Consultative Committee for Thermometry (CCT)

Report of the 32nd meeting

(21-22 May 2026)

to the International Committee for Weights and Measures

Contents

LIST OF MEMBERS OF THE CONSULTATIVE COMMITTEE FOR THERMOMETRY

as of 21 May 2026

President

Dr Dolores del Campo Maldonado, member of the International Committee for Weights and Measures also Centro Español de Metrología [CEM], Madrid.

Executive Secretary

Dr S. Solve, International Bureau of Weights and Measures [BIPM], Sèvres.

Members

All-Russian Scientific Research Institute of Physical Technical Measurements, Rosstandart [VNIIFTRI], Moscow.

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Czech Metrology Institute [CMI], Brno.

D.I. Mendeleyev Institute of metrology, Rosstandart [VNIIM], St Petersburg.

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Instituto Português da Qualidade [IPQ], Caparica.

Korea Research Institute of Standards and Science [KRISS], Daejeon.

Laboratoire National de Métrologie et d'Essais [LNE], Paris.

Measurement Standards Laboratory of New Zealand [MSL], Lower Hutt.

National Institute of Metrological Research/Istituto Nazionale di Ricerca Metrologica [INRIM], Turin.

National Institute of Metrology [NIM], Beijing.

National Institute of Standards and Technology [NIST], Gaithersburg.

National Measurement Institute of Australia [NMIA], Lindfield.

National Metrology Centre, Agency for Science, Technology and Research [NMC, A*STAR], Singapore.

National Metrology Institute of Japan, National Institute of Advanced Industrial Science and Technology [NMIJ/AIST], Tsukuba.

National Metrology Institute of South Africa [NMISA], Pretoria.

National Metrology Institute of Turkey /TÜBITAK Ulusal Metroloji Enstitüsü [UME], Gebze-Kocaeli.

National Physical Laboratory [NPL], Teddington.

National Research Council of Canada [NRC], Ottawa.

Norwegian Metrology Service/Justervesenet [JV], Kjeller.

Physikalisch-Technische Bundesanstalt [PTB], Braunschweig.

Slovak Metrology Institute/Slovenský Metrologický Ústav [SMU], Bratislava.

VSL Dutch Metrology Institute [VSL], Delft.

VTT Technical Research Centre of Finland Ltd, Centre for Metrology / Mittatekniikan keskus [MIKES], Espoo

The Director of the International Bureau of Weights and Measures [BIPM], Sèvres.

Observers

FSB - Laboratory for Process Measurements [FSB-LPM], Zagreb.

Instituto Nacional de Metrología de Colombia [INM Colombia], Bogotá, D.C.

National Scientific Centre "Institute of Metrology" [NSC IM], Kharkiv.

Standards and Calibration Laboratory [SCL], Hong Kong.

1. OPENING OF THE MEETING

The Consultative Committee for Thermometry held its 32nd meeting at the International Bureau of Weights and Measures (BIPM) headquarters in Sèvres, and on-line, on 21 and 22 May 2026.

The CCT President, Dr Dolores del Campo, opened the meeting, welcoming all attendees, and gave the floor to the BIPM Director, Dr Annette Koo.

Dr Koo wished all attendees a happy World Metrology Day 2026 and recalled some numbers about the BIPM and the CIPM MRA: there are currently 65 Member States and 35 Associates States and Economies in the Metre Convention, and 259 institutes participating in the CIPM MRA, comprising 97 NMIs, 4 international organizations and 158 DIs. Currently, there are 2 038 comparisons and 26 405 CMCs in the KCDB. Dr Koo reminded the CCT that the preparatory work for the upcoming CGPM 2026 is underway, including preparation of the seven resolutions, which are listed on the BIPM website and the BIPM Work Programme 2028-2031. She related that the CIPM has endorsed *Metrologia* (which is now open access) as the journal of choice, and that comparison reports are no longer published in *Metrologia*: they are published on the BIPM website with DOIs assigned by BIPM. She noted that the fourth edition of the International Vocabulary of Metrology (VIM4) voting draft has been completed by JCGM WG2, and will retain the traditional definition of measurement uncertainty, because the new definition had not received wide agreement. Finally, a new MoU with UNESCO was signed in December 2025 (the old MoU had been signed in 1949).

