Annex I–JRP protocol

Version Date: 12 May 2025

24RPT03 A2TM

Advancement of air temperature metrology capabilities

Start date: 01 June 2025

Duration: 36 months

Coordinator
Tomaš Kopunec
SMU

Glossary

BIPM	International Bureau of Weights and Measure
CCT	Consultative committee for thermometry, part of BIPM
CCT-WG-CTh	CCT Working Group for Contact Thermometry
CCT-WG-Env	CCT Working Group for Environment
CIPM	Committee for Weights and Measures
CMC	Calibration and measurement capability
DAC	Data Access Committee
DI	Designated institute
DUTs	Devices under test
EMN	European Metrology Networks
EURAMET	European Association of National Metrology Institutes
ILC	Inter laboratory comparison
ISO	International Organization for Standardization
ITS-90	International temperature scale of 1990
NMI	National metrology institute
ORE	Open Research Europe
RMO	Regional metrology organisation
TC-IM	EURAMET technical committee for Interdisciplinary Metrology
TC-T	EURAMET technical committee for thermometry
VIM	International Vocabulary of Metrology
WMO	World Meteorological Organisation

Contents

Section A: Key data

A1 Project data summary

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Participant details:

no.	Participant Type	Short Name	Organisation legal full name	Country
1	Internal Beneficiary	SMU	Slovenský Metrologický Ústav	Slovakia
2	Internal Beneficiary	BEV-PTP	Physikalisch-Technischer Pruefdienst des Bundesamtfuer Eich- und Vermessungswesen	Austria
3	Internal Beneficiary	CMI	Cesky Metrologicky Institut	Czechia
4	Internal Beneficiary	DTI	Teknologisk Institut	Denmark
5	Internal Beneficiary	IMBiH	Institut za mjeriteljstvo Bosne i Hercegovine	Bosnia and Herzegovina
6	Internal Beneficiary	INRIM	Istituto Nazionale di Ricerca Metrologica	Italy
7	Internal Beneficiary	INTA	Instituto Nacional de Técnica Aeroespacial Esteban Terradas	Spain
8	Internal Beneficiary	JV	Justervesenet	Norway
9	Internal Beneficiary	NSAI	National Standards Authority of Ireland	Ireland
10	Internal Beneficiary	UL	Univerza v Ljubljani	Slovenia
11	Internal Beneficiary	VTT	Teknologian tutkimuskeskus VTT Oy	Finland
12	External Beneficiary	BRML	Biroul Roman de Metrologie Legala	Romania
13	External Beneficiary	CTU	České Vysoké Učení Technické v Praze	Czechia
14	External Beneficiary	INM	I.P. Institutul Naţional de Metrologie	Moldova, Republic of
15	Unfunded Beneficiary	PTB	Physikalisch-Technische Bundesanstalt	Germany

A2 Financial summary

	Internal Beneficiaries	External Beneficiaries	Unfunded Beneficiaries	Associated Partners	Total	Total eligible
Labour (€)	499 069.00	62 600.00	20 491.00		582 160.00	582 160.00
Subcontracts (€)						
T&S (€)	83 000.00	16 500.00	3 000.00		102 500.00	102 500.00
Equipment (€)						
Other Goods, Works and Services (€)	37 500.00	7 300.00			44 800.00	44 800.00
Internally Invoiced Goods and Services (€)	17 222.00				17 222.00	17 222.00
Financial Support to Third Parties (not applicable to JRPs)						
Indirect (€)	154 892.25	21 600.00	5 872.75		182 365.00	182 365.00
Total costs (€)	791 683.25	108 000.00	29 363.75		929 047.00	929 047.00
Costs as % of Total costs	85%	12%	3%	0%		
Total Eligible Costs (€)	791 683.25	108 000.00	29 363.75		929 047.00	929 047.00
EU contribution (€)	**791 683.25**	**108 000.00**			**899 683.25**	**899 683.25**
EU contribution as % of total EU contribution	88%	12%	0%	0%		
Months	104.2	21.3	3.0		128.5	128.5

A3 Work packages summary

WP No	Work Package Title	Active Participants (WP leader in bold)	Months
WP1	Mobile sub-chamber system development	**BEV-PTP,** CTU, CMI, DTI, INRIM, JV, SMU, VTT, UL, NSAI, BRML	39.7
WP2	Development of measurement and calibration procedures in air	**SMU,** BEV-PTP, CTU, CMI, DTI, IMBiH, INM, BRML, INRIM, INTA, JV, VTT, UL, NSAI	19.3
WP3	Interlaboratory comparison making use of the developed procedure together with the mobile sub-chamber system	**INTA,** BEV-PTP, CTU, CMI, DTI, IMBiH, INM, BRML, INRIM, JV, SMU, VTT, UL, NSAI, PTB	24.1
WP4	Knowledge transfer in the field of air temperature measurements and calibration	**DTI**, BEV, CTU, CMI, IMBiH, INM, BRML, INRIM, INTA, JV, SMU, VTT, UL, NSAI, PTB	17.5
WP5	Creating impact	**INRIM**, all participants	14.8
WP6	Management and coordination	**SMU**, all participants	13.3
		Total months	**128.5**

The information in tables A2 and A3 reflect the estimates of resources as of the start of project in June 2025. The tables will not necessarily be updated during the course of the project.

Section B: Overview of the research

B1 Summary of the project

Air temperature measurements hold pivotal importance across various fields such as energy storage, manufacturing and climate studies. Despite their importance, air temperature measurements are presumed to have reached their accuracy limits and there are currently no standardised guidelines for conducting air temperature measurements, leading to disparities in calibration capabilities among metrological laboratories. This project will aim to develop metrology capability in air temperature measurements, enabling the creation of new CMCs in laboratories that currently lack them, while also contributing to the enhancement of CMCs in laboratories already possessing them. Guidelines on accurate measurement and calibration practices and determining the components of uncertainty budgets will be produced.

B2 Excellence

B2.a <u>Overview of the objectives</u>

The overall objective of the project is to develop metrology capability in air temperature measurements. The specific objectives are:

1. To design and build a mobile and easy to set-up sub-chamber system for use with commercially available climatic chambers and laboratory setups. This system will be able to control all the key influential parameters (temperature distribution, radiation, irradiation of the device under test (DUT), humidity, pressure, wind speed, and self-heating of the sensors) in the temperature range of -40 °C to 80 °C with a target reference uncertainty of 15 mK. (WP1)
2. To develop a calibration procedure to characterise air temperature of the devices under test (DUTs) and reflect the metrological performance (e.g., temperature range from of -40 °C to 80 °C with a target reference uncertainty of 15 mK) of the developed mobile sub-chamber system developed in objective 1 using contact thermometry. This procedure will include determination of i) key influential parameters (temperature distribution, radiation, irradiation of the DUT, humidity, pressure, wind speed, and self-heating of the sensors) together with their quantification, ii) dynamic behaviour of sensors, iii) uncertainty and iv) their correlations, and a methodology on how to perform inter-laboratory comparison within the developed setup. (WP2)
3. To carry out an inter-laboratory comparison using the procedure developed from Objective 2 together with the mobile sub-chamber system from Objective 1 and at least 5 DUTs. When carrying out the comparison further characterisation of the system in different laboratory setups and conditions as well as a basis for future comparisons in terms of hardware and procedures that will improve the currently used approaches will be considered. (WP3)
4. To transfer knowledge in the field of air temperature measurements and calibration within the consortium to enable a common base for further development in research capabilities as well as measurement and calibration techniques of atmospheric air temperature. This will include the development of a good practice guide on air temperature measurement and calibration. (WP4)
5. To facilitate the take up and long-term use of the air temperature measurement capabilities, technology, and infrastructure developed in the project by the measurement supply chain (including NMIs/DIs, calibration and testing laboratories), and end users (such as industry, instrument manufacturers, and regulators). The consortium will discuss the approach internally and with other EURAMET NMIs/DIs, for instance through EURAMET TC-Thermometry (T) and the EMN for Climate and Ocean Observation and EMN for Energy Gases, to ensure a coordinated and optimised strategy for developing traceability in this field across Europe.

B2.b List of deliverables

Relevant objective (Activity delivering the deliverable)	Deliverable number	Deliverable description	Deliverable type	Participants (Lead in bold)	Delivery date
1 (A1.1.2)	D1	Report on the key parameters (temperature distribution, radiation, irradiation of DUT, humidity, pressure, wind speed and self-heating of the sensors) which have a significant influence on the air temperature measurement of DUTs and the design of the sub-chamber	Report	**BEV-PTP,** CTU, CMI, JV, SMU, NSAI	Nov 2025 (M06)
1 (A1.3.9)	D2	Report on the design and manufacture of a mobile and easy to set up climatic sub-chamber system that is able to control all key influential parameters (temperature distribution, radiation, irradiation of DUT, humidity, pressure, wind speed and self-heating of the sensors) in the temperature range from of -40 °C to 80 °C with a target reference uncertainty of 15 mK	Report	**SMU**, BEV-PTP, JV	Aug 2027 (M27)
2 (A2.1.4)	D3	Report summarising the most common air temperature calibration techniques used in laboratories both commercially and within EURAMET	Report	**SMU**, VTT, IMBiH	Mar 2026 (M10)
2 (A2.2.7)	D4	Calibration procedure on how to characterise air temperature of DUTs in the range of -40 °C to 80 °C with a target reference uncertainty of 15 mK including determination of i) key influential factors parameters (temperature distribution, radiation, irradiation of DUT, humidity, pressure, wind speed and self-heating of the sensors) together with their quantification, ii) dynamic behaviour of sensors, iii) uncertainty and iv) their correlations Part of the calibration procedure will be report on how employment of the additional network-level redundant data at the vicinity of the DUT during the calibration procedure will reduce the calibration uncertainty.	Calibration procedure	**VTT**, SMU, BEV-PTP, CMI, DTI, IMBiH. INRIM, INTA, JV, NSAI, UL, BRML, CTU, INM, PTB	Nov 2027 (M30)
3 (A3.1.4)	D5	Inter-laboratory comparison protocol to perform air temperature measurements with the mobile climatic sub-chamber system and at least 5 selected DUTs	ILC protocol	**SMU,** INTA, BEV-PTP, CTU, CMI, DTI, IMBiH, INM, BRML, INRIM, JV, VTT, UL, NSAI, PTB	May 2027 (M24)
4 (A4.1.3)	D6	Summary report documenting the video demonstrations of selected existing systems for air temperature calibration within EURAMET to transfer knowledge within the consortium and interested stakeholders	Report	**DTI**, BEV-PTP, INRIM, NSAI, SMU	Feb 2026 (M09)

4 (A4.1.7)	D7	Good practice guide on the measurement and calibration of air temperature using contact thermometry including evaluation of uncertainties and specification of sub-chamber system	Good practice guide	**NSAI**, INTA, BEV-PTP, CTU, CMI, DTI, IMBiH, INM, BRML, INRIM, JV, SMU, VTT, UL, PTB	May 2028 (M36)
n/a	D8	Evidence of contributions to or influence on new or improved international guides, recommendations and standards with a specific focus on the following guides and committees: CIPM CCT WG ENV, EURAMET TC-T, EURAMET TC-T WG best practice, EURAMET EMN- Energy Gases, EURAMET EMN- Climate and Ocean Observation and CEN/TC 423. Examples of early uptake of project outputs by end-users. Updated dissemination, communication and exploitation plan.	Reporting documents	**SMU**, all participants	May 2028 (M36) + 60 days
n/a	D9	Delivery of all technical and financial reporting documents as required by EURAMET	Reporting documents	**SMU**, all participants	May 2028 (M36) + 60 days

B2.c Need for the project

Understanding and accurately assessing the measurement uncertainty associated with air temperature readings remains an ongoing scientific and technical challenge. This issue has spurred research initiatives and discussions within organisations such as EURAMET TC-T, BIPM CCT, and the WMO. Currently, there are no universally accepted guidelines or specifications for performing air temperature measurements and calibrations using contact temperature sensors. To ensure the accuracy and comparability of these measurements, it is essential to establish a standardised procedure. Additionally, standardisation in the development of a measurement uncertainty budget is crucial for achieving consistent and comparable results in both measurements and calibrations.

Various experiments have also been conducted to address specific challenges in atmospheric air temperature measurements, considering factors such as sensor dynamics, site characteristics, radiation effects, wind, and precipitation. Notable projects, including EMRP projects ENV07 MeteoMet and ENV58 MeteoMet2, have focused on these issues. Despite these efforts, significant challenges remain in reducing the uncertainty of in-situ air temperature measurements and in the calibration of thermometers in air.

Discrepancies in air temperature measurements, primarily due to radiant errors, are often underestimated, even in highly controlled environments such as metrological laboratories where thermal radiance is minimal. These discrepancies are influenced by several factors, including the radiant environment, airspeed, surface emissivity, and the size of the thermometer or object being measured. Surprisingly, even in optimal laboratory conditions, these factors can cause thermometers to deviate from the true air temperature by approximately 0.1 °C. Larger objects may exhibit even greater deviations, sometimes varying by several tenths of a degree. While these differences may seem minor, they hold significant importance across various fields of precision metrology.

Currently, the methods used to calibrate air temperature sensors vary widely across different laboratories. These methods include measurements conducted in climatic chambers, submerged volumes in stirred baths, and direct measurements in baths. Each method offers different levels of precision and is applicable over specific temperature ranges, with its own set of challenges. An easy to set-up sub-chamber system for use with commercially available climatic chambers and laboratory setups is needed (Objective 1)

In addition, a common issue across these methods is the lack of standardised guidelines for consistently conducting air temperature measurements. Developing a standard procedure is crucial for ensuring the comparability and accuracy of calibrations. (Objective 2)

This standardisation effort should prioritise the definition of protocols for interlaboratory comparisons, and the development of a measurement system specifically designed for air temperature assessments in climatic chambers. Furthermore, it should outline the critical variables—such as temperature, radiation, humidity, pressure, and wind speed—that need to be considered to comprehensively evaluate uncertainty, thereby enhancing the comparability of measurement results. (Objective 3)

The absence of a standardised guide for the calibration of thermometers in air was notably identified at the EURAMET TC-T meeting in 2017. This recognition has led to initiatives aimed at fostering collaborative research for the creation of such a guide under the EURAMET TC-T Working Group on Guides. (Objective 4)

B2.d <u>Progress beyond the state of the art</u>

Objective 1: Sub-chamber system

The results and findings from the EURAMET project No. 1459 have clearly shown the differences in air temperature measurements and calibrations throughout the European metrological community. These differences and discrepancies need to be addressed and one of the most effective tools is the introduction of comprehensively defined sub-chamber system. Sub-chamber system approaches so far have been used and developed on different levels of complexity and applications in the past with mixed levels of success. These sub-chambers are normally developed to address predominantly temperature homogeneity in a climatic chamber with a specific system, narrow temperature range and specific sensor geometries. This project, through the development and construction of the sub-chamber system, will go beyond the existing technological standards by addressing the current gap in characterising the key parameters influencing measurements within the sub-chamber's volume. This system will enable the simultaneous real-time monitoring of critical variables such as temperature profiles, radiation effects, humidity, pressure, and wind speed, providing a comprehensive and precise overview of the environmental conditions surrounding the Device Under Test (DUT). Additionally, by analysing the correlations between these various influencing factors, the system will contribute to significant improvements in the accuracy of air temperature measurements conducted through contact methods.

