajaani

University of Applied Sciences and University of Jyväskylä, Sports Technology, European Social Fund project). Furthermore, there were record number of 7 PhD projects running in 2020. All of these exploited the technologies developed in CEMIS research and development collaboration. By the end of 2020, in total 83 master students have been graduated from the unit.

The unit was implementing six research & development projects in 2020: "From sport test to international service product in Vuokatti (ERDF)", "New educational pathway for athletes - support for dual career (ESF)", "Developing the expertise work in Vuokatti-Ruka Olympic training center (ERDF)", "Improvement of operational environment (Ministry of Education and Culture)", "High Altitude training research project Vuokatti (ERDF)" as well as the CEMIS joint project "Innovation platforms for Wellbeing, Health and Sports, HYTELI (ERDF)".

In the "From sport test to international service product in Vuokatti" project, new athlete testing services were finalized and introduced with Vuokatti Sport, for example, methods developed in CEMIS collaboration were presented. The project has been implemented together with Vuokatti Sports Technology Unit and Vuokatin Säätiö (Vuokatti Sport). The project has resulted in various tests used in cross country skiing, biathlon and skiing equipment and related customer feedback. For example, athlete tests of biathlon and methods of equipment testing are based on strong CEMIS collaboration. The project also produced several marketing videos (Figure 8.1.) that presented special competences of Vuokatti in expert functions, facilities and new test services. These videos are available at: [Vuokatti Sport - Become A Champion - YouTube](#).



Figure 8.1. PhD researcher of Vuokatti unit, Miika Köykkä presents biathlon test competences of Vuokatti in the Youtube video of Vuokatti Sport.

CEMIS collaboration

The role of University of Jyväskylä in CEMIS centre has been to work as an expert of sport sciences and sports technology and a developer of methods of sport performance measurement as well as to develop tools for top level sport coaching, especially for Nordic skiing sport. This role has been performed in practice in Innovation platforms for Wellbeing, Health and Sports - HYTELI project that focuses on creating an innovation environment that supports the athlete testing services in Vuokatti, coaching and research and enables technology experiments, new openings in collaboration with companies and development of new services. The CEMIS collaboration was also described in our article in [Helsingin Sanomat](#), [Innovation appendix](#) that was published in September.

In HYTELI project, University of Jyväskylä has been responsible for general project coordination and coordination of Sports Technology Innovation Platforms work package including sensor integrations to ski equipment and a biathlon rifle together with VTT MIKES and KUAS as well as introducing virtual models of sport events to skiing treadmill environment. KUAS has been responsible for implementing virtual skiing routes of professional sport events while University of Jyväskylä has taken care of both collecting data to model the realistic route profile and bringing the models to the skiing treadmill environment. University of Jyväskylä has also dealt with testing the finalized methods with athletes.

As highlights of Sports Technology Innovation Platforms work package, we can mention especially development steps with sensor integrations; the first version of roller ski sensing and the advanced version of the ski pole force sensor (Figure 8.2). Force sensors integrated to skiing equipment woke up interest among Finnish equipment manufacturers and led to international project preparations with five Finnish companies; VTT was the country coordinator in project preparations. Our work with skiing event simulations resulted in the virtual environment of the sprint route in Oberstdorf World Championship competition. This was demonstrated successfully in Vuokatti in the end of 2020. The model for creating virtual environments was considered viable and the implementation of virtual models for sprint and biathlon routes of Beijing Olympics was set as a final objective.

The development of automatic motion analysis based on a position modeling algorithm started in 2020 together with CSC. In Vuokatti skiing laboratory, skiing video shootings were performed with four skiers. Along with video shooting, VICON motion analysis system was utilized. The goal of the work was to develop self-trained position model for treadmill skiing and compare its accuracy to VICON, the “gold” standard of motion analysis. In athlete testing, performing motion analysis with traditional methods would require placing marking pins to the athlete in order to identify and calculate joint angles. However, position modelling and machine learning may help to remove the

above mentioned heavy manual work effort. Development of the propulsion component, the force component that brings the skier forward, was continued in the PhD project of Shuang Zhao. Sensor integrations partly relate to defining propulsion because it requires both force-related and motion analysis data.



Figure 8.2. Roller ski sensors and ski pole force sensors implemented in HYTELI project.

Operations of CSC – IT Center for Science in Kajaani

CSC operations at CEMIS in 2020 focused on HYTELI and TÄRY projects. Additionally, the collaboration with Kajaani University of Applied Sciences (KUAS) in Data-analytiikan kiihdyttämö project that ended at the end of the year belong to CEMIS operations. These projects have enabled CSC to work with significant challenges of machine-learning and machine vision and gained experience on lifecycle of analytics projects that are based on companies' needs and experience on communicating results.