The following attended:

Members

M. Akoshima (NMIJ/AIST), K. Anhalt (PTB), S. Bell (NPL), R.A. Bergerud (JV), R. Caballero Santos (CEM), V. Cabral (IPQ), D. Cardenas-Garcia (CENAM), Y.K. Chong (NMC, A*STAR), D. Cywiak-Córdova (CENAM), D. Del Campo Madonado (CCT President, CEM / CIPM), W. Dong (NIM), E.K. Ejigu (NMISA), L. Eusébio (IPQ), Y. Fan (NMC, A*STAR), X. Feng (NIM), V. Fernicola (INRIM), J. Ferreira (IPQ), V. Fuksov (VNIIM), C. Gaiser (PTB), P. Ganesan (NMC, A*STAR), R. Gavioso (INRIM), C. Gözönünde (UME), B. Hay (LNE), F. Jahan (NMIA), S. Janssens (MSL), M. Kalemci (UME), L. Knazovicka (CMI), S. Kondratiev (VNIIM), A. Koo (BIPM Director), T. Kopunec (SMU), V.G. Kytin (VNIIFTRI), J. Langley (NMIA), S.-W. Lee (KRISS), W. Lei (NMIA), G. Lopardo (INRIM), E. Lopes de Souza Junior (INMETRO), X. Lu (NIM), G. Machin (NPL), M. Maloba (NMISA), M.I. Maniur (SMU), J.M. Mantilla (CEM), M.-J. Martín Hernández (CEM), E. Martines-Lopez (CENAM), B. Mascarenhas Lozano (INMETRO), R. Mokhutsoane (NMISA), E. Molloy (MSL), R. Moretz Sohn (INMETRO), I. Müller (PTB), H. Nasibli (UME),H. Ogura (NMIJ/AIST), A.A. Falnes Olsen (JV), M. Panman (VSL), P. Pavlasek (SMU), J. Pearce (NPL), A. Peruzzi (NRC), A. Petukhov (VNIIFTRI), K.N. Quelhas (NIST), P. Rourke (NRC), M. Sadli (LNE-LCM/Cnam), P. Saunders (MSL), Y. Shimizu (NMIJ/AIST), F. Sparasci (LNE), R. Strnad (CMI), S. Tabandeh (MIKES), W. Tew (NIST), A.D. Todd (NRC), M. Vinge (VNIIFTRI), M. Voldan (CMI), I. Yang (KRISS), H. Yoon (NIST).

Observers

A.J. Bohórquez Garzón (INM Colombia), J. Cheung (SCL), J.A. Monroy Garzon (INM Colombia), R. Pushchyn (NSC IM), C.A. Sanchez (INM Colombia), D. Šestan (FSB-LPM), D. Zvizdic (FSB-LPM).

Representatives of Institutes from Member States invited to attend as Observers

N.M. Alqahtani (SASO-NMCC).

Guests

H. Abe (NMIJ/AIST), N. Al Dawood (SASO-NMCC), R. Benyon Puig (INTA), W. Bich (ISO), J. Bojkovski (MIRS/UL-FE/LMK), C.D. Ehrlich (OIML), J.-R. Filtz, C. Herrera Ruiz (LACOMET), A. Kowal (INTiBS), A. Merlone (INRIM), R. Rusby (NPL).

Also present

C. Paredes (BIPM), S. Solve (CCT Executive Secretary, BIPM), K. Yamazawa (JCRB Executive Secretary).

2. Approval of the agenda

The agenda of the meeting (CCT/2026-01) was unanimously approved.

3. Approval of *Rapporteurs*

Dr Andrea Peruzzi and Dr Patrick Rourke were appointed as *rapporteurs* of the meeting. They will produce the draft report of the meeting in the month following the meeting.

4. Tribute to Pieter Bloembergen and Michael Moldover

Dr del Campo lamented that, in the two years since the last CCT meeting, our community has lost two prominent figures, Dr Pieter Bloembergen and Dr Michael Moldover, and gave the floor to Prof. Graham Machin and Dr Howard Yoon for a brief tribute to each of them respectively.