In recent years, multiple efforts have been made by laboratories to develop sub-chamber systems; however, these initiatives have largely focused on a narrow range of influencing factors. Most of these systems were tailored to meet the specific needs of individual laboratory setups, which limited their usability and metrological performance across different laboratory environments. The new sub-chamber system will go beyond the state of the art by overcoming these limitations by reducing the impact of varying climatic chamber conditions and enhancing the system's portability and adaptability within the consortium.

Objective 2: Measurement and calibration procedures

Beyond the design of the equipment itself, one of the most critical components of any measurement process is the establishment of a robust procedure that ensures the highest possible accuracy. In the context of contact air temperature measurements, current procedures predominantly focus on the characterisation of the climatic chamber rather than the actual conditions and measurements inside the chamber. This approach overlooks essential influencing factors such as radiation effects, humidity, pressure, and wind speed. The project will go beyond the state of the art by developing a procedure that offers state-of-the-art guidance on the characterisation of these critical variables, this will enable a more precise evaluation of sensor performance under a range of well-defined conditions. This, in turn, will lead to a more accurate and realistic determination of the uncertainty budget in contact air temperature measurements, something that has not yet been achieved at such a complex and interconnected level.

Objective 3: Inter-laboratory comparison

Currently, there are no standardised guidelines or specifications for uniformly conducting air temperature measurements and calibrations using contact temperature sensors. The project will go beyond the state of the art by carrying out an inter-laboratory comparison to evaluate the feasibility of using the newly developed procedures and the sub-chamber system as a future tool for validating laboratory air calibration capabilities. This system is expected to establish a standardised approach for air temperature comparisons across the European region, benefiting from the clearly defined influencing factors in climatic chamber measurements. It will also provide a more robust and objective evaluation of each laboratory's capabilities. The project will also progress the state of the art by focusing on further expanding the testing of the sub-chamber system across various laboratory setups, emphasizing its versatility and universality. This testing will be carried out in the early phases of system development to ensure optimal performance and adaptability.

Objective 4: Knowledge transfer

Additionally, the project will facilitate the transfer of knowledge within the consortium, particularly in the areas of air temperature measurements and calibration. This knowledge exchange through training materials, hands on workshops and exchange of researchers will help establish a common foundation for advancing research capabilities, as well as improving measurement and calibration techniques for atmospheric air temperature.

Members of the consortium will be kept informed of the results and outcomes from relevant previous projects, including EMRP ENV07 MeteoMet, EMRP ENV58 MeteoMet2, and EURAMET projects No. 1576 and 1459, with a special focus on contact air temperature measurements and the factors that influence them.

B2.e Gender dimension

This project does not have a gender dimension.

This project concerns the development of a climatic chamber sub-chamber system for the purpose of air temperature measurement improvement and does not have any particular gender-specific consequences or any foreseen gender-specific findings. Implementations of hardware development together with measurement procedures have several potential benefits in society at large, for instance by enabling better process management in a number of industrial settings. In turn, this has the potential to increase the energy storage and generation efficiency, more reliable metrological observations, improve the quality of food and pharmaceutical good, and improve the operational safety. All of the listed areas have an effect on different areas of society. However, neither of these potential benefits differs for men and women.

The dissemination activities include reports, peer reviewed papers and practical demonstrations of measurements conducted with the sub-chamber system. The results of the demonstrations are not expected to affect one specific gender in any particular way. The project will communicate its dissemination activities in a manner that highlights to all genders the benefits of the project.

B2.f Open science

Within this project we will address open science by emphasis on collaborative work and the broad, early sharing of knowledge and tools throughout the research process. This project will incorporate open science practices, recognizing their potential to enhance research quality and efficiency, and to accelerate the progress of knowledge and innovation through the sharing of results. Such practices increase the reusability of findings and improve their reproducibility. The project will adhere to open science principles in line with Regulation (EU) 2021/695, which establishes Horizon Europe—the Framework Programme for Research and Innovation—and outlines the rules for participation and dissemination.

Sharing of gained knowledge, results of multilateral comparison and guidance documents will be treated with the open access approach via multiple channels which will include the publishing trough the project website, presentation during technical and consultative committee meetings and through presentations on international conferences. The project plans to publish 3 peer-reviewed papers, all of which will be made available through open access form. The choice of journal will be guided by the intended audience. Preprints of the project manuscripts will be submitted to an appropriate open access platform. Since the scientific publication process can be lengthy, depending on the chosen journal, the project will submit preprints to widely used and accessible repositories prior to formal publication, ensuring the timely dissemination of results to stakeholders.

The project will responsibly manage the digital research data generated, adhering to the requirements outlined in the Grant Agreement. The consortium will strive to follow the FAIR principles by creating and regularly updating a data management plan, depositing data in widely used and trusted repositories, and ensuring open access to data produced during the project. Additionally, the metadata for deposited data will be made openly available under a CC0 license or equivalent, aligned with the FAIR principles, and accompanied by the necessary information as stipulated in the Grant Agreement.

During the course of the project an interlaboratory comparison will take place which demands for its success the comparability and reproducibility of outputs from various laboratories. This process will be ensured by the compatibility of project consortium participants through their quality management systems that follow ISO/IEC 17025 standard and through the year experience and common practices used within the EURAMET TC-T community. The project will disseminate its results to relevant technical committees such as CCT Working Group for Environment (CCT-WG-Env) and Working Group for Contact Thermometry (CCT-WG-CTh), EURAMET TC-T WG, EURAMET TC-T WG best practice in order to provide a further layer of peer review of the project’s results.

The project will responsibly manage research data in accordance with the FAIR principles, ensuring open access to data under the guideline 'as open as possible, as closed as necessary,' as specified in the Grant Agreement. Participants will release documented source code, calibration data and the calculation of uncertainty ensuring the ease of use and reuse. While GitHub is the likely platform for sharing, other suitable alternatives may also be considered.

The project will consider Open Research Europe (ORE) as a potential journal for its publications. ORE, recently established by the European Commission for use by its project's beneficiaries, offers a no-cost, open access platform with an open peer-review process. This publishing venue allows for transparency, as reviewers' comments, recommendations, and authors' responses are available for public viewing, making it an ideal outlet for EU-funded research.

The project will create an online social media presence (for instance: LinkedIn, X / Twitter) to facilitate stakeholder engagement. This group will feature regular updates on project progress, including key milestones, the completion of specific tasks. It will also serve as a platform to gather stakeholder feedback, such as through invitations to workshops. Throughout the project, participants will maintain close communication with the EURAMET TC-T, where all participants are represented, and the CCT, where several participants have representation.

B2.g Research data management and management of other research outputs

Research data management and management of other research outputs will be addressed in accordance with the requirements of the Grant Agreement. A data management will be produced and submitted to EURAMET at month 9 in accordance with the Reporting Guidelines issued by EURAMET. An updated version of the data management plan will be submitted to EURAMET at month 36 (+ 60 days).

B3 Potential outcomes and impact from the project

B3.a Projected outcomes for industrial and other user communities

Several industrial sectors and user communities stand to benefit significantly from advancements in air temperature measurement using contact methods. Among the most pertinent areas are energy storage, energy production, indoor climate control particularly for the storage of perishable goods and pharmaceutical products, meteorological observations, climate studies, relative humidity realisation, and both dimensional and mass metrology. Across all the countries involved in this project, these industries and communities are integral, and the findings and developments from the project could be directly implemented to enhance their operations.

Currently, there is a noticeable variance in the practices used by different stakeholders, leading to a wide range of measurement uncertainty and reliability in the measured air temperature. This inconsistency poses challenges for industries that rely on precise air temperature measurements, as variations can affect everything from the efficiency of energy storage systems to the quality control of temperature sensitive products. The advancements made through this project will address these discrepancies by improving the accuracy and reliability of air temperature measurements.

With enhanced measurement capabilities, National Metrology Institutes (NMIs) and Designated Institutes (DIs) will be equipped to provide more stable and precise calibration services to regional clients. This will not only lead to more accurate air temperature measurements in industrial settings but also support the development of new, innovative applied thermometry techniques. These techniques can significantly improve process control across various industries, leading to better outcomes in terms of efficiency, product quality, and resource management.

Throughout the project, participants will actively demonstrate the new measurement techniques and the sub-chamber system developed to selected stakeholders from industry and other relevant communities. These demonstrations will illustrate various ways in which the newly developed national capabilities can be exploited to improve industry practices. The calibrated sub-chamber system, in particular, will play a crucial role in disseminating traceability, ensuring that the benefits of these advancements are effectively transferred to the end-users. By showcasing practical applications and providing clear examples of the advantages of improved measurement techniques, the project aims to foster broader adoption and integration of these new capabilities across the relevant sectors.

B3.b Projected outcomes for the metrological and scientific communities

The project will significantly enhance European capabilities in contact air temperature measurements by leveraging the collective efforts of the consortium. Together, the consortium will focus on developing and characterising a practical sub-chamber system for the air temperature calibration of contact sensors, along with establishing best measurement practices for its use. This collaborative approach will enable the project participants to jointly advance their capabilities, acquire valuable knowledge, and gain practical experience in air temperature measurements across a range of -40 °C to 80 °C. The knowledge gained and the hardware developed through this project will lay the foundation for further research and collaborative efforts in the field of thermometry. Additionally, the project’s outcomes will build upon and expand the existing body of research from previous initiatives, such as EMRP project ENV07 MeteoMet, EMRP project ENV58 MeteoMet2, and EURAMET projects No. 1576 and 1459.

Beyond improving measurement capabilities, the project will also enhance regional cooperation within EURAMET by supporting less experienced NMIs and DIs across multiple European regions. It will help these institutions identify and develop areas of specialisation, fostering greater collaboration and strengthening the overall network of expertise in metrology.

Importantly, this research will have a significant impact not only within the metrology community but also in fields such as meteorology and climatology, which heavily depend on accurate air temperature measurements. By developing a comprehensive, traceable measurement system with improved uncertainty, the project will provide these communities with invaluable tools for advancing research in their respective areas.

Upon completion of the project, the participating NMIs and DIs will have substantially enhanced their competencies, making them well-equipped to actively engage in future calls within the European Partnership on Metrology (EPM) and other subsequent programmes. This newly acquired expertise will enable these institutions to contribute more effectively to initiatives where precise air temperature measurement is critical.

The advanced capabilities developed through this project will be particularly valuable in setting standards related to air temperature measurement, which are expected to play a key role in future project calls. Given that all the countries involved in this project have significant industrial sectors where accurate air temperature determination is essential, the competencies gained will be directly applicable. This will not only improve the accuracy and reliability of air temperature measurements but also support broader industrial and technological advancements within these regions. By equipping the NMIs and DIs with the necessary skills and knowledge, the project ensures that they are better prepared to contribute and benefit from future collaborative opportunities, ultimately strengthening the metrology landscape across Europe.

Another important outcome of the project is in supplementing other project and research activities that deal with environmental thermodynamic where better understanding of air measurements and factors affecting them are essential for further development in the area of environmental metrology.

B3.c Projected outcomes for relevant standards

The consortium's engagement with standardisation committees and metrology committees, and the projected outcomes for relevant standards are described in section C, Task 5.1, where Task 5.1 is the Dissemination and Communication task in the Impact WP.

B3.d Projected wider impact of the project

Air temperature measurements are frequently conducted to define specific thermal conditions, which are essential in a wide range of applications as they affect multiple other key parameters. These areas include industrial processes, energy storage and production, indoor climate control for storage of perishable goods, meteorological observations, climate studies, relative humidity realisation, dimensional and mass metrology. As can be seen air temperature is universally measured and its value affects the effectives, safety and environmental impact within these areas and processes used within them. An improved measurement of air temperature would help to improve temperature control and indication which will have numerous positive economic benefits for industry, food and drug safety, energy storage, meteorological and climate observations. This enhancement in metrology of air temperature measurement will have a wider impact on the competitiveness of European industry and science in diverse fields. More detailed examples of impacts follow:

Economic impact:

- Industrial manufacturing of various mechanical elements relies heavily on precise, effective and fast production. Precise temperature of the environment is necessary to apply essential corrections of thermal expansion, ensuring that components are produced with accurate dimensions.
- In automotive industry properties of materials used in car production are subject to rigorous environmental testing and accelerated aging where temperature is an essential quantity. By improving the measurement uncertainty, a more exact lifetime of a part can be determined thus reducing the number of produced replacement parts and lead to improved safety.
- Quality of production and quality control heavily relies on manufacturing conditions one of which is temperature of the environment where the production takes place. Again, by introducing a more reliable measurement in air the project outputs will enable manufacturers to improve the control of quality in production.
- In the area of energy storage, the efficiency of battery charging and overall capacity is directly affected by the temperature at which the storage device operates. As the overall energy density of batteries created by today's technology has reached its limits, the effectiveness of energy use becomes more important. By a well-defined temperature measurement outside the battery, project outputs will enable

end users (e.g., battery producers and companies building high-capacity energy storage facilities) to better optimise the charging cycles and optimise the battery capacity by active temperature regulation.

- In the storage of perishable goods, the ambient temperature impacts the shelf life and quality of the products. These products do not only include food products but also pharmaceutic and electronics. The improper determination of storage conditions can have a devastating impact on health safety and economic impact as well.

