PROGRESS REPORT TO CCT 2026

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1. ORGANISATION

At MIKES, metrology activities are currently organised in three metrology research teams. Thermometry belongs to the Process Metrology team, which is responsible for metrology activities related to temperature, humidity, and digital transformation in the related process measurement areas.

Dr Richard Högström is the Research Team Leader of the Process Metrology team. The team currently consists of 13 people. Dr Shahin Tabandeh continues to be responsible for thermometry activities within the team, while Dr Richard Högström is responsible for humidity-related activities.

The thermometry area has increasingly expanded from conventional calibration and scale maintenance towards digitally enabled, distributed, and application-driven temperature metrology. This includes sensor network metrology, embedded SI traceability, photonic and quantum thermometry, AI-assisted calibration approaches, uncertainty evaluation for distributed measurement systems, and data quality assessment in real-world measurement networks.

2. MAINTENANCE AND DISSEMINATION OF SI UNITS

Temperature

The national thermometry activities have continued to maintain and disseminate traceability to the SI for temperature measurements. However, the scope of calibration services has been reduced. Non-contact thermometry and high temperature contact thermometry calibration services are not offered any more due to limited customer request. On the other hand, efforts have been made in developing thermometry towards new forms of traceability for practical and industrial applications.

The work has included conventional contact thermometry, air temperature metrology, surface and process thermometry, low-temperature primary thermometry, photonic thermometry, and digitally supported temperature measurement systems. Particular attention has been given to uncertainty evaluation under realistic operating conditions and to methods that support reliable temperature measurements outside traditional laboratory calibration environments.

The thermometry area has also strengthened its activities in industrial and distributed measurement contexts. This includes the development of methods for embedded SI traceability, AI-assisted calibration tools, thermometry for industrial process control, and distributed thermal measurement systems. These activities are closely linked to the wider digital transformation of metrology and the need to provide traceable measurement information directly in industrial and environmental applications.

Comparisons

VTT MIKES has been participating in the following comparisons:

- EURAMET.T-K9 (ITS-90 SPRT calibration from the Ar TP to the Zn FP)
- EURAMET P1459 (Air Temperature Comparison -80 °C…+60 °C)
- EURAMET P1149 (Surface temperature calibrations)

Humidity

Humidity metrology activities have continued to maintain and disseminate traceability for humidity measurements. The scope has included trace water measurement, dew-point and frost-point generation, process gas humidity, and humidity measurements under demanding industrial conditions.

A major research direction after 2020 has been trace water measurement in ultra-pure process gases. This work has included the development and improvement of thermodynamic saturation-based trace water standards, the extension of measurement capabilities towards very low frost-point temperatures, and the investigation of water vapour enhancement factors in non-polar carrier gases.

Humidity and thermometry activities are also increasingly connected through digitalisation, uncertainty propagation, and process measurement needs. The work supports applications in high-purity manufacturing, environmental monitoring, process control, and advanced sensor-based measurement systems.

Comparisons:

MIKES has been participating in the following comparisons:

- EURAMET P1189 comparison (10 %rh to 95 %rh @ -10 °C to 70 °C)
- EURAMET.T-K8 (Comparison in high dew-point temperatures)
- COOMET.T-S5 (10 %rh to 95 %rh @ 10 °C, 25 °C and 50 °C)

3. RESEARCH

Within the field of CCT, VTT MIKES has participated in and coordinated several European metrology research projects. The research has covered primary thermometry, trace water measurement, photonic and quantum thermometry, embedded SI traceability, air temperature metrology, and sensor network metrology.

18SIB02 Real-K, Realisation of the redefined kelvin

Development of Coulomb blockade thermometry for primary thermometry in the temperature range up to 25 K.

Demonstration of the dissemination of the kelvin by Coulomb blockade thermometry.

VTT MIKES acted as a work package leader.

20IND06 PROMETH2O, Metrology for trace water in ultra-pure process gases

Development of improved trace water measurement methods for ultra-pure process gases.

Improvement of thermodynamic saturation-based trace water standards.

Extension of trace water generation capabilities towards very low frost-point temperatures.

Investigation of water vapour enhancement factors relevant to non-polar carrier gases and high-purity process environments.

22DIT02 FunSNM, Fundamental principles of sensor network metrology

VTT MIKES is the coordinator of the project.

Development of metrological principles for sensor networks, including uncertainty evaluation, data quality assessment, SI traceability, and robustness in real-world environments.

Development of methods for uncertainty propagation in networks of heterogeneous sensors.