4.1. Tribute to Pieter Bloembergen

Prof. Machin gave a tribute to Dr Pieter Bloembergen. For full details, see document CCT/2026-08.

Prof. Machin recalled he had met Dr Bloembergen in 1991, by which time Dr Bloembergen had already made outstanding contributions to the development of the new ITS-90 and to non-contact thermometry. Those who knew him appreciated his sharp and inquisitive mind. After retiring from VSL, he had a long 'second career' working for many years at NMIJ (Japan) and NIM (China), chiefly on high-temperature fixed points. Prof. Machin recalled Dr Bloembergen's amazing publication record, patience, rigour, lively discussions and cooperations, and concluded that he was full of zest for life to the end (17 August 2024).

4.2. Tribute to Michael Moldover

Dr Yoon gave a tribute to Dr Michael Moldover. For full details, see document CCT/2026-10.

Dr Yoon retraced the major steps of the career of Dr Moldover. Dr Moldover attended the Bronx High School of Science (from which nine graduates have won Nobel science prizes) and obtained his PhD from Stanford University in 1966. He was Assistant Professor at University of Minnesota from 1966 to 1972, then worked at NIST From 1972 to 2022, publishing nearly 200 papers. He won many awards, including the prestigious Presidential Rank Award (2009). He was a NIST Fellow and a Fellow of the American Physical Society.

We are all familiar with his pioneering measurement of the Boltzmann constant with acoustic gas thermometry and, when we look at the measurements used in the CODATA Adjustment 2017, we cannot help but notice that all those acoustic thermometry measurements are 'children' of his first measurements from 1988. In fact, he loved to share ideas and support people with great generosity (he gave his spherical resonator to NIM with no reservations), and he was always present for you and listening to you.

5. Status of the actions targeted at the 31st Meeting of the CCT

The status of the actions targeted at the 31st Meeting of the CCT was reviewed:

CCT31/A1: Dr D. del Campo to bring data management topic to the CIPM, in relation with digitalization and towards a general approach to data management and archiving, including all metadata in the documents, their revisions, DOIs, repositories and archive schemes. Status: completed.

CCT31/A2: Dr D. del Campo to ask the CIPM for agreement of the transformation of the TG digitalization into a WG and propose the new terms of reference. Status: completed.

CCT31/A3: WG-CMC, to come to next CCT with revised service categories, and reduction of the number of CMCs and duration of comparisons. Status: ongoing.

CCT31/A4: WG-CTh and WG-NCTh to present to the next CCT meeting an analysis on the conditions for a future update of the ITS-90. Status: completed.

CCT31/A5: WG-KC, to develop guidelines, by the time of the next CCT, to assist the pilots of key comparisons in the analysis of the results. Status: ongoing.

CCT31/A6: WG-CTh and WG-KC, to prepare a new CCT-K9 draft protocol by the time of the next CCT meeting. Status: ongoing.

CCT31/A7: Dr D. del Campo, to ask CIPM to include a representative of CCT WG-ENV among the members of the CIPM- STG-CENV. Status: completed.

CCT31/A8: Dr D. del Campo to continue the discussion within WG-Strategy about the admission of INM (Colombia) as a member. Status: completed.

6. News from the BIPM

The news update from the BIPM was shared by the BIPM Director, Dr Annette Koo, during the Opening of the meeting (see Section 1 above).

7. Highlights of Working and Task Groups' progress

7.1. Highlights of CCT Working Group for Calibration and Measurement Capabilities (CCT-WG-CMC), KCDB and JCRB

Prof. Jovan Bojkovski reported on the activities of the WG-CMC and on the news from the KCDB and the JCRB. For full details, see document CCT/2026-WG02.

7.1.1. Problems and suggestions in the review of submitted CMCs

The AFRIMETS Chair noted that disagreements in the application of the CMC Review Protocols often arise from different interpretations of the same Review Protocol and called for further harmonization between the different RMOs.

Prof. Bojkovski also mentioned an unfortunate case in which 56 SIM CMCs were submitted by the previous RMO Chair to the inter-RMO review stage without any intra-RMO (SIM) review. He said that this is unacceptable, but that it was considered exceptional, very unlikely to repeat, and due to the fact that, at the time of submission, the CMC writer and the RMO chair were the same person.