Environmental impact:

- Air temperature measurement is a crucial aspect of environmental monitoring, as it provides essential data for understanding and managing the Earth's climate and ecosystems. Temperature is a key indicator of atmospheric conditions and plays a significant role in weather patterns, climate change, and the overall health of the environment. Consistent and accurate temperature data allows scientists to track long-term climate trends, such as global warming, and assess their impacts on biodiversity, agriculture, and water resources. In the context of climate change, air temperature measurements help identify shifts in regional climates and their effects on ecosystems. Furthermore, temperature data is critical for predicting extreme weather events such as droughts, floods, and storms, enabling better preparedness and mitigation strategies. By monitoring temperature, environmental agencies can better understand these dynamics and implement policies to protect public health and ecosystems. An improve air temperature measurement is vital for tracking climate changes, predicting extreme weather events, and supporting environmental conservation efforts. It provides critical data for scientists and policymakers working to safeguard ecosystems and ensure sustainable development in the face of global challenges.
- A better understanding of the measurement of air temperature will result in more efficient means of maintaining cold chains for the storage and transport of both pharmaceutical substances and perishable goods. This in turn will lead to a reduction in the energy requirement for such activities, thereby reducing the carbon emissions from energy generation in transportation and storage.

Social impact:

- Although this project does not have a direct social impact, many essential products in a green and sustainable society depend on processes that rely on precise and reliable air temperature measurements. By improving the understanding of air temperature measurements and developing new measurement techniques we are helping the European industries to optimise, maintain, and advance their production processes.
- Improved capabilities in the measurement of air temperature will also better inform as to the extent of climate change from a meteorological perspective. This in turn will lead to a greater awareness of climate change and implications for society as a whole. It could lead to a cultural change among communities who perhaps are not yet convinced that climate change is taking place.

B3.e Summary of the project's impact pathway

SPECIFIC NEEDS	EXPECTED RESULTS	DCE MEASURES
What are the specific needs that triggered this project? Accurate temperature measurements are required in a broad range of industries and areas. It is important in complying to the EU energy directive, helping achieve the goals of Industry 4.0, the accurate monitoring of climate change, and in the EU goal of reaching net zero emissions by 2050. In addition, the lack of a standardised guide for the calibration of thermometers in air was highlighted at the EURAMET TC-T meeting in 2017, leading to initiatives to promote collaborative research for its development. Discrepancies in air temperature measurements, primarily due to radiant errors, are often underestimated. These discrepancies are influenced by several factors (e.g. surface emissivity, size of the thermometer). Surprisingly, even in optimal laboratory conditions, these factors can	*What do you expect to generate by the end of the project?* New mobile sub chamber system that reduces the impact of varying climatic chamber conditions in the temperature range from of -40 °C to 80 °C with a target reference uncertainty of 15 mK. Calibration procedure that offers state of the art guidance on the characterisation of critical variables, enabling a more precise evaluation of sensor performance under a range of well-defined conditions. Inter laboratory comparison performed (and associated protocol) to evaluate the feasibility of using the newly developed procedures and the sub chamber system as a future tool for validating laboratory air calibration capabilities. Knowledge transfer within the consortium, particularly in the areas of air	*What dissemination, communication and exploitation measures will you apply to the results?* <u>Communication</u> • Project website • 4 papers at international conferences (e.g., MMC, TEMPMEKO, IMEKO, CIM and others) • LinkedIn discussion group • Technical group meetings of metrological bodies (BIPM CCT, EURAMET TC-T) <u>Dissemination</u> • Stakeholder workshops • Reports to the CCT-WG-Env and the EURAMET TC-T. • Openly published results of the comparison

cause thermometers to deviate from the true air temperature by approximately 0.1 °C-0.2 °C which hold significant importance across various fields of precision metrology. Currently, the methods (e.g. sub- chamber systems) used to calibrate air temperature sensors vary widely across different laboratories. Each method offers different levels of precision and is applicable over specific temperature ranges. A common issue across these methods is the lack of standardised guidelines for consistently conducting air temperature measurements. Developing a standard procedure is crucial for ensuring the comparability and accuracy of calibrations.	temperature measurements and calibration. Good practice guide on the measurement and calibration of air temperature using contact thermometry including evaluation of uncertainties and specification of sub-chamber system.	• 3 papers published in peer review journals Exploitation • New calibration service utilising the developed sub-chamber system with the connected measurement methods • Inter laboratory comparison protocol developed in close collaboration with the EURAMET TC-T community • Good practice guide published on the project website and made available to the EURAMET TC-T community.
TARGET GROUPS	**OUTCOMES**	**IMPACTS**
Who will use or further up-take the results of the project? Who will benefit from the results of the project? **Metrology institutes** BEV-PTP, CMI, DTI, INRIM, IMBiH, INM, BRML, INTA, JV, SMU, VTT, UL, NSAI and PTB who are part of the consortium will adopt the new measurement techniques and developed hardware solutions as a service. **Accredited laboratories** who will make use of the newly provided services and measurement procedures and hardware. **Industrial companies** in the respected countries of each consortium member that focus of storage of goods, energy storage facilities, pharmaceutic companies, automotive industry **Research organisation and institutions** who focus on environmental studies and observations and heavily rely on air temperature measurements. **Broader metrological community**, EURAMET TC-T, BIPM CCT who will be able to benefit from the new guides and methods developed.	*What change do you expect to see after successful dissemination and exploitation of project results to the target group(s)?* Enhanced measurement capabilities will enable **metrology institutes** to offer stable and precise calibration services to regional clients. Accredited laboratories will be able to provide improved calibrations in terms of reduced uncertainty of sensors that are used in air. The laboratories will be able to provide more custom tailored calibrations that can mimic the intended use of the sensors (for example: air flow, irradiation, humidity etc.). Furthermore, the sub-chamber system will enable a more streamlined and effective bilateral comparison which is essential for the QMS. Industrial companies (e.g., manufacturing of various goods, transportation companies that handle perishable goods, pharmaceutical storage companies as well as various laboratories) will be able to access more stable and precise air temperature measurement. This will lead to more accurate air temperature measurements in industrial settings. **Research organisations and institutions** will be able to improve their measurements of air and by extent gas by simulating the extreme conditions of the surrounding medium. These conditions include flow speeds and flow behaviour, irradiation effects, moisture/ water content effects, pressure. This kind of ability could be expanded for extreme high velocity flows for occurring in aeronautical applications. **Broader metrological community** will be able to benefit from the new guides and methods developed.	*What are the expected wider scientific, economic and societal effects of the project contributing to the expected impacts outlined in the work programme and call scope?* Scientific impact: Impact in the scientific area will on the more précises determination of experimental conditions in laboratories reducing the possibility of false and inconclusive results. Economic impact: More stable and precise air temperature measurement leading to an improvement in quality of production and quality control More well-defined air temperature measurements leading to better monitoring of the efficiency of battery charging and overall capacity Environmental impact: Consistent and accurate temperature data allows scientists to track long-term climate trends, such as global warming, and assess their impacts on biodiversity, agriculture, and water resources. Temperature data is critical for predicting extreme weather events such as droughts, floods, and storms, enabling better preparedness and mitigation strategies. Social impact: Improved capabilities in the measurement of air temperature will also better inform as to the extent of climate change from a meteorological perspective. This in turn will lead to a greater awareness of climate change and implications for society as a whole. It could lead to a cultural change among communities who perhaps are not yet convinced that climate change is taking place.

B4 The quality and efficiency of the implementation

B4.a <u>Overview of the consortium</u>

The consortium brings together established NMIs and DIs together with academia with varying degrees of experience with contact air temperature measurement. This mixture of organisation enables a transfer of experiences in the field, developing the capabilities of air temperature measurements across Europe as well as the possibility of developing a more universal and robust approaches.

SMU is the Slovakian national metrology institute with experience in contact thermometry. SMU is well experienced with air temperature calibration in a climatic chamber with further development experience in climatic sub-chamber in a EURAMET bilateral project No.1576. SMU has participated in temperature related EMRP and EMPIR projects IND01 HITEMS, 15SIB02 InK 2 or 18SIB02 Real-K as well as EURAMET Air temperature metrology project No. 1459. SMU will be the coordinator of the project.

BEV-PTP is the Austrian national metrology institute. It offers services in all basic areas of metrology, including basic metrology, development of national standards, research and development in metrology, transfer of units, calibration of standards and measuring instruments. BEV-PTP has participated in numerous EURAMET and EMPIR projects.

CMI is the Czech national metrology institute. CMI provides services in all basic fields of metrology, including fundamental metrology, development of national standards, research and development in metrology, transfer of units, calibration of standards and measuring instruments. CMI provides certification of reference materials, state metrology assessment of measuring instruments and other services too. CMI has participated in a number of EMRP, EMPIR and Metrology Partnership projects.

DTI, the Danish designated institute in contact thermometry and has laboratory facilities for measuring air temperature. DTI has participated in numerous EMRP, EMPIR and Metrology Partnership projects within air temperature measurements under difficult conditions.

IMBiH is the national metrology institute for Bosnia and Herzegovina. IMBiH's Laboratory for Temperature and Humidity has laboratory facilities for measuring air temperature. IMBiH has actively participated in various EMRP and EMPIR projects in the field of temperature and humidity measurements.

INRIM is the Italian national metrology research institute. It is responsible for the maintenance of the SI units, as well as research in fundamental and applied metrology, dissemination and knowledge transfer. INRIM has coordinated a number of international and national projects in the field of temperature and thermodynamic metrology. INRIM can provide many facilities and equipment, as well as expertise, in temperature measurements and the evaluation of calibration and measurement uncertainties.

INTA is the Spanish designated institute for absolute and relative humidity, as well as radio frequency. In addition to conducting scientific research and developing systems and prototypes in its areas of expertise, it provides technological services to companies, universities, and institutions. Acting as both a technological centre and the metrology laboratory for the Ministry of Defense, INTA's Metrology and Calibration Center has experience in several EURAMET projects.

JV is the Norwegian national metrology institute and has expertise in contact thermometry, radiation thermometry, humidity and air temperature. JV is a member of the CCT and is currently in lead of the WG Env TG air. JV is experienced in several EMPR, EMPIR and Metrology Partnership projects.

NSAI is the Irish national metrology institute and is responsible for establishing, maintaining and developing the national measurement standards for physical quantities and their dissemination. The Temperature and Humidity section of the NSAI maintains the national standards for temperature and humidity, including air temperature measurement. NSAI has a climatic chamber, capable of providing temperatures from -70 °C to +180 °C. NSAI has experience as in EMPIR projects. NSAI also currently chair the EURAMET TC-T best practice working group, responsible for the publication of guides on thermometry and temperature calibration.

UL is designated institute of Slovenia for temperature and humidity and has leading facilities for the measurement and calibration of air temperature sensors. In the number of EURAMET projects (Air temperature Measurement project No. 1459) these capabilities were confirmed.

VTT is the finish national metrology institute, both realising the SI units and engaging in high-level metrological research, innovating measurement applications alongside industry. VTT will be in the project dominantly involved in data analysis and the evaluation of calibration improvement of the sub-chamber system.

BRML is the Romanian national metrology institute**.** BRML has participated in various EMRP and EMPIR projects in the field of temperature measurement and will participate in the initial determination of the metrological characterisation of the sub-chamber prototype in WP1.

CTU the Czech Technical University in Prague (CTU) is a leading technical research university. The department of microelectronics is well-equipped for sensors design, electronics design and measurement that is needed for this project. CTU has participated in many national and international grants and will be mainly responsible for the design of sensor networks inside the sub-chamber system.

INM is the Moldovan national metrology institute. INM has participated in EMPIR projects in the field of temperature measurement.

PTB is the German national metrology institute, working in most fields of science and technology. PTB has experienced metrological experts in contact thermometry, humidity and digitalisation. PTB is involved in a number of EMPIR and Metrology Partnership projects as well as EURAMET projects. PTB will be mainly involved with the ILC.

Section C: Detailed project plans by work package

C1 WP1: Mobile sub-chamber system development

The aim of this work package is to design and build a mobile sub-chamber system which can be used with typical climatic chambers and laboratory setups in the range of -40 °C to 80 °C with a target reference uncertainty of 15 mK. The process of development will include the initial testing and characterisation of the sub-chamber system together with the measurements of dominant influential factors on the sensors that will be subject of measurement within the sub-chamber system. All of the gathered data will be used for further optimisation of the system in order to achieve the best possible measurement uncertainty. The work package is broken down into three tasks.

Task 1.1 - to design and model a mobile sub-chamber system for air temperature measurements in climatic and environmental chambers.

Task 1.2 - to construct the sub-chamber system based on the agreed design that has been determined in Task 1.1.

Task 1.3 - to characterise the initially designed sub-chamber system.

C1.a Task 1.1: Design and modelling of the sub-chamber system

The aim of this task is to design and model a mobile sub-chamber system for air temperature measurements in climatic and environmental chambers. Key construction parameters of the sub-chamber system will be investigated and determined. These include ideal geometry, construction material and surface finish as well as the selection and design of reference and supportive sensors that will enable the total characterisation of the inner volume of the sub-chamber system.