Investigation of correlations, calibration strategies, automation, semantic technologies, and digital infrastructures for sensor network metrology.

Validation in real-world case studies, including environmental monitoring, smart buildings, district heating, and industrial process-related sensor networks.

The project is highly relevant to thermometry because it provides methods for distributed temperature measurement systems and for digitally supported, network-level calibration and uncertainty assessment and contributes to the initial activities of the new task group CCT-TG-DTMS.

23FUN01 PhoQus-T, Photonic and quantum sensors for practical integrated primary thermometry

Development of practical primary thermometry based on photonic and quantum sensors.

Work on photonic thermometry using silicon ring resonator structures and related sensor technologies.

Design, simulation, manufacturing, characterisation, calibration, and uncertainty evaluation of photonic temperature sensors.

Contribution to the practical dissemination of thermodynamic temperature in the range relevant to emerging technologies.

VTT is a work package leader and is active in the fabrication and packaging of the sensors using in-house facilities.

23FUN11 ThermoSI, Thermometry with embedded SI traceability for industrial applications

Development of embedded SI traceability for industrial thermometry.

Work on practical primary thermometry, self-validation, gas and combustion thermometry, surface thermometry, and industrial process control.

Development of an AI-assisted low-cost insert for dry-block calibrators to connect phosphor thermometry with thermal imaging techniques.

Support for industrial needs related to energy efficiency, emissions reduction, process control, and traceable temperature measurement in operational environments.

24RPT03 A2TM, Advancement of air temperature metrology capabilities

Development of metrology capabilities for air temperature measurements with contact sensors.

Development of procedures and tools for consistent air temperature measurement and calibration.

Development of a portable sub-chamber system compatible with climatic chambers and laboratory setups.

Evaluation of calibration improvement and uncertainty components in meteorological and applied air temperature measurements.

MIKES has also contributed to an ESA-related thermal management project on the development and testing of a novel graphene-based thermal strap for space applications. The work investigated whether a graphene-based thermal strap could replace conventional solutions for scientific instrumentation onboard the Athena satellite. The strap was tested against thermal, mechanical, and cleanliness requirements and reached TRL 5. The activity connects thermometry and thermal metrology with aerospace thermal management, requiring reliable temperature measurement, heat-transfer characterisation, and testing under application-relevant conditions.

In addition to project-based research, the thermometry area has increasingly addressed digitalisation-related topics. These include uncertainty-aware artificial intelligence, dynamic calibration, sensor drift evaluation, digital calibration workflows, software-supported uncertainty propagation, machine-readable metrological information, semantic descriptions of sensors and measurement systems, and digital methods for evaluating data quality in distributed temperature measurements.

The development of sensor network metrology has become one of the major new directions. It extends thermometry from individual sensor calibration towards the metrological assessment of complete measurement systems, including fixed, mobile, distributed, and mixed-quality sensors. This work supports the future need for traceable digital measurement infrastructures in environmental monitoring, industrial processes, smart buildings, energy systems, and climate-related applications.

4. ACTIVITIES FOR CREATING IMPACT

Metrology organisations

CCT:

- WG Hu
- WG Env
- TG-Env-AirT
- WG Dig

EURAMET:

- Technical Committee for Thermometry (TC-T)
- TC-T WG Strategy
- TC-T WG Digitalisation
- TC-T WG Humidity

Accreditation organisations

MIKES experts have continued to support accreditation-related activities by providing technical expertise and assessments where needed. These activities support the quality infrastructure in Finland and ensure the correct application of thermometry and humidity metrology in accredited laboratories and industrial settings.

Conferences and workshops

MIKES has contributed to international conferences, workshops, and stakeholder events in thermometry, humidity, sensor network metrology and digital transformation in this period, Activities include presentations, workshop participation and organisation, project meetings, stakeholder events, and training related to European metrology projects.

The thermometry and humidity areas have contributed to dissemination through EURAMET project meetings, CCT-related meetings, IMEKO events, digitalisation workshops, industrial stakeholder meetings, and training activities for end users. Particular emphasis has been placed on explaining how uncertainty, calibration, SI traceability, and data quality can be applied in modern distributed measurement systems.Conferences and workshops

The development of sensor network metrology is especially relevant for industry because it supports the use of large numbers of sensors in complex environments where traditional calibration approaches alone are not sufficient. The work helps users understand measurement uncertainty, data quality, sensor drift, correlations, and the reliability of measurement information in operational systems.

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