All RMOs lamented difficulties in the traceability of the reviewer comments on the submitted CMCs in the current KCDB version. In addition, writers were not automatically informed when new reviewers' comments were uploaded, which could lead to extended delays.

7.1.2. New CMC review protocols and amendments of existing ones

The reduction of service categories (for example, reduction of thermocouple service categories to only one) was discussed. It was concluded that any simplification of service categories introduces undesired ambiguities in the consequent CMC declarations, and it was thus decided not to reduce the number of service categories. However, it was decided to harmonize as much as possible the CMC entries and the way CMC uncertainties are presented.

Two CMC Review Protocols were discussed. The CMC Review Protocol for calibration of thermocouples at HTFP is not within the ITS-90, but requires an RMO supplementary comparison, which could also be open to possible participants from other RMOs. The CMC Review Protocol for thermal conductivity measurements is being circulated for comments among the RMOs until September 2026.

7.1.3. Actions taken to address CCT-K9 results

The RMO chairs reported on the actions taken by the respective NMIs to solve inconsistencies among the laboratories evidenced by the results of CCT-K9 key comparison, and those were considered satisfactory.

7.1.4. KCDB news

In the framework of the Capacity Building and Knowledge Transfer (CBKT) Programme, the CIPM Summer School on "Supporting RMO TC/WG Chairs" will take place at BIPM headquarters on 30 June – 2 July 2026.

The KCDB has received several software updates since 2024: display of the CMC PID in the 'Advanced Search'; CMC 'Quick Search'; module for the CMC statistics on the JCRB Review Performance; Pilot Back-Office for comparison final report submission; improving the accessibility and usability of the comments tool by writers to address reviewers' comments; and a new version of the KCDB API for CMC Search.

Further updates are planned in consultation with the CCs: add control menu for CMC parameters to the CMC Submission Web form; add new metadata in the list of comparison participants to the comparison form; implement a new API to query comparison data; and develop a template to streamline the submission and publication process for comparison results.

7.1.5. JCRB news

CIPM MRA documents P-12, P13 and G-11 were revised. The change in P-13 concerns the implementation of the CIPM decision on CMC withdrawal and suspension. The change in G-11 concerns the way comparison reports are published.

Dr Kazuaki Yamazawa, Executive Secretary of the JCRB, with the help of the RMO Chairs, gathered information on the comparisons that are older than five years (about 100 comparisons) and found that, in 40 % of the cases, the reason for the delay is in the measurement phase, and that, in another 40 % of the cases, the reason for the delay is data processing and reporting.

Using the available statistical tools, it was possible to review the RMO performance in the CMC review process. Prof. Bojkovski congratulated APMP Chair, Dr Xiaojuan Feng, for the commitment of APMP to the review process (performed 100 % of the assigned reviews) and SIM Chair, Dr Carolina Herrera, for the substantial improvement of SIM performance (84 % of the assigned reviews).

The number of 'hanging CMCs' (CMC submission remaining in "JCRB: Revision Requested" for over 6 months) has been significantly decreased (from 32 at the beginning of February to 2 at the end of April) thanks to the improved communication between writers and reviewers.

The CCT President, Dr del Campo, asked how the intended harmonization of CMC entries and corresponding uncertainty presentation will be communicated and Prof. Bojkovski replied that it will be done through the RMO Chairs and with the help of illustrative examples that he will prepare.

7.1.6. Time limits for validity of KCs and CMCs

Prof. Bojkovski invited the community to reflect on the time after which a key comparison needs to be repeated. He made the example of CCT-K1 and CCT-K2 that were conducted approximately 25 years ago and have never been repeated. A related issue is the lifetime of a CMC: in the KCDB there are examples of CMCs that were published approximately 25 years ago. Can these CMCs still be considered valid? The answer depends on many factors: are the equipment, location of the laboratory, and personnel still the same? And how many calibration certificates were released by the laboratory for the specific service category?
Prof. Bojkovski informed that the WG-CMC is inclined to propose a CMC lifetime of 15 years, after which the CMC is considered expired and greyed-out.