Activity number	**Activity description**	**Participants (Lead in bold)**
A1.1.1 M02	SMU with support of BEV-PTP, CMI, JV and NSAI will produce and carry out a survey within the EURAMET community to determine the most used climatic and environmental chambers. SMU will collate this information and determine the optimal geometrical parameters (e.g. inner working volume) of the climatic sub-chamber system.	**SMU,** BEV-PTP, CMI, JV, NSAI
A1.1.2 M06	BEV-PTP together with CTU, CMI, JV, SMU and NSAI will determine and specify the key parameters (e.g., temperature distribution, radiation, irradiation of DUT, humidity, pressure, and wind speed, and self-heating of the sensors) which will have a significant influence on the design of the mobile and climatic sub-chamber. Various sub-chamber designs are to be investigated. BEV-PTP will additionally draft a machine-readable report/determination of parameters/measurement parameter, measurements influences; measurements values (raw data), administrative data (erp, eg., order data). BEV-PTP together with CTU, CMI, JV, SMU and NSAI will produce a report on the key parameters (temperature distribution, radiation, humidity, pressure, wind speed and self-heating of the sensors, irradiation of DUT etc.) which have a significant influence on the air temperature measurement of DUTs and the design of the sub-chamber. Once the report has been agreed by the consortium, the coordinator on behalf of BEV-PTP, CTU, CMI, JV, NSAI and SMU will then submit it to EURAMET as **D1** *“Report on the key parameters (temperature distribution, radiation, humidity, pressure, wind speed and self-heating of the sensors, irradiation of DUT etc.) which have a significant influence on the air temperature measurement of DUTs and the design of the sub-chamber”*	**BEV-PTP,** CTU, CMI, JV, NSAI, SMU
A1.1.3 M03	SMU, with support from BEV-PTP and JV, will determine the most suitable construction materials, material coatings and surface finishes that can be applied to the sub-chamber system to ensure the best possible thermal properties and reduce radiation effects.	**SMU**, BEV-PTP, JV
A1.1.4 M09	BEV-PTP with support from CTU, CMI, JV, SMU and NSAI will propose an initial design for the geometry of the mobile and climatic sub-chamber system. This design should respect the most used dimensions of the inner climatic chamber working volume that was gathered in A1.1.1. The chamber design should consider both the key influential factors on the measurement within a climatic chamber that were determined in A1.1.2 and the surface finishes determined in A1.1.3.	**BEV-PTP,** CTU, CMI, JV, NSAI, SMU

A1.1.5 M10	CTU will design a network of temperature and humidity sensors that fits to dimensions and needs of the mobile and climatic sub-chamber designed in A1.1.4. CMI will consult with CTU to formulate a sensor calibration routine in order to best suit the custom-made sensors. BEV-PTP together with CTU will determine and document the software requirement specifications for the designed sensors.	**CTU**, BEV-PTP, CMI
A1.1.6 M12	JV with support of SMU will design and test an exchangeable hardware solution for the sub-chamber system design to enable an optical inlet/outlet in the exchangeable measurement volume/probe section. This will make it possible to control the irradiation of the DUT.	**JV**, SMU
A1.1.7 M12	BEV-PTP, with support of JV and NSAI, will select the most suitable sensors for measuring the key influential factors determined in A1.1.2 that can be used within the designed sub-chamber from A1.1.4.	**BEV-PTP,** JV, NSAI
A1.1.8 M10	BEV-PTP with support from CTU, CMI, JV, SMU, NSAI and UL will determine at least three suitable reference sensor candidates that have the potential to be used as a reference in the sub-chamber system. -	**BEV-PTP,** CTU, CMI, JV, NSAI, SMU, UL
A1.1.9 M14	CMI with support of CTU, BEV-PTP, JV, NSAI and SMU will perform CFD heat transfer and airflow simulations of various sub-chamber operation scenarios, based on specifications, technical details of the sub-chamber, and sensors selection from A1.1.2, A1.1.4, A1.1.5, A1.1.6, A1.1.7 and A1.1.8.	**CMI**, CTU, BEV-PTP, JV, NSAI, SMU

C1.b Task 1.2: Construction of the sub-chamber system and sensor characterisation

The aim of this task is to construct the sub-chamber system based on the agreed design that has been determined in Task 1.1 and furthermore the construction of temperature and humidity sensor as well as their integration into the system together with the selected sensor of other determined dominant influential quantities. Furthermore, this task will deal with the initial testing of sensors in order to ensure their proper function and expected parameters.

Activity number	Activity description	Participants (Lead in bold)
A1.2.1 M13	CTU will build a network of temperature and humidity sensors determined in A1.1.5 for the sub-chamber system. CMI will calibrate the sensor network based on routine developed in A1.1.5. CTU will transport the temperature and humidity sensors network to BEV-PTP. SMU with support of CTU and CMI will ensure that the network fits the needs of further project activities.	**CTU,** CMI, SMU
A1.2.2 M16	BEV-PTP will build four prototypes in total from materials that have been selected from A1.1.3 and based on the design created in A1.1.4. BEV-PTP will then circulate them between BEV-PTP and SMU, for an initial test phase to identify possible improvement measures and make any changes to the sub-chamber system. The temperature and humidity sensors network from A1.2.1 will be integrated into the constructed prototypes.	**BEV-PTP**, SMU
A1.2.3 M14	The selected sensors from A1.1.7 and three candidate reference sensors from A1.1.8 will be purchased and calibrated by BEV-PTP and SMU. The calibration report will be made available to all consortium for measurement uncertainty budget calculations. Once calibrated, SMU will transport their sensors to BEV-PTP.	**SMU,** BEV-PTP
A1.2.4 M16	DTI and UL will calibrate three candidate reference sensors from A1.2.3 with the best possible measurement uncertainty in the temperature range from -40 °C to 80 °C together with the characterisation of sensors main uncertainty components. The best performing sensor in terms of measurement uncertainty will be selected for further use as a reference thermometer in the developed sub-chamber system. In addition, CTU will develop an additional multimeter system for the measurement with the selected reference sensors.	**DTI**, UL, CTU
A1.2.5 M17	SMU and BEV-PTP will integrate all of the manufactured and purchased sensors from A1.2.1 and A1.2.4 into the constructed sub-chamber system prototypes from A1.2.2. All of the sensors will be provided to BEV-PTP with cooperation with SMU which will facilitate the sensor integration.	**SMU,** BEV-PTP
A1.2.6 M13	DTI will design, construct and characterise a radiation-shielded reference thermometer based on the aspiration principle with an uncertainty less than 15 mK. JV, UL and CTU will assist in reviewing the design of the thermometer before construction.	**DTI**, JV, UL, CTU

A1.2.7 M14	BEV-PTP, INRIM and SMU will ensure that the files prior to publishing contain all the information needed to build the reference thermometer. DTI will publish the design files for the thermometer, developed in A1.2.6, in an open-access repository.	**DTI,** INRIM, SMU, BEV-PTP

C1.c Task 1.3: Characterisation and optimisation of the sub-chamber system

The aim of this task is to characterise the initially designed sub-chamber system. This design will follow theoretical knowledge, calculations and simulations which can only mimic the true conditions that occur in a laboratory setting. Therefore, a testing prototype of the key influential factors like temperature distribution, wind speed, pressure, self-heating of the used reference sensors, humidity, radiation effects, irradiation of DUT that are known to have dominant contribution to the measurement uncertainty needs to be determined and in the case of unsatisfactory results modified. Specifically, the testing of controlled irradiation of DUT (Devices Under Test), sub-chamber stability and temperature distribution, self-heating and sensor size effects, emissivity of sensor housing will be as well subject of this task.

Activity number	Activity description	Participants (Lead in bold)
A1.3.1 M19	BEV-PTP, and SMU will organise an initial circulation of three prototype sub-chamber systems from A1.2.2 (one prototype to each participant). The initial metrological parameters that will be determined will be the temperature stability in four points in the temperature range -40 °C to 80 °C as well as temperature distribution with the installed network sensors from A1.2.5. The reference temperature sensor that will be used in these prototypes will be from A1.1.8 and A1.2.6.	**BEV-PTP,** SMU
A1.3.2 M20	The initial test data from A1.3.1, sensor calibration and measurement data from A1.2.1 and A1.2.3 together with the created CFD heat transfer and airflow simulations from A1.1.9 will be analysed by CMI with support of VTT. This analysis will focus on the evaluation of proper function of the proposed design and if possible, improvement should be made to the initial design from A1.1.4 to achieve the reference uncertainty of 15 mK.	**CMI,** VTT
A1.3.3 M19	JV with support from SMU, will integrate sensors from A1.2.5 into the prototype with climatic sub-chamber from A1.2.2. JV, with support from SMU, will work on a chamber in chamber solution of the sub-chamber system design from A1.1.4 in order to test the possibility of improved thermal stability, temperature distribution and radiation effects.	**JV,** SMU
A1.3.4 M20	JV with the support of SMU will integrate the developed exchangeable hardware solution for controlled sensor (DUT) irradiation that was done in A1.1.9 into A1.3.3. The compatibility of the designed hardware solution with the sub-chamber system will be done together with the testing of the correct function of controlled sensor irradiation.	**JV,** SMU
A1.3.5 M23	JV together with UL will apply well known radiation to at least five air temperature probes that are commonly used in climatic chambers and characterise how this will influence the indicated temperature.	**JV**, UL
A1.3.6 M24	BEV-PTP, BRML and SMU will characterise the properties of the chamber with various sensors that will be subject to calibration (use of dummy sensors with changing heating possibility and thermal conductivity) to identify the influences of different designs (size, diameter, self-heating).	**BEV-PTP,** BRML, SMU
A1.3.7 M26	NSAI with support from UL will carry out a series of tests to determine whether the number of probes under test installed in the chamber has an influence on the measurements obtained. The testing will also determine the influence of self-heating when multiple probes are installed.	**NSAI,** UL
A1.3.8 M26	UL with support from JV will use special pairs of Platinum Resistance Thermometers (PRTs) coloured with high emissivity colour and different diameter to measure radiation effects. At least two coating types will be used (high emissivity close to 1 and low emissivity close to 0) and 3 diameters (3mm, 6mm, 10mm).	**UL**, JV

A1.3.9 M27	Using input from A1.1.4, A1.3.1 (stability and temperature distribution), A1.3.5 (irradiation), A1.3.6 (self-heating and sensor size) and A1.3.7 (emissivity of sensor housing), SMU with support of BEV-PTP and JV, will write on report on the design and manufacture of a mobile and easy to set up climatic sub-chamber system that is able to control all key influential parameters (temperature distribution, radiation, irradiation of DUT, humidity, pressure, wind speed and self-heating of the sensors) in the temperature range from of 40 °C to 80 °C with a target reference uncertainty of 15 mK. SMU, BEV-PTP and JV will review the report. Once the report has been agreed by the consortium, the coordinator on behalf of SMU, BEV-PTP and JV will then submit to EURAMET as **D2** "*Report on the design and manufacture of a mobile and easy to set up climatic sub-chamber system that is able to control all key influential parameters (temperature distribution, radiation, irradiation of DUT, humidity, pressure, wind speed and self-heating of the sensors) in the temperature range from of 40 °C to 80 °C with a target reference uncertainty of 15 mK*"	**SMU**, BEV-PTP, JV

C2 WP2: Development of measurement and calibration procedures in air

The aim of this work package is to develop a measurement and calibration procedure which enables characterisation of the devices under test (DUTs) and reflects the metrological performance of the developed mobile sub-chamber system for the measurement of air temperature primarily by contact thermometry. The work package is broken down into two tasks.

Task 2.1 - to determine the most common air temperature measurement and calibration techniques used in laboratories, both commercially and within EURAMET.

Task 2.2 - to develop a measurement and calibration procedure custom tailored for the designed and constructed sub-chamber system.

C2.a Task 2.1: Determination of the most commonly used temperature measurement and calibration practices in air

The aim of this task is to determine the most common air temperature measurement and calibration techniques used in laboratories, both commercially and within EURAMET. This task will deliver valuable insight and analysis of the currently used measurement methods in order to define point that can be improved.

Activity number	Activity description	Participants (Lead in bold)
A2.1.1 M06	SMU and IMBiH will design a web-based questionnaire to analyse the commercially used air temperature calibration techniques. The target audience will be calibration laboratories, industry and other organisations performing such measurements to determine the weak points of currently used practices. SMU, BEV-PTP, CTU, CMI, DTI, IMBiH, INM, BRML, INRIM, INTA, JV, VTT, UL and NSAI will each circulate the questionnaire within their own country. SMU and IMBiH will collate the feedback.	**SMU**, BEV-PTP, CTU, CMI, DTI, IMBiH, INM, BRML, INRIM, INTA, JV, VTT, UL, NSAI
A2.1.2 M07	DTI, with support of SMU and VTT, will conduct a survey within the EURAMET TC-T community to determine the measurement and calibration procedures used when the contact medium is air. The focus of this survey will be on the used devices, procedures specifics, and uncertainty budget components.	**DTI**, SMU, VTT
A2.1.3 M08	NSAI, with support of SMU, will organise and host an online workshop for the consortium and stakeholders where the currently gained and summarised information from A2.1.1 and A2.2.2 will be presented to gain further feedback from the stakeholder community and to stimulate the exchange of information with the consortium.	**NSAI**, SMU
A2.1.4 M10	The gained information from A2.1.1, A2.1.2 and A2.1.3 will be summarised by SMU, with support of VTT and IMBiH, into a report summarising the most common air temperature calibration techniques used in laboratories both commercially and within EURAMET. This report will be circulated between the consortium and stakeholder community (defined in A5.1.1). Once the report has been agreed by the consortium, the coordinator on behalf of SMU, VTT and IMBiH will then submit to EURAMET as **D3** *"Report summarising the most common air temperature calibration techniques used in laboratories both commercially and within EURAMET"*	**SMU**, VTT, IMBiH

C2.b Task 2.2: Development and implementation of the measurement procedure

The aim of this task is to develop a measurement and calibration procedure custom tailored for the designed and constructed sub-chamber system. This procedure will consider the specific geometry and characteristic of the designed device (temperature distribution, radiation, irradiation of DUT, humidity, pressure, wind speed, and self-heating of the sensors) as well as the aspects of currently used measurement and calibration practices used for measurement of temperature in air. Part of the procedure development will be the determination of dynamic behaviour of sensors, measurement uncertainty, correlations of individual uncertainty components and a methodology on to perform inter-laboratory comparison within the developed setup Further area where this task will be focused will be the creation of a control and readout software in order to achieve best measurement results and to enable an easy and unified data collection which will be essential for the effective ILC in subsequent task.