CSC – IT Center for Science 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.

During 2020 CSC Kajaani datacenter was expanded according to plans. As part of the DL2021 project of the Ministry of Education and Culture, Mahti supercomputer was installed and introduced. Mahti is a sturdy liquid-cooled supercomputer that is able to solve extremely heavy computing tasks. It is the most powerful supercomputer in Nordic countries in terms of computing power. After the opening of MAHTI, the next generation national data management and computing environment of Finland is ready.

The growth of Kajaani unit in the field of supercomputers shall continue. During 2020, tendering of LUMI supercomputer acquisition was performed and a distinguished supercomputer manufacturer HPE Cray was chosen as the supplier. LUMI is one of the three large systems that European Joint Undertaking EuroHPC (<https://eurohpc-ju.europa.eu>) shall acquire in the coming years. The LUMI consortium is coordinated by CSC.

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 2020, and CEMIS has also provided an excellent channel for this work.



Figure 9.1. A view of LUMI datacenter (under construction) in Kone building of Renforsin Ranta business park. CSC shall be responsible for operating LUMI datacenter.

Machine vision applications for sports and wellbeing

The HYTELI project at CSC has focused on further development of image-based human pose estimation. In the project, a Master's thesis has started to study collecting high quality video reference material and training neural network models used in human pose estimation to serve especially the needs of ski applications. In order to collect adequate reference material, the work also aims at developing a method for combining results of a motion capture system, 3D measurements and camera-based pose estimation as well as calibrating the video camera.

Camera-based pose estimation could also be used for other purposes that required earlier a separate motion capture device. In this project, the method has been developed to monitor the test subject in a dynamic balance test developed at Vuokatti, to determine the pose and movements of a skier's body in ski application as well as to determine a skier's pole angle automatically.



Figure 9.2. In HYTELI project, CSC developed further human pose estimation methods for dynamic balance tests and treadmill 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 2020 CSC supported KUAS staff in enhancing analytical expertise and building industrial collaboration. In this project CSC studied opportunities of machine learning in industrial use case based on vibration measurement data received from an industry partner.

Accelerating the deployment of analytics in businesses

CSC co-ordinated a joint data analytics accelerator project with KUAS providing support to regional businesses in deploying analytics. The active business co-operation continued also in 2020 and culminated in fall when projects were finalized and

results communicated to companies. The project ended in October 2020.

During the project, a straightforward process for introduction of analytics was developed to enable companies and communities to conduct rapid experiments on what data analytics could provide them. For the introduction, a maturity model ("steps of analytics") describing the process and a template for the analytics plan ("canvas") were established. CSC has been able to utilize these tools and experiences in other similar actions supporting the introduction of analytics.

Pilot actions were implemented with four companies and pilots involved also other participating companies. Workshops were conducted with 16 companies and with communication even larger number of companies were reached. For each pilot, a deep business analysis was performed. This included conducting interviews and literature reviews for companies operating in same business domain and evaluating potential of delivering analytics services as a subcontractor.

Publications

In 2020 a total of 27 international peer-reviewed academic publications and 23 professional and conference publications were produced at CEMIS. Additionally, CEMIS resulted in five Diploma/Master's theses, 15 University of Applied Sciences Master's degrees and 106 theses in science, engineering and business administration.

Diploma and Master's Theses

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Mäntysalo, Arja (2020) The effect of balance training and plyometric speed training on balance in older women. Faculty of Sport and Health Sciences. University of Jyväskylä, Master's thesis in Sport Coaching and Fitness Training. 96 pp, 3 appendices.

Löppönen, Antti (2020) The effect of paddle stroke variables measured by inertial measurement unit on the speed of the kayak. Faculty of Sport and Health Sciences, University of Jyväskylä, Biomechanics, Master's thesis. 63 pp, 1 appendix.

Alatalo, Sanna (2020) The effect of plyometric training on balance and neuromuscular system in young and elderly women. The Faculty of Sport and Health Sciences, University of Jyväskylä, Master's thesis in Science of Sport Coaching and Fitness Testing, 67 pages

Karhu, Katja (2020) Physiological recovery from eccentric and concentric exercise. The Faculty of Sport and Health Sciences, University of Jyväskylä. Master's Thesis of Exercise Physiology, 75 p.

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Karczewska-Lindinger M., Hakkarainen A., Linnamo V., Lindinger S. (eds) (2020) *Science and Skiing VIII*. ISBN: 978-951-39-8077-1

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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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