Dr Howard Yoon expressed the need for a serious discussion before taking such a decision that would lead to automatically-expiring CMCs/KCs. Prof. Bojkovski replied that other CCs have clear guidelines and the CCT should have such guidelines too, even when stipulating a different lifetime for different types of key comparisons. Dr Yoon added that we should also consider the fact that the NMIs' internal quality systems should be able to guarantee the validity of CMCs even in the absence of new comparisons.

The CCT President Dr del Campo reminded that the CIPM MRA has a requirement for continuous comparisons, but it does not specify a repeat period. She supported the idea of CCT having a clear policy on this matter, stating that it would increase transparency and therefore trust. She proposed that WG-CMC and WG-KC work together to prepare a policy document on this matter, based also on a survey of NMIs.

Dr Peter Pavlasek commented that putting an end date to CMCs is a drastic move and should be connected to the validation of equipment and personnel. He expressed reluctance to expend significant resources when alternate solutions could be more efficient.

Dr del Campo stated that the CCT needs to discuss such issues but must also follow the rules. She elaborated that the CCT should justify that 20-25 year old CMCs are still good and trustworthy.

Dr Vito Fernicola expressed the need of increasing communication between NMIs and the KCDB, to update the information presented in the KCDB. He highlighted the issue of real age vs. apparent age, since some KCs are registered years before they start. For example, the new CCT-K6 key comparison has been registered in the KCDB as initiated in 2021, but the measurements have not been started yet.

7.2. Highlights of CCT Working Group for Key Comparisons (CCT-WG-KC)

Dr Andrea Peruzzi reported on the activities of the WG-KC. For full details, see document CCT/2026-WG04. Dr Peruzzi recalled the current WG-KC membership and informed the CCT on the membership changes.

In the past two years, the WG provided its review services to 26 different comparisons. In the same time frame, 16 comparisons were closed (11 of them made it to approval and publication in the KCDB and five of them were declared abandoned) and eight new comparisons were initiated.

Dr Peruzzi summarized the history of all CCT KCs. The first cycle of KCs was completed at the end of 2024 (when CCT-K8 was published) and the second cycle is well underway (CCT-K9, CCT-K10 and CCT-K7.2021 already completed and CCT-K6.2021 initiated).

In the last CCT Meeting (May 2024), the WG-KC was charged with the preparation of a document that could provide guidance to CCT KC pilots on the analysis of KC results (action CCT31/A5). The WG-KC has been working on such document since then, see document CCT/2026-04 "Guide to the Analysis of CCT Key Comparison Results". Dr Peruzzi highlighted the main difficulties encountered, the main features, the status and future steps of this document. Dr Peruzzi lamented the lack of a KCRV definition and of a description of the method for KCRV computation in the CIPM MRA documents. Moreover, the statements that can be found on the CIPM MRA documents about the KCRV (that it can be considered to be a close approximation to the SI value or to the true value) do not seem to be appropriate for the CCT, because CCT KCs are run in terms of T_{90}, which is only an approximation to the SI and an operationally-defined quantity. Differently from the recommendation made in CIPM-MRA-G11, that for CIPM KCs a description of the method to be used to determine the KCRV should be included in the protocol, this CCT document sets the general principles to be followed in the analysis of the results, without prescribing a specific method for computing the KCRV. Dr Peruzzi clarified some of the most relevant of these principles: the adoption of a statistical model that explicitly relates the measured values to the true value of the measurand, the optimality criterion that the KCRV is intended to satisfy, and the requirement that the statistical model should be able to detect, evaluate and propagate dark uncertainty, which manifests itself as dispersion of the measured values in excess of what the reported uncertainties suggest that it should be.

Dr Peruzzi encouraged all CCT members to read the document and send their comments within two weeks after the end of the CCT meeting. After this time, Dr Peruzzi will take two additional months to address all comments in a revised version of the document, that will be submitted for CCT approval by email.

7.3. Highlights of CCT Working Group on Digitalization (CCT-WG-Dig)

Dr Patrick Rourke reported on the activities of the WG-Dig. For full details, see document CCT/2026-WG05.