Activity number	Activity description	Participants (Lead in bold)
A2.2.1 M13	Based on the gained information from the A1.2.1, A1.2.2, A1.2.3, A1.2.4, A1.2.5, A1.2.6 and A2.1.4 a calibration procedure for the developed and optimised sub-chamber system will be created by BEV-PTP with the support SMU, CTU, CMI, DTI, IMBiH, INM, BRML, INRIM, INTA, JV, VTT, UL and NSAI. This procedure will join together both the unique aspects of the newly developed and constructed hardware as well as the best measurement and calibration practices. The procedure will be created in a form that will as well create a methodology how to perform inter laboratory comparison within the developed setup.	**BEV-PTP**, SMU, CTU, CMI, DTI, IMBiH, INM, BRML, INRIM, INTA, JV, VTT, UL, NSAI
A2.2.2 M22	SMU, BEV-PTP and JV, with support of BRML, will implement the procedure created in A2.2.1 and apply it to a real-life measurement scenario in order to optimise the procedure the sub-chamber system. The measurement will be done on same set of selected five air temperature probes that are commonly used in climatic chambers from A1.3.5 and in at least four temperature points within the temperature range -40 °C to 80 °C.	**SMU**, BEV-PTP, JV, BRML
A2.2.3 M24	VTT, with support from BEV-PTP, will develop a control and readout software based on the specifications and design of the sub-chamber (A1.2.2). VTT, with support from BEV-PTP will also develop corresponding test protocols for analysing the raw data, for the automated calculation of the measurement uncertainty budget and for the creation of corresponding result reports.	**VTT**, BEV-PTP
A2.2.4 M25	VTT develop and distribute at least 40 wireless sensors of different kinds to monitor local air temperature, humidity and pressure in the climatic chamber in the absence and presence of the sub-chamber to BEV-PTP, JV and SMU for measurement realisation. This activity will include design and realisation of the appropriate topology for a local sensor network, aggregation of the data through a gateway and data analysis with a special focus on appropriate treatment of the correlations, dynamic behaviour of the sensors and measurands and use of metrological redundancy in the system.	**VTT**, BEV-PTP, SMU, JV
A2.2.5 M26	Based on the outcome of A2.2.4 and calibration results of A2.2.2, VTT together with BEV-PTP, SMU and JV will characterise and validate the effectiveness of the calibration in the sub-chamber and the calibration procedure developed in A2.2.1.	**VTT,** BEV-PTP, SMU, JV
A2.2.6 M30	VTT together with SMU and support of BEV-PTP and JV will use the outcome of A2.2.5 and study how employment of the additional network-level redundant data at the vicinity of the DUC during the calibration procedure will reduce the calibration uncertainty. INM, together with VTT, BEV-PTP, JV and SMU, will summarise the findings in a paper.	**VTT**, BEV-PTP, JV, INM, SMU
A2.2.7 M30	Using input from A2.2.5 and A2.2.6, VTT, with support from SMU, BEV-PTP, CMI, DTI, IMBiH. INRIM, INTA, JV, NSAI, UL, BRML, CTU and INM will finalise the calibration procedure of DUTs in air including determination of key influential factors (temperature distribution, radiation, irradiation of DUT, humidity, pressure, wind speed and self-heating of the sensors) together with their quantification, ii) dynamic behaviour of sensors, iii) uncertainty and iv) their correlations Part of the calibration procedure will be a report on how employment of the additional network level redundant data at the vicinity of the DUT during the calibration procedure will reduce the calibration uncertainty. Once the report has been agreed by the consortium, the coordinator on behalf of VTT, SMU, BEV-PTP, CMI, DTI, IMBiH. INRIM, INTA, JV, NSAI, UL, BRML, CTU and INM will then submit to EURAMET as **D4** *“Calibration procedure on how to characterise air temperature of DUTs in the range of -40 °C to 80 °C with a target reference uncertainty of 15 mK including determination of i) key influential factors parameters (temperature*	**VTT**, SMU, BEV-PTP, CMI, DTI, IMBiH. INRIM, INTA, JV, NSAI, UL, BRML, CTU, INM

	distribution, radiation, irradiation of DUT, humidity, pressure, wind speed and self-heating of the sensors) together with their quantification, ii) dynamic behaviour of sensors, iii) uncertainty and iv) their correlations. Part of the calibration procedure will be report on how employment of the additional network level redundant data at the vicinity of the DUT during the calibration procedure will reduce the calibration uncertainty."	

C3 WP3: Inter-laboratory comparison making use of the developed procedure together with the mobile sub-chamber system

The aim of this work package is to validate the sub-chamber design and test its robustness across different laboratories. This will be accomplished via an inter-laboratory comparison using the developed procedure along with the mobile sub-chamber system. The inter-laboratory comparison (ILC) will test the results obtained from the characterisation of the sub-chamber and evaluate the suitability of the measurement procedure. The ILC will also allow identifying and analysing any potential disparities between laboratories. The results will provide valuable insights into the capabilities of leading national metrology institutes in air temperature measurements. The work package is broken down into three tasks.

Task 3.1 - to develop the protocol that will be followed by the participants in the inter-laboratory comparison.

Task 3.2 - to perform all the measurements determined in the created protocol from Task 3.1.

Task 3.3 - to evaluate the ILC based on the participants in the inter laboratory comparison and assess the suitability of the developed method and the design of the sub-chamber for measuring air temperatures within the project's specified uncertainty limits.

C3.a <u>Task 3.1 Planning the inter-laboratory comparison</u>

The aim of this task is to develop the protocol that will be followed by the participants in the inter-laboratory comparison. This protocol shall include, at a minimum, the following elements: a description of the travelling standard and auxiliary equipment; general instructions, which may cover guidelines for handling the travelling standard during transport, storage, and measurement processes; identification of the inter-laboratory comparison participants, including the pilot laboratory and the coordinator; a detailed description of the measurement process, including information such as the measurement range, specific points to be measured, and other relevant details; the schedule of the measurement campaign; selection of the reference value; a description of the data to be reported and the reporting template; and the communication procedure with the coordinator.

Activity number	**Activity description**	**Participants (Lead in bold)**
A3.1.1 M14	INTA, BEV-PTP, BRML, INM and SMU will jointly select the most suitable reference sensor from A1.1.8, A1.2.4 and A1.2.6 together with the auxiliary equipment for the inter-laboratory comparison (ILC). Based on preliminary results from A1.3.1, the travelling standard and auxiliary equipment will be selected. The selection process shall consider the metrological characteristics of the different equipment to ensure they are best suited for the purpose of the inter-laboratory comparison.	**INTA**, BEV-PTP, BRML, INM, SMU
A3.1.2 M15	INTA will, with help of all participants, select at least five participants within the consortium to perform the ILC. To ensure that the results of the inter-laboratory comparison are representative, at least five laboratories with the highest metrological capabilities (e.g. lowest uncertainty) in the field should be selected.	**INTA,** SMU, BEV PTP, CTU, CMI, DTI, IMBiH, INM, BRML, INRIM, JV, VTT, UL, NSAI, PTB
A3.1.3 M15	INTA will, in consultation with all participants, select at least five DUTs for the ILC within the circulating sub-chamber system. The DUTs should be selected based on their sensing type and typical usage in the most commonly used applications. Each DUT will have an identical backup DUT in the unlikely case of breakage.	**INTA,** SMU, BEV PTP, CTU, CMI, DTI, IMBiH, INM, BRML, INRIM, JV, VTT, UL, NSAI, PTB

A3.1.4 M24	SMU, with support of selected ILC participants form A3.1.2, will create an inter-laboratory comparison protocol to perform air temperature measurements with the mobile climatic sub-chamber system and at least 5 selected DUTs. The protocol shall include gained information from A2.2.1 and 2.2.2 and outline all steps of the ILC. It should contain the description of the travelling standard and auxiliary equipment; general instructions, which may cover guidelines for handling the travelling standard during transport, storage, and measurement processes; identification of the inter laboratory comparison participants, including the pilot laboratory and the coordinator; a detailed description of the measurement process, including information such as the measurement range (t = -40 °C up to t = 80 °C), specific points to be measured, and other relevant details; the schedule of the measurement campaign; selection of the reference value; a description of the data to be reported and the reporting template; and the communication procedure with the coordinator. Once the protocol has been agreed by the consortium, the coordinator, on behalf of all participants will submit to EURAMET as **D5** *"Inter laboratory comparison protocol to perform air temperature measurements with the mobile climatic sub-chamber system and at least 5 selected DUTs"*	**SMU**, INTA, BEV PTP, CTU, CMI, DTI, IMBiH, INM, BRML, INRIM, JV, VTT, UL, NSAI, PTB

C3.b Task 3.2: ILC measurement phase

The aim of this task is to perform all the measurements determined in the created protocol from Task 3.1. During this phase, the sub-chamber system with all embedded support and reference sensors will circulate among the participants according to the schedule established in the protocol. This phase will include an initial and final characterisation of the traveling standard by the pilot laboratory to ensure that the metrological characteristic of the sub-chamber system is preserved throughout the process. The participants are responsible for performing the measurements as outlined in the protocol and reporting the results and other required data to the coordinator for subsequent analysis.

Activity number	Activity description	Participants (Lead in bold)
A3.2.1 M26	BEV-PTP, as the ILC coordinator, will characterise the circulating sub-chamber system (and one spare system in case on damage) in order to determine its proper function before the start of ILC. The characterisation will include the temperature stability and temperature distribution. The pilot laboratory will initiate the measurement campaign by conducting a full set of measurements as described in the ILC protocol (A3.1.4).	**BEV-PTP,** INTA, CTU, CMI, DTI, IMBiH, INM, BRML, INRIM, JV, SMU, VTT, NSAI, UL, PTB
A3.2.2 M32	INTA will ensure that all participants involved in the ILC will receive the travelling standard and auxiliary equipment according to the planned schedule to perform the measurements outlined in the protocol (A1.3.4). Once measurements are completed, the standard and auxiliary equipment will be packed and shipped to the next participant, continuing this process until the final verification by the pilot laboratory. The order and the circulation of the system will be described in the ILC protocol. Each ILC participant will be responsible for the transport to the next laboratory.	**INTA**, BEV-PTP, CTU, CMI, DTI, IMBiH, INM, BRML, INRIM, JV, NSAI, SMU, VTT, UL, PTB
A3.2.3 M32	INTA will gather all the measurement information that was determined by the ILC protocol from A3.1.4. All participants involved in the ILC A3.1.2 will submit their results and any additional data that could improve the ILC measurement result to the BEV-PTP for inclusion in the ILC report. INTA will check the data for their completeness based on the ILC protocol.	**INTA**, BEV-PTP, CTU, CMI, DTI, IMBiH, INM, BRML, INRIM, JV, NSAI, SMU, VTT, UL, PTB

C3.c Task 3.3: Evaluation of measured data

The aim of this task is to evaluate the ILC based on the participants in the inter-laboratory comparison and assess the suitability of the developed method and the design of the sub-chamber for measuring air temperatures within the project's specified uncertainty limits. The analysis of the inter-laboratory comparison results will identify systematic errors and biases, as well as any other factors that may influence the effectiveness of the developed method or the efficiency of the sub-chamber.

Activity number	Activity description	Participants (Lead in bold)
A3.3.1 M34	INTA and VTT, with the input form the ILC participants, will analyse the results of the inter-laboratory comparison and prepare a report detailing the level of compatibility of the results from all of the ILC participants.	**INTA**, VTT, BEV-PTP, CTU, CMI, DTI, IMBiH, INM, BRML, INRIM, JV, NSAI, SMU, UL, PTB
A3.3.2 M35	INRIM, with the support of BEV-PTP and the ILC participants, will compile a report from the inter-laboratory comparison results. This report will be distributed to all participants.	**INRIM,** BEV-PTP, INTA, CTU, CMI, DTI, IMBiH, INM, BRML, JV, NSAI, SMU, VTT, UL, PTB

C4 WP4: Knowledge transfer in the field of air temperature measurements and calibration

The aim of this work package is to transfer knowledge in the field of air temperature measurements and calibration within the consortium. This will create a common base for further development in research capabilities as well as measurement and calibration techniques of atmospheric air temperature will be developed in this work package. The work package is broken down into two tasks.

Task 4.1 – to create training material for the consortium and interested stakeholders outside the consortium on how to use the measurement chamber

Task 4.2 – to exchange researchers between the consortium where hands-on training on the developed sub-chamber will be carried out.

C4.a Task 4.1: Creation of training materials and hands on workshops

The aim of this task is to create training materials for the consortium and interested stakeholder outside the consortium on the use of the measurement chamber. The material will all be digital, ensuring availability to future interested parties. The material will contain state of the art material on the general field of measuring air temperature and specific knowledge on the use of the developed measuring chambers. Further purpose of this task will be to create a direct knowledge transfer between the consortium with a high level of knowledge on the developed sub-chamber system as well as air temperature measurements, to participants and other interested parties with a lower level of knowledge. This objective will be done through a series of workshops and other training activities.

Activity number	Activity description	Participants (Lead in bold)
A4.1.1 M04	DTI, with the assistance of NSAI and UL, will perform a literature review of available material covering the physical background and practical considerations of air temperature physics.	**DTI**, NSAI, UL
A4.1.2 M07	INRIM, with the assistance of DTI and NSAI, will produce video demonstrations of selected existing systems for air temperature calibration to transfer knowledge in the field of air temperature measurements. The videos will be made available on the project website (A5.1.6) for a specialist audience.	**INRIM,** DTI, NSAI
A4.1.3 M09	DTI, BEV-PTP, and SMU with the assistance of INRIM and NSAI will write a summary report documenting the video demonstrations of selected existing systems for air temperature calibration to transfer knowledge within the consortium and interested stakeholders. The summary report will be made publicly available on the project website (A5.1.6) and promoted to EURAMET TC-T, BIPM CCT WG ENV and WMO. Feedback from these stakeholders will be taken into account in the good practice guide in A4.1.7. Once the summary report has been agreed by the consortium, the coordinator, on behalf of all participants will submit to EURAMET as **D6** *"Summary report documenting the video demonstrations of selected existing systems for air temperature calibration*	**DTI**, BEV-PTP, INRIM, NSAI, SMU

	within EURAMET to transfer knowledge within the consortium and interested stakeholders."	
A4.1.4 M08	UL, with support from all participants, will organise and host a workshop that will be focused on the direct knowledge transfer between participants with a high level of knowledge on the developed sub-chamber system as well as air temperature measurements, to participants and other interested parties with a lower level of knowledge within the EURAMET community and outside as well. The workshop will focus on presenting outputs of project up to M8 and collecting feedback.	**UL,** INTA, BEV PTP, CTU, CMI, DTI, IMBiH, INM, BRML, INRIM, JV, SMU, VTT, NSAI, PTB
A4.1.5 M14	BEV-PTP, with support from all participants, will organise and host a workshop that will be focused on the direct knowledge transfer between participants with a high level of knowledge on the developed sub-chamber system as well as air temperature measurements, to participants and other interested parties with a lower level of knowledge within the EURAMET community and outside as well. The workshop will focus on presenting outputs of project up to M14 and collecting feedback.	**BEV-PTP**, INTA, NSAI, CTU, CMI, DTI, IMBiH, INM, BRML, INRIM, JV, SMU, VTT, UL, PTB
A4.1.6 M24	SMU, with support from all participants, will organise and host a workshop that will be focused on the direct knowledge transfer between participants with a high level of knowledge on the developed sub-chamber system as well as air temperature measurements, to participants and other interested parties with a lower level of knowledge within the EURAMET community and outside as well. The workshop will focus on presenting outputs of project up to M24 and collecting feedback.	**SMU**, INTA, BEV PTP, CTU, CMI, DTI, IMBiH, INM, BRML, INRIM, JV, NSAI, VTT, UL, PTB
A4.1.7 M36	NSAI, with support from all participants, will prepare a good practice guide on the measurement and calibration of air temperature using contact thermometry including evaluation of uncertainties and specification of sub-chamber system. The guide will incorporate input from the project technical activities and will put a focus on Digital Certificates (e.g. reftypes), PTB will support the harmonisation of terminology with existing international guidelines and schemes. Once the good-practice guide has been agreed by the consortium, NSAI on behalf of all participants then submit it to EURAMET as **D7** *"Good practice guide on the measurement and calibration of air temperature using contact thermometry including evaluation of uncertainties and specification of sub-chamber system"* The guide will also be submitted to the EURAMET TC-T working group "Best Practices" for comments and adoption as a EURAMET guide.	**NSAI,** INTA, BEV-PTP, CTU, CMI, DTI, IMBiH, INM, BRML, INRIM, JV, SMU, VTT, UL, PTB

C4.b Task 4.2: Exchange of researchers within the consortium

The aim of this task is to exchange researchers within the consortium. The exchanges will ensure improved working-relations between the participants and create a high-level knowledge transfer from the hosting participant.

Activity number	**Activity description**	**Participants (Lead in bold)**
A4.2.1 M11	VTT will host a SMU researcher from the field of thermometry at their home institution to improve their knowledge in data analysis, measurement uncertainty evaluation and measurement practices with specific focus on the analysis of air temperature measurements together including hands-on training on the developed sub-chamber. The length of this hosting will be for two weeks.	**VTT**, SMU
A4.2.2 M19	DTI will host at least 2 IMBiH researchers from the field of thermometry to transfer knowledge regarding the results of DTI's activities carried out in A1.2.6. The duration of this visit will last up to two weeks.	**IMBiH**, DTI
A4.2.3 M07	BEV-PTP will host a SMU researcher from the field of thermometry at their home institution to improve their knowledge in data analysis, measurement uncertainty evaluation and measurement practices with specific focus on the analysis of air temperature measurements together including hands-on training on the developed sub-chamber. The length of this hosting will be for two weeks.	**BEV-PTP**, SMU

C5 WP5: Creating impact

C5.a Task 5.1: Dissemination and communication

Activity number	Activity description	Participants (Lead in bold)
A5.1.1 M01	SMU, with support from all participants, will define the key stakeholders of the project. This will include the internal metrology community as well as end users (e.g., customers of calibration serviced and accreditation bodies).	**SMU**, all participants
A5.1.2 M03	SMU will set up will set-up an on-line Discussion Group on LinkedIn to exchange information among the members of the project and the end-users. This Discussion Group will be used to promote the latest information from the project to end-users and on the project webpage (A5.1.6). Other social media platforms such as X (previously known as Twitter) will also be used for promoting the latest achievements obtained by the project. The consortium will tag EURAMET on X and LinkedIn with '@EURAMET' 'and @EURAMET' - The European Association of National Metrology Institutes' respectively so that EURAMET can share if appropriate. Also, hashtags such as #measurementscience, #metrology, #EUfunded, #EUPartnership should be used if possible.	**SMU**
A5.1.3 M36	INRIM will, with the support of all participants, create a direct connection and cooperation with the BIPM Task Group on Air temperature (TG Air) and BIPM TG Humidity, in order to present and discuss the results of the sub-chamber	**INRIM,** all participants
A5.1.4 M36	INRIM will, with the support of all participants, present the good practice guide for the calibration of thermometers in air A4.1.7 (AX.X.X) to the BIPM CCT.	**INRIM,** all participants
A5.1.5 M08, M20, M32	INRIM will, with the support of all participants, present the results of the project at the EURAMET TC-T. The anticipated outcomes from the project's activities will play a crucial role in the development of the EURAMET guide for calibrating thermometers in air, a key deliverable of the ATM EURAMET project No.1459. The TC-T convenes once a year, while the ATM project holds meetings biannually.	**INRIM**, all participants
A5.1.6 M03, M36	A project website will be set up by INRIM. The website will be the vehicle by which the consortium communicates with the wider community detailing for e.g. events, presentations, reports and recent developments. The website will be updated at least every three months. The project website will clearly acknowledge, in a prominent position on the homepage (e.g. in the header, footer or centre and in a readable size), the Metrology Partnership. This will be done by including either i) the Partnership project website header/footer badge and both (ii) the acknowledgement and (iii) disclaimer text (this text can be anywhere on the homepage). Alternatively, it will be done by using the Partnership acknowledgement badge (which includes all 3 points).	**INRIM**, all participants
A5.1.7 M36	The participants will present at least 4 papers at international conferences. Ideal candidates are: • MMC 2025 • Tempmeko 2025 • IMEKO World Congress 2027 • CIM 2026 • Technical Committee for Temperature and Humidity within the DKD 2026 • MEASUREMENT 2026 Further relevant conferences may be identified during the project.	**SMU,** all participants
A5.1.8 M36	INRIM with the input from the consortium will create a project e-newsletter which will be made available with the stakeholders (defined in A5.1.1) on a yearly basis. The purpose of this e-newsletter is to keep them informed about the progress of the project.	**INRIM**, all participants

<table>
<tr><td>A5.1.9
M36</td><td>The participants will submit at least 3 papers to peer-reviewed journals during the course of the project. Papers may be based on input from A2.2.6 and A3.3.2. Target journals include:
• Measurement Science and Technology
• International Journal of Thermophysics
• Metrology
• Measurement IMEKO
• Metrologia
• National Journal of Metrology from Republic of Moldova
The expectations are that at least 2 out the 3 publications will be the result of a collaborative effort from participants from different countries.
The authors of the peer reviewed papers will clearly acknowledge the financial support provided through the Partnership as required by EURAMET in accordance with Article 17, Article 18, and Annex 5 of the Grant Agreement with the following text:
"The project (24RPT03 A2TM) has received funding from the European Partnership on Metrology, co-financed from the European Union's Horizon Europe Research and Innovation Programme and by the Participating States."
The authors will ensure that the following meta data is submitted and included for each paper:
• Funder name: European Partnership on Metrology
• Funder ID: 10.13039/100019599
• Grant number: 24RPT03 A2TM
The participants will comply with the open access requirements detailed in the Grant Agreement Annex 5 Article 17 by also depositing each paper in a suitable open access trusted repository.
The participants will also submit all papers (and any associated datasets if applicable) to the EURAMET repository link.</td><td>INRIM, all participants</td></tr>
<tr><td>A5.1.10
M36</td><td>INRIM, BEV-PTP, SMU and UL will support with promoting the workshops for stakeholders and outside the consortium (A4.1.4, A4.1.5 and A4.1.6) via promotion on the project's website (A5.1.7). Furthermore INRIM, with support of all participants, will also contact EURAMET-MSU to ask if they can be promoted on the EURAMET website. The project participants will liaise with existing and potential future EMNs e.g., EMN Climate Ocean, any relevant EURAMET TC, to see whether there are any other EURAMET funded projects, EU funded Partnerships or any research/industrial projects, that could be utilised to increase the outreach of this event.
A report will be made summarising the workshop's contents. The report is published on the projects homepage and communicated through social media such as LinkedIn.</td><td>INRIM, all participants</td></tr>
<tr><td>A5.1.11
M36</td><td>CMI, IMBiH, INRIM, JV and VTT are members of the EMN Energy gases.
BRML, CMI, DTI, IMBiH, INRIM, INTA, JV and VTT are members of the EMN Climate and Ocean Observation.
Involvement in these two EMNs will enable direct engagement with the metrology network. The anticipated outcomes from the project's activities will play an important role as the air temperature measurements are important for impact on weather patterns, influence on ecosystems and link to ocean and cryosphere.
CMI and BRML will keep the EMNs updated with progress from the project during its lifetime. They will also liaise with the EMNs or any other relevant EURAMET EMN to see whether there are possible synergies that could be built on. For example, to understand if there are any other EURAMET funded projects, EU funded Partnerships or any research/industrial projects, that could be utilised to increase the outreach of the projects such as organisation of joint events.</td><td>CMI, IMBiH, INRIM, JV, VTT, BRML, DTI, INTA</td></tr>
</table>

A5.1.12
M36

Information on the results of the project will be disseminated to a range of standards bodies and committees and feedback sought (see details below and in the table in Section B3.c).

Standards Committee / Technical Committee / Working Group	**Participants involved**	**Likely area of impact / activities undertaken by participants related to standard / committee**
CEN/TC 423 "Means of measuring and/or recording temperature in the cold chain"	**NSAI**	NSAI, who are TC423 committee members, will disseminate the relevant outcomes of the project to the secretary and members of the committee. The outcomes and finding from the project will make important input for this committee as the cold chain efficiency is dependent on air temperature measurements with unwanted consequences on product Integrity and safety, compliance with regulatory standards and preservation of product quality. The committee will meet annually.
CAI (Czech Accreditation Institute)	**CMI**	CMI will present progress and outcomes of the project to the Czech Accreditation Institute in regular intervals and will collect feedback from the organisation in order to incorporate valuable insights from the view of accreditation within the Czech Republic. CMI will further propose a guidance material to CAI on measuring temperature in air. The institute will meet annually.
INAB (Irish National Accreditation Board)	**NSAI**	NSAI will prepare guidance on measuring temperature in air, based on the outcomes of the project and present to INAB at the end of the project.
DKD (Technical Committee for temperature and humidity)	**PTB**	PTB will present the progress and outcomes from the project in the area of air temperature measurement to DKD together with possible guidance resulting from the project findings and measurement results. The institute will meet annually.
SNAS (Slovak national Accreditation body)	**SMU**	SMU will present progress and outcomes of the project to the Slovak national Accreditation body in regular intervals and will collect feedback from the organisation in order to incorporate valuable insights from the view of accreditation within the Czech Republic. CMI will further propose a guidance material to SNAS on measuring temperature in air.
EURAMET TC-T WP Best Practice	**NSAI**, BEV-PTP, PTB	NSAI, with the assistance of BEV-PTP and PTB will deliver a draft good practice guide (A4.1.7) for review by the working group.
WMO	**INRIM**	Through their involvement in the WMO Congress, INRIM will have the opportunity to present the project results and advocate for their inclusion in global decisions and high-level recommendations.
CIPM CCT WG ENV	**INRIM**, BEV-PTP, CMI, JV, SMU, VTT	As the chair of the CCT WG ENV, INRIM, along with BEV-PTP, CMI, JV, SMU and VTT, will present updates on the progress of various project activities to the working group. Given the focus on air temperature measurements, the outcomes will be highly relevant to the CCT WG ENV community. The WG ENV convenes annually, while the CCT meets biennially, with the next WG ENV meeting scheduled for 2025.

C5.b Task 5.2: Exploitation and uptake

Activity number	Activity description	Participants (Lead in bold)
A5.2.1 M36	A dissemination, communication and exploitation plan (DCE) will be created at the beginning of the project by INRIM, with support from all participants, and submitted to EURAMET at M9 (+45 days). It will be reviewed and updated at least at each project meeting. The DCE plan will provide further details on the following expected results: • Key expected result 1 - Developed mobile sub-chamber system (A1.2.5, A2.2.5) • Key expected result 2 - ILC protocol to perform air temperature measurements with the mobile climatic sub-chamber system and at least 5 selected DUTs (A3.1.4) • Key expected result 3 - Good practice guide on the measuring and calibration of air temperature using contact thermometry including evaluation of uncertainties and specification of sub-chamber system (A4.1.7)	**INRIM**, all participants
A5.2.2 M04	A questionnaire will be prepared by INRIM and used to collect feedback from the stakeholders (defined in A5.1.1) about their interest in the project with a specific indication on whether the project addresses their current and foreseeable metrological needs. The information will be used in the design of the sub-chamber (A1.1.4) and development of the measurement and calibration procedure (A2.2.1).	**INRIM**, all participants
A5.2.3 M36	Key expected result 1: Developed mobile sub-chamber system. SMU and BEV-PTP will create a new calibration service that will make use of the developed sub-chamber system with the connected measurement methods. The newly developed calibration capabilities will be inserted into the portfolio of services and news will be provided to customers by each participant via email communication. Similarly potential customers from other NMIs or DIs will be informed by presentation at an annual EURAMET TC-T meeting.	**SMU**, BEV-PTP
A5.2.4 M36	Key expected result 2: ILC protocol to perform air temperature measurements with the mobile climatic sub-chamber system and at least 5 selected DUTs. SMU with support of selected ILC participants will create an inter-laboratory comparison protocol to perform air temperature measurements with the mobile climatic sub-chamber system and at least 5 selected DUTs. The protocol shall include gained information from A2.2.1 and 2.2.2 and outline all steps of the ILC. This ILC protocol will reflect the measurement capabilities of the ILC participants and will be agreed in an online consensus meeting. This approved ILC protocol will then be circulated within the whole consortium for further comments and modifications. The ILC protocol will be subject to changes after the conclusion of the ILC in order to reflect possible problematic points that emerged during the course of the ILC. The final version of the protocol will be provided to the EURAMET TC T working group “Best Practices” for final comments. This will ensure the ILC protocols uptake in the EURAMET TC-T community.	**SMU**, all participants
A5.2.5 M36	Key expected result 3: Good practice guide on the measuring and calibration of air temperature using contact thermometry including evaluation of uncertainties and specification of sub-chamber system The guide will be submitted to the EURAMET TC T working group “Best Practices” for comments and adoption as a EURAMET guide. The guide will also be made available on the project website.	**NSAI**, all participants
A5.2.6 M36	The consortium will identify measures that they will use to demonstrate that the project has increased / developed the capabilities of their consortium and other NMIs/Dis in Europe. Summaries will be produced at months 18 and 36, demonstrating how the project helped less experienced NMIs in the consortium to develop their capabilities. Where appropriate this improvement will be quantified. All participants will provide input to these summaries and the coordinator will provide this information demonstrating the narrowing of the capability gap at the mid-term review and at the end of the project.	**INRIM**, all participants
A5.2.7 M36	The consortium will plan how their project will contribute to KPI 2.4 *(An average of at least EUR 50 million of European turnover per year from new or significantly improved products and services)*	**SMU**, all participants

All IP and potential licencing/exploitation will be handled in accordance with the Grant Agreement and the Consortium Agreement.