Dr Rourke recapped the history of the CCT Application Programming Interfaces (APIs), through which important CCT reference data is now available to both humans and machines in easily usable form. He explained what data is included within the first set of APIs, and how it may be accessed: a human-friendly web user interface; a machine-friendly API interface to the server; and human-friendly HTML tables and tab-delineated text files. He announced the beginning of the public beta test of the APIs at https://si-digital-framework.org, and invited all present to try using them. He indicated that the preferred method to send feedback about the APIs is via https://github.com/TheBIPM/SIDF-CCT-API-issues. He noted that formal CCT approval will eventually be required to remove the "beta version" tag from the API pages.

Dr Rourke explained the contributions of the WG-Dig to the updated CCT Strategy 2025-2030+ document (see document CCT/2026-02). He mentioned that the second set of CCT APIs is already in development, covering: thermodynamic inaccuracy of the ITS-90 (T-T_{90}), by Dr Jean-Laurent Hippolyte at NPL (alpha version complete, nearly ready for testing); humidity, by Dr Shahin Tabandeh at VTT MIKES (alpha version complete, some testing already complete); and thermophysical quantities (development planning discussions on-going).

Dr Rourke mentioned that, as indicated in the “system metrology” section of the updated CCT Strategy 2025-2030+ document, the WG-Dig has discussed distributed interconnected measurement systems and would like to propose the creation of a new CCT Task Group on Distributed Thermal Measurement Systems (CCT-TG-Dig-DTMS) to focus on aspects of sensor networks relevant to the CCT. He thanked Dr Tabandeh, who is very connected on this topic and led the creation of the draft Terms of Reference for the proposed TG. Dr Rourke outlined the rationale for the creation of the new TG, and the proposed the draft objectives (see document CCT/2026-07).

Dr Eduardo Lopez (INMETRO) was concerned about the usability of API data to human beings without “chunking”, as chunking information into smaller pieces is important for human beings to understand. Dr Rourke replied that it is a matter of jurisdiction, as the WG-Dig is not empowered to make scientific decisions and these are deferred back to the other WGs. As an example, considering the ITS-90 definition document, there are tables with many coefficients and digits but, when these are digitalized, the source document must be respected. However, Dr Rourke said that the WG-Dig is open to feedback on how APIs’ presentation of the data could be made more friendly to people. The President suggested that Dr Lopez send his suggestions to Dr Rourke.

Dr Weston Tew (NIST) asked if there are industrial consensus standards (such as IEC/ISO or ASTM) under development regarding distributed temperature measurement systems and was concerned that, if there is not a strong standardization effort, then we may incur the risk of proprietary technologies. He explained the typical path of emerging new technologies: in the first phase proprietary technologies could dominate, then later, once the technology has matured enough, consensus standards can emerge. Dr Tew wondered in which phase we are now with distributed temperature measurement systems. Dr Rourke replied that there are many activities undertaken by the metrology community, including European research projects and standardization efforts, but stated that he does not know where we stand with respect to proprietary issues. Dr Shahin Tabandeh added that there are some ISO standards already in place, but they are not metrologically rigorous, the traceability concept is not well established in them, and they do not harvest all the information that can be obtained from the redundancy provided by a system of sensors rather than by an individual sensor. Dr Tabandeh noted that the last point is addressed by some research projects initiated in Europe, Asia and America. He said that if a metrological framework is not established, people will use these systems, but not in a trustworthy way.

The CCT President asked if there was unanimous consensus on the establishment of a new Task Group on Distributed Thermal Measurement Systems. As there was no objection, the formation of this new TG was formally approved by the CCT.

7.4. Highlights of CCT Working Group for Contact Thermometry (CCT-WG-CTh)

Dr Christof Gaiser reported on the activities of the WG-CTh. For full details, see document CCT/2026-WG06.

Dr Gaiser mentioned that one activity connected to reviewing and reporting on measurements of $T - T_{90}$ is the European DireK-T project (involving also non-European NMIs), which is the first attempt to directly compare primary thermometers in the range 4 K – 303 K using three methods (AGT, DCGT and RIGT). For the determination of $T - T_{90}$ above 400 K, as requested by recommendation 1 of the 29th CCT (2021), a new high-temperature AGT has been developed at four laboratories up to 700 K or 1300 K. A review article summarizing the results for $T - T_{90}$ in the lowest range of the ITS-90 (0.65 K – 4.2 K) has been published, providing equations for $T - T_{90}$ and its uncertainty in this range.

Concerning recommending KCs in contact thermometry, Dr Gaiser noted that different NMIs are making significant progress on alternatives to the mercury triple point (mainly CO_2 and SF_6) for the purpose of an amended version of the ITS-90 or a new ITS-XX, so in the coming years a first KC of such alternatives will be recommended. In addition, the comparison of primary thermometers performed within the European DireK-T project can be regarded as a precursor to a possible KC of thermodynamic temperature.

Dr Gaiser related that updates to the Guide to the Realization of the ITS-90 PRT chapter proposed by Dr Patrick Rourke and Dr Richard Rusby were discussed, and a subgroup is working on their implementation. Dr Jonathan Pearce and Dr Bernd Fellmuth have been working on an update of the 1996 Bedford *et al.* paper on recommended values for secondary reference points. With the help of an expert in eutectic points (invited expert) the work will be soon completed and published.

Concerning novel contact thermometry techniques, another European project (PhoQuS-T) is working on photonic and quantum sensors for practical integrated primary thermometry. A third European project (INFOTherm) is engaged in improving fibre-optic thermometry.

Dr Gaiser summarized the activities of the TG on future thermodynamic temperature traceability (TG-TTT), established during the last CCT meeting and chaired by Dr Jonathan Pearce. This TG has already achieved its initial objectives: primary thermometry is being disseminated by some NMIs, practical primary thermometers and *in situ* traceability through self-validating thermometers are being developed. The findings were published in Pearce, J.V., Machin, G. Todd, A.D.W., Martín, M.J., Pan, Y., Zhou, K., Olsen, A.A.F., “Future traceability of practical primary thermometry and self-validating thermometry” *Phil. Trans. R. Soc. A* **384**, 20240453, https://doi.org/10.1098/rsta.2024.0453 (Jan 2026). Future aims, which require the extension of the lifetime of the TG, are a survey of the readiness of the selected techniques (including new techniques such as magnetic field fluctuation thermometry), mapping realistic traceability chains for each one of them, and establishing performance benchmarks.

Finally, Dr Gaiser recalled that during the last CCT meeting the WG-CTh and WG-NCTh were tasked with an analysis of the conditions for a future update of the ITS-90. The result of such analysis is the proposed Recommendation T 1 (2026) to the CIPM "Criteria for the establishment of a new International Temperature Scale" (see document CCT/2026-03). The CCT President and Prof. Machin thanked Dr Gaiser for achieving agreement on such an important issue. The CCT President asked if there was anyone opposing this recommendation. Nobody opposed so the recommendation was unanimously approved.

7.5. Highlights of CCT Working Group for Non-Contact Thermometry (CCT-WG-NCTh)

Prof. Graham Machin reported on the activities of the WG-NCTh. For full details, see document CCT/2026-WG03. He proposed a minor revision to the Terms of Reference of WG-NCTh.

Prof. Machin shared that the CCT-K10 key comparison of ITS-90 above the Ag point has been completed and published and is now being used to substantiate CMC entries. He also noted that the CCT-K11 key comparison of Body Temperature Calibrators, piloted by Dr Xiaofeng Lu (NIM), is progressing. The European loop led by PTB has been completed, but there have been delays with the APMP loop because the transfer artefact did not perform satisfactorily (the PTB transfer artefact is now being circulated within APMP). It is hoped that the comparison measurements will be completed by the end of 2026.

Four more definitive HTFP temperature values have been added to the *MeP*-K annex. The WG had a long discussion about the merits of progressing the Industrial Radiation Thermometry Guide. Most of the issues in industrial non-contact thermometry are environmental (emissivity, reflection, …), rather than instrumental in nature. The conclusion of the WG was to endorse Dr Peter Saunders' recommendation not to proceed with a guide for industrial radiation thermometry. However, the WG is supporting industry through IEC standardization, providing experts for two IEC standards in preparation (dual wavelength thermometry WG contribution led by Dr Lenka Knazovicka and thermal imaging WG contribution led by Dr Maria-Jose Martin).

Dr Saunders, a WG-NCTh member, supplied the WG-Dig with equations on which to base the API for $T - T_{90}$ and $u(T - T_{90})$ and Prof. Machin acted as WG focal point for the revision of CCT Strategy on behalf of the WG-NCTh.