C6 WP6: Management and coordination

C6.a Task 6.1: Project management

Activity number	Activity description	Participants (Lead in bold)
A6.1.1 M36	The project will be managed by the coordinator from SMU, who will be supported by the project management board consisting of one member from each participant. The members of the project management board will guide the project, attend the project meetings, help organise the progress meetings and call additional meetings if needed to ensure the overall project's success. The project management board will monitor project activities, to facilitate the completion of deliverables by set deadlines and to take responsibility for frequent communication between the participants. SMU will set up, host and manage a MS Teams or SharePoint site for internal sharing of data, documents and work in progress.	**SMU**, all participants
A6.1.2 M36	The work package leaders will report on the on-going progress of the project to the coordinator by e-mail and online meetings.	**SMU**, BEV-PTP, DTI, INTA, INRIM
A6.1.3 M36	The coordinator, with support from the participants, will manage the project's risks to ensure timely and effective delivery of the scientific and technical objectives and deliverables.	**SMU**, all participants
A6.1.4 M36	The consortium will ensure that any ethics issues identified are addressed.	**SMU**, all participants

C6.b Task 6.2: Project meetings

Activity number	Activity description	Participants (Lead in bold)
A6.2.1 M01	The kick-off meeting involving all participants will be held approximately one month after the start of the project,	**SMU**, all participants
A6.2.2 M36	There will be five formal project meetings. These include the kick-off (A6.2.1), midterm (around M18- INRIM) and the final meetings (around M36- JV), all of which will be held face-to-face. In addition, there will be two further project meetings will be held online around M9 and M27. The meetings will review progress and will be used to ensure participants are clear as to their role for the next period.	**SMU**, all participants
A6.2.3 M36	In addition to the formal project meetings, technical meetings will be held as needed. These may involve the entire consortium or only parts of it. Some meetings may involve only the regional participants where the meetings relate to the planning of regional smart specialisation.	**SMU**, all participants

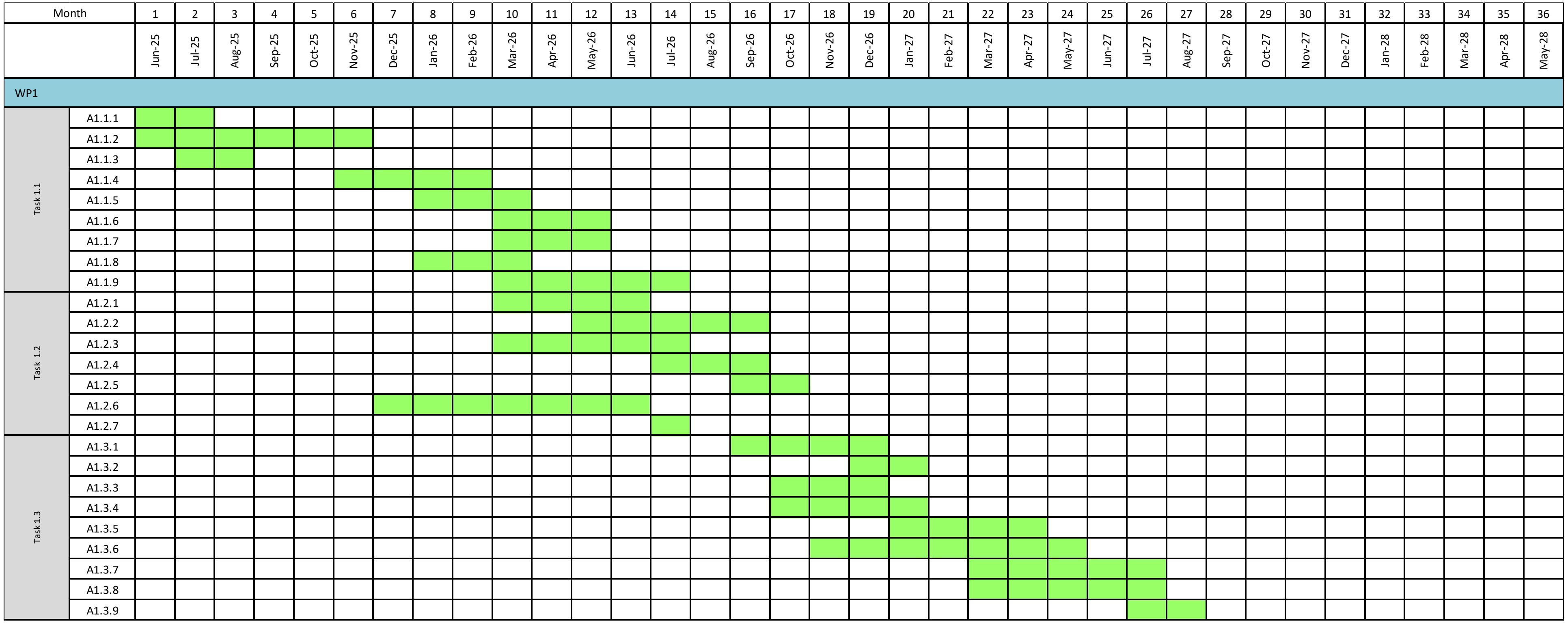
C6.c Task 6.3: Project reporting

Activity number	Activity description	Participants (Lead in bold)
A6.3.1 M01	One month after the start of the project a publishable summary will be produced and submitted to EURAMET.	**SMU**, all participants

A6.3.2 M09 +45 days	Following Articles 19 and 21 and the data sheet of the grant agreement, Interim 1 Reports will be submitted to EURAMET at month 9 (February 2026 + 45 days), in accordance with the procedures issued to enable EURAMET to comply with its obligations to report on the programme to the European Commission. The following reports will be required. • Progress report (Interim). • Data management plan (DMP). • Dissemination, communication and exploitation plan (DCE). All participants will provide input to these reports and the coordinator will provide these to EURAMET. Where necessary, additional reports and / or information may be requested to enable EURAMET to comply with its obligations to the European Commission.	**SMU**, all participants
A6.3.3 M18 +60 days	Following Articles 19 and 21 and the data sheet of the grant agreement, Period 1 Reports will be submitted to EURAMET at month 18 (November 2026 + 60 days), in accordance with the procedures issued to enable EURAMET to comply with its obligations to report on the programme to the European Commission. The following reports will be required. • Progress report (Periodic) and financial reports. • Outcomes and impact report • Updated publishable summary. All participants will provide input to these reports and the coordinator will provide these to EURAMET. Where necessary, additional reports and / or information may be requested to enable EURAMET to comply with its obligations to the European Commission.	**SMU**, all participants
A6.3.4 M27 +45 days	Following Articles 19 and 21 and the data sheet of the grant agreement, Interim 2 Reports will be submitted to EURAMET at month 27 (August 2027 + 45 days), in accordance with the procedures issued to enable EURAMET to comply with its obligations to report on the programme to the European Commission. The following reports will be required. • Progress report (Interim). If requested as an outcome of a midterm review or periodic reporting, any, or all, the following reports may need to be delivered: updated outcomes and impact report, updated publishable summary and an updated dissemination, communication and exploitation plan. EURAMET will inform the coordinator if these reports are required at Interim 2 reporting. All participants will provide input to these reports and the coordinator will provide these to EURAMET. Where necessary, additional reports and / or information may be requested to enable EURAMET to comply with its obligations to the European Commission	**SMU**, all participants
A6.3.5 M36 +60 days	Final Reports and Period 2 reports will be delivered at month 36 (May 2028 + 60 days) in accordance with Articles 19 and 21 and the data sheet of the grant agreement. The following reports will be required: • Progress report (Periodic) and financial reports. • Final public report. • Updated data management plan and an updated dissemination, communication, and exploitation plan. • Updated outcomes and impact report (including impact and exploitation questionnaires). All participants will provide input to these reports and the coordinator will provide these to EURAMET. Where necessary, additional reports and / or information may be requested to enable EURAMET to comply with its obligations to the European Commission.	**SMU**, all participants
A6.3.6 M23	Some projects will be subject to a midterm review in Spring 2027. Where projects are selected for a midterm review, reports (project self-assessment, updated publishable summary and presentation) will be delivered prior to the midterm reviews for Call 2024, following the schedule detailed by EURAMET for the specific review. All participants will provide input to these reporting documents and the coordinator will provide the documents to EURAMET.	**SMU**, all participants

Formal reporting will be in line with EURAMET's requirements and will be submitted in accordance with the Reporting Guidelines.

C7 Gantt chart



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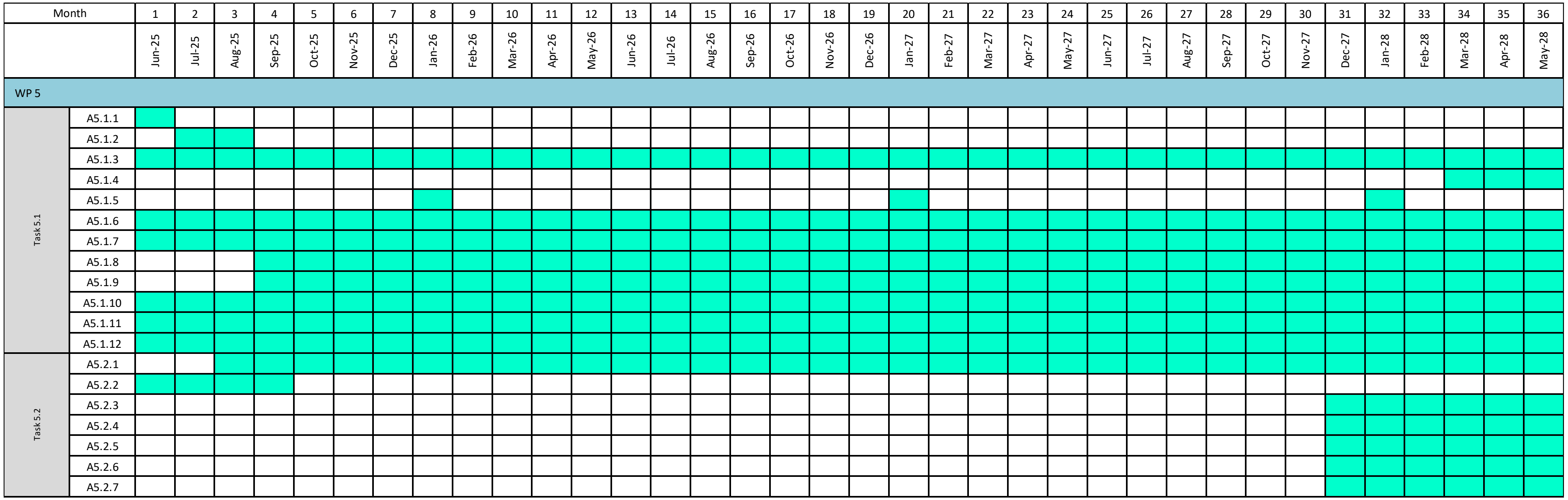
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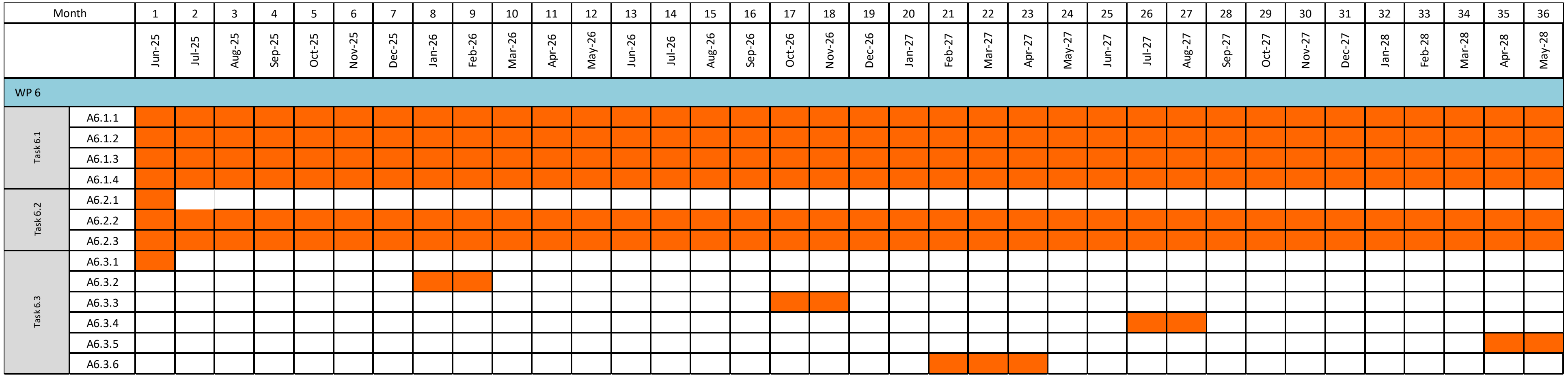
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Section D: Risk and risk mitigation

D1 Scientific/technical risks

Risk (description)	**Likelihood, impact and severity of occurrence**	**Mitigation** i.e. what the consortium will do to decrease the likelihood of the risk occurring	**Contingency** i.e. what the consortium will do if despite the mitigation the risk still occurs
Task 1.1: (A1.1.4, A1.1.6) The proposed design is too complex for practical manufacturing and its dimensions would be incompatible with used climatic chamber	Likelihood after mitigation: Low Impact: The sub-chamber system use would be significantly affected. Level of severity: Medium	The consortium will focus the design creation on the practical aspect together with the best possible measurement performance. The dimensions of the chamber will consider all of the participants equipment and ease of use.	The consortium will consult a company with more experience in machining and construction.
Task 1.1: (A1.1.7, A1.1.8) There are no suitable sensors for measuring influential quantities and commercial reference sensors	Likelihood after mitigation: Low Impact: The sub-chamber system use would have increased measurement uncertainty. Level of severity: Medium	The consortium will investigate and contact manufacturers in advance of the relevant activity start if suitable sensors are available.	In the case that a specific sensor with adequate parameter cannot be purchased or built a next best sensor type will be used. In the case that the sensors cannot be integrated into the design the sub-chamber system will be modified accordingly.
Task 1.2: (A1.2.1) A significant delay or inability to manufacture temperature and humidity sensors	Likelihood after mitigation: Low Impact: The sub-chamber system finalisation would be delayed, or its main function would be restricted. Level of severity: Medium	The consortium will investigate and contact manufacturers in advance of the relevant activity start if suitable sensors are available.	When the commercial sensors would not meet the requirements a custom solution from consortium or suppliers will be used.
Task 1.2: (A1.2.2) A significant delay or inability to manufacture sub-chamber system prototypes	Likelihood after mitigation: Low Impact: The sub-chamber system finalisation would be delayed, or its main function would be restricted. Level of severity: Medium	The consortium will determine an alternative member (within the consortium) to produce the sub-chamber system prototypes.	If the manufacturing capacity within the consortium will not be enough to create the sub-chamber system prototypes a commercial manufacturer will be approached.
Task 1.2: (A1.2.3) A significant delay or inability to purchase reference temperature sensors.	Likelihood after mitigation: Low Impact: The sub-chamber system finalization would be delayed, or its main function would be restricted. Level of severity: Medium	The consortium will select best suitable reference sensors already in the consortium's ownership.	If the commercial sensors do not meet the requirements, a custom solution from consortium or suppliers will be used.
Task 1.3: (A1.3.1, A1.3.3) The prototypes are damaged during the transport to the participants	Likelihood after mitigation: Low Impact: The sub-chamber circulation will be delayed. Level of severity: Medium	The consortium will use an experienced courier to minimise the risk of damage during delivery. In addition, the participant responsible for shipping will ensure that the prototype is sufficiently packaged. -	In the case of prototype damage, the next available prototype will be sent to the affected participants. This will be possible as 4x prototypes will be built. In the case of repeated damage to the system another prototype will be shared with in person delivery to minimise the breakage risk.

Task 1.3: (A1.3.2) The test measurements with constructed sub-chamber system prototypes reveal a necessary redesign	Likelihood after mitigation: Low Impact: The sub-chamber circulation will be delayed. Level of severity: Medium	The consortium will closely monitor and analyse the preliminary measurement results with the sub-chamber system.	If the manufacturing capacity within the consortium is not be enough to create the sub-chamber system prototypes a commercial manufacturer will be approached.
Task 2.1: (A2.1.1, A2.1.2, A2.1.3) The information received with regards to the air temperature calibration used is not e complete, low on number of responses or not relevant	Likelihood after mitigation: Low Impact: The information that should form the basis for the most commonly used temperature measurement and calibration practices in air will be incomplete. Level of severity: Medium	A repeated communication with relevant stakeholders and EURAMET TC-T community will be done in order to get sufficient and relevant information.	The communication will be done with the support of EURAMET and TC-T. Another possible gaining of information would be the expansion beyond EURAMET and Europe.
Task 2.2: (A2.2.5) The calibration procedure used and sub-chamber measurement data do not have sufficient clarity in order to determine if the sub-chamber system can improve the calibration process in air	Likelihood after mitigation: Low Impact: The improvement of temperature measurement and calibration in air will be unclear. Level of severity: Medium	The consortium will analyse the preliminary results in each step to make adjustments.	A new measurement approach to evaluate the effectiveness of the sub-chamber system will be proposed and implemented.
Task 3.1: (A2.1.2) The delay from other tasks reduces the time available to perform the ILC with 5x participants.	Likelihood after mitigation: Low Impact: Delay in the ILC or reliable results not achieved. Level of severity: Medium	The consortium will have a series of online meetings to determine possible delays and their correction.	A further reduction of the total number of participants of the ILC to 3x in total to achieve its realisation.
Task 3.1: (A2.1.3) No consensus on the ILC protocol between the selected participants	Likelihood after mitigation: Low Impact: Delay in the ILC or reliable results not achieved. Level of severity: Medium	The consortium will discuss the ILC during regular online and in person meetings in order to effectively amend the ILC protocol.	If the consensus is not achieved, the ILC participant who cannot fulfil the ILC protocol will be replaced by another participant from the consortium.
Task 3.2: (A3.2.2) Malfunction, lost or damage of the travelling standard and/or the auxiliary equipment	Likelihood after mitigation: Low Impact: Delay in the ILC or reliable results not achieved. Level of severity: High	Establish a well defined packing and unpacking procedure, including the acquisition of necessary insurance.	Select back up equipment that can be used as traveling standard or auxiliary measurements.
Task 3.2: (A3.2.2) Unexpected delay during the ILC	Likelihood after mitigation: Low Impact: Delay in the ILC or reliable results not achieved. Level of severity: Medium	Establish early on during the project the schedule for all participants, so all participants are well prepared to perform the measurements process in advance.	Accelerate the analysis phase to make up for the lost time.
Task 3.3: (A3.3.1) The ILC data from the participants is delayed or not delivered.	Likelihood after mitigation: Low Impact: Delay on the ILC results and report. Level of severity: Medium	Reminders prior to the activity deadline will be sent to the relevant participants as well after the end date if no data is provided.	An alternative ILC participant will be selected that will realise the measurements.

Task 4.1: (A4.1.4 – A4.1.6) Inability to host / organise the workshop	Likelihood after mitigation: Low Impact: Knowledge transfer and interaction with the stakeholders will be reduced. Level of severity: Medium	The consortium will agree on a possible substitute.	The workshop will be transformed into a full online format.
Task 4.2: (A4.2.1 – A4.2.3) Inability to send or to host a researcher	Likelihood after mitigation: Low Impact: Knowledge transfer and development of capabilities will be reduced. Level of severity: Medium	The consortium will discuss the hosting details well in advance to determine possible amendments acceptable to both parties.	An alternative host or guest researcher will be selected from the project consortium.

D2 Management risks

Risk (description)	**Likelihood, impact and severity of occurrence**	**Mitigation** i.e. what the consortium will do to decrease the likelihood of the risk occurring	**Contingency** i.e. what the consortium will do if despite the mitigation the risk still occurs
Key personnel are lost to the project through staff changes, illness, or other absence during the project timeframe	Likelihood after mitigation: Low Impact: Loss of key staff may delay tasks or make them impossible to complete within the project. Level of severity: High	The grouping of experts within the consortium should minimise the areas where knowledge is held by a single person. All participants will involve at least two staff members in the activities. All the participants will identify backups for key workers wherever possible to reduce the overall risk to the project. Project plans will be shared within the consortium and results and methodology will be documented. The consortium will assist participants that need additional training due to staff changes.	If a key member leaves the project, then the participant concerned will be responsible for appointing a replacement. The remaining participants will carry out their activities as planned. If the participant affected cannot carry out activities which other participants depend on, the remaining participants will assist each other to ensure the necessary activities are completed. However, this may still lead to a delay in delivery.
Inter-dependencies between technical activities and tasks are too complex	Likelihood after mitigation: Low Impact: Tasks are delayed, or it is not possible to deliver them. Level of severity: High	Technical meetings run by WP leaders have been scheduled to ensure proper sharing of knowledge. The interdependencies between tasks will be considered at meetings to ensure that this is addressed properly in the planning of the work. The technical WPs will be closely managed by their WP leaders to ensure that they deliver their own outputs.	In most cases, activities on the critical path have some overlap in time and thus a delay in the output of one deliverable does not necessarily cause an immediate delay in another.
Project management becomes ineffective due to poor communication	Likelihood after mitigation: Medium Impact: Lack of focus and coherence will lead to duplication of effort or to important tasks being neglected. Level of severity: Medium	In addition to the formal project meetings, technical meetings will be held as needed. These may involve the entire consortium or only parts of it. Some meetings may involve only the regional participants where the meetings relate to the planning of regional smart specialisation. Full use will be made of teleconferencing facilities to	Increased management resources will be devoted to improving communication.

		allow maximum participation at project meetings. It is expected that following the Covid pandemic the participants have adequate systems and experience with remote interactions.	
Problems dealing with Intellectual Property (IP) ownership and/or exploitation might occur and could be a source of potential conflict	Likelihood after mitigation: Low Impact: Disagreement between the participants could delay the project (in implementing the work and publishing results). Level of severity: Medium	All beneficiaries will sign the grant agreement, and all participants will sign the consortium agreement, which includes IP clauses. IP will be handled accordingly.	Independent arbitrators will be used in the event of disagreement between participants.
The onsite facilities of participants, and/or access to public/commercial services or sites is restricted for a period of time during the project due to an extraordinary event or situation that is beyond the participants' control e.g. COVID-19	Likelihood after mitigation: Low Impact: Activities and deliverables are delayed, or no longer able to be completed. Level of severity: Medium	In most cases, activities on the critical path are independently carried out and can be completed at one participant despite issues arising at a different participant.	Where possible, work will be reassigned to an alternative participant, or rephased, therefore minimising delays and technical deviations that would have a negative impact on the project. If necessary, the consortium will contact EURAMET to discuss options according to the grant agreement.
Organisation of workshops, training and joint demonstrator activities in a post- or trans-COVID world	Likelihood after mitigation: Low Impact: Failure to show the outputs at workshops or through demonstrator activities risks reducing the knowledge transfer and impact from the project. Level of severity: Medium	Although COVID travel restrictions have been removed, there is the possibility that some restrictions may be re-introduced nationally or internationally, or organisations may apply their own restrictions. Some flexibility is built into the tasks and activities with nominal locations and dates, but these will be reviewed nearer the time and the consortium will decide on the appropriate locations of such activities e.g. to take advantage of/cope with moved external events.	Alternatives such as webinars or online meetings can be used.
Environmental and Health and Safety: Staff involved in the project does not follow the relevant H&S procedures.	Likelihood after mitigation: Low Impact: Staff may become injured. Level of severity: High	All participants are experienced in these types of tests and are aware of the health and safety procedures to follow. In case of doubt, the staff will revise these procedures before initiating the work.	The participants will discuss the possibility of reallocating work within the consortium. If necessary, parts of the work will be re-scoped in agreement with EURAMET.
Due to current unstable situation in eastern Europe, work is unable to be undertaken in Bosnia and Herzegovina (IMBiH) and Moldova (INM).	Likelihood after mitigation: Low Impact: Tasks are delayed. Level of severity: Medium	The participants will be contacted by the WP leaders on a regular basis to monitor the progress in specific activities as well as to detect any possible complications originating from various sources. If any significant delays or inability to deliver the activity work will be considered as high probable potential replacement participant for the consortium that will overtake the work will be defined.	The activities will be overtaken by the selected participant from the consortium with sufficient capabilities.

Due to current unstable situation in eastern Europe, participants are unable to travel to Bosnia and Herzegovina (IMBiH) or Moldova (INM).	Likelihood after mitigation: Low Impact: Tasks are delayed. Level of severity: Medium	The participants will be contacted by the WP leaders on a regular basis to monitor the progress in specific activities as well as to detect any possible complications originating from various sources. If any significant delays or inability to deliver the activity work will be considered as high probable potential replacement participant for the consortium that will overtake the work will be defined.	The activities will be overtaken by the selected participant from the consortium with sufficient capabilities.

D3 Ethics

The Partnership Ethics Review 2024 has given JRP 24RPT03 A2TM "Ethics clearance".

Ethical integrity

The participants will ensure that all ethics issues related to activities in the project are addressed in compliance with ethical principles (including the highest standards of research integrity as set out in the ALLEA European Code of Conduct for Research Integrity https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/european-code-of-conduct-for-research-integrity_horizon_en.pdf), the applicable international and national law, and the provisions set out in the grant agreement. This includes the ethics issues identified in the ethics screening and the submitted documents, and any additional ethics issues that may emerge in the course of the project. In the case where any substantial new ethics issues arise, participants will inform the granting authority EURAMET e.V, and for each ethics issue applicable, participants will follow the guidance provided in the Horizon Europe *'How to complete your ethics self-assessment' guide'*.

The consortium will ensure that appropriate procedures, policies and structures (https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/guideline-for-promoting-research-integrity-in-research-performing-organisations_horizon_en.pdf) are in place to foster responsible research practices, to prevent questionable research practices and research misconduct, and to handle allegations of breaches of the principles and standards in the Code of Conduct.

Data protection

By signing or acceding to this grant agreement and / or consortium agreement each participant asserts that the requirements of the General Data Protection Regulation (GDPR) 2016/679 which entered into force on 25 May 2018 will be met. Under the regulation, the data controllers and processors are fully accountable for the data processing operations. Any violation of the data subject rights may lead to sanctions as described in Chapter VIII, art.77-84 of the GDPR.

If personal data are transferred from the EU to a non-EU country or international organisation, such transfers will be in accordance with Chapter V of the GDPR 2016/679. If personal data are transferred from a non-EU country to the EU (or another third state), such transfers will comply with the laws of the country in which the data was collected.

Non-EU countries

The consortium will ensure that participants and collaborators, including those from non-EU countries, fully adhere to Horizon Europe ethics standards and guidelines, no matter where the research or activities are carried out and that research or activities performed outside the European Union are compatible with EU, national and international legislation and can be legally conducted in one of the EU Member States. If applicable, details on the material, samples and/or equipment which will be imported to/exported from EU must be provided and the adequate authorisations and/or export licences granted by the relevant authorities have been or will be obtained and kept on file by the consortium.

Section E: References

[1] EURAMET-calibration guideline No. 20: Guidelines on the Calibration of Temperature and / or Humidity Controlled Enclosures, TC-T, Version 5.0, 09/2017

[2] DKD-R 5-7: Calibration of Climatic Chambers.

[3] ISO 17714:2007 - Air temperature measurements

[4] EMA CPMP/QWP/609/96/Rev 2 - GUIDELINE ON DECLARATION OF STORAGE CONDITIONS: A: IN THE PRODUCT INFORMATION OF MEDICINAL PRODUCTS

[5] IEC 60068-3-5 – Environmental Testing – Part 3-5: Confirmation of the Performance of Temperature Chambers.

[6] IEC 60068-3-6 – Environmental Testing – Part 3-6: Confirmation of the Performance of Temperature/Humidity Chambers.

[7] IEC 60068-3-6 – Environmental Testing – Part 3-7: Measurements in Temperature Chambers for Tests A and B

[8] IEC CEI 60068-3-11 – Environmental Testing – Part 3-11: Calculation of Uncertainty of conditions in Climatic Test Chambers