Regarding the question of whether CCT-K10 results can be used to substantiate CMCs in thermodynamic temperature, Dr Saunders prepared a discussion paper and gave a presentation during the WG-KC meeting which concluded they could. The discussion paper has been sent to the WG-CMC and WG-KC chairs for discussion.

The WG-NCTh proposes a new TG "On the feasibility of using non-contact thermometry to measure $T - T_{90}$ between Sn and Ag point with <10ppm", having as its first task the production of a discussion document on different technical areas that require investigation to minimize uncertainty. Dr del Campo emphasized the importance of such work, and that it supports CCT recommendations. The new TG was unanimously approved by the CCT. The NMIs that are interested in contributing to this TG should contact Prof. Machin as soon as possible.

7.6. Highlights of CCT Working Group for Humidity (CCT-WG-Hu)

Dr Hisashi Abe reported on the activities of the WG-Hu. For full details, see document CCT/2026-WG08.

Dr Abe summarized the status of KCs in the field of humidity: CCT-K8 and EURAMET.T-K8 have been approved for equivalence, the protocols for the new key comparisons CCT-K6.2021 and EURAMET.T-K6.2021, piloted by E+E, are currently under preparation, and the APMP.T-K6.2013 report is at Draft A status. The CMC review protocol for humidity is currently being revised. Dr Abe reminded the CCT that the WG-Hu convenes the ISHM conference and is in active liaison with CCQM (on moisture measurement), WMO, IAPWS and other organizations. The WG is also discussing the digitalization of essential humidity functions (saturation vapour pressure of water and water vapour enhancement factor) and testing a prototype API for water vapour enhancement factor. The members of the WG are engaged in different research activities, such as trace-moisture measurement in gases (EURAMET project PROMETH$_2$O), laser spectroscopy-based hygrometers and compact humidity generators. The WG is also working on the first version of a document on humidity quantities, units, symbols and realizations and has prepared a proposal to the CCT for using %rh as the standard unit symbol for relative humidity.

Dr Abe gave the floor to Dr Stephanie Bell, who gave a short presentation on the WG-Hu proposal to adopt %rh as unit symbol of relative humidity. %rh is already the *de facto* unit symbol of relative humidity, as it is used by all major relative humidity instrument companies (but not in a consistent form) and by many NMIs, accreditation bodies and other authorities. Such an approach is needed to distinguish values of relative humidity from other humidity quantity percentages, such as fraction of water vapour in air, so the percentage symbol by itself does not provide enough clarity. Also, there are some language variants and non-standardized capitalisations (%rh, %RH, %rF, %UR, …) and this approach will bring welcome standardization to the expression. Dr Bell clarified that the unit symbol is independent from the exact definition of the unit itself.

Initially, the WG-Hu had drafted a CCT recommendation to the CIPM, but later, following correspondence between the CCT President and the CCU President, it became clear that the CIPM would not accept such a recommendation. Therefore, it was decided to redirect the recommendation to the CCT itself (see document CCT/2026-05).

Dr Bell commented on the reason why the %rh symbol is not in the SI. In principle, the quantity relative humidity is dimensionless (or of dimension 1, unit symbol 1, usually unwritten). In theory, quantities of dimension one are already handled well in the SI, although, in practice, they maybe not be, and there is an extensive *Metrologia* literature on the inadequacy of unit symbol 1 for many quantities. In theory, there is also a rule that says that a unit symbol must not contain a reference to the measurand, but this rule is not 100 % enforced. In fact, the SI can (and does) make many exceptions to the rules by choice (for example, °C). The proposal is not meant for inclusion in the SI (WG-Hu is neutral on this possibility), but rather to recognize the *de facto* unit symbol that is in widespread use and harmonize its notation (English language version, lower case letters). As a recommendation, users would not be forced to adopt it: it would provide guidance on which version is preferred. However, the recognition of non-SI units/symbols is well recognized (see Table 8 in SI brochure), for example, time in days (symbol d), electronvolt (symbol eV), and logarithmic ratio quantities – decibel (symbol dB). Dr Bell related that other CCs are addressing similar cases. For example, the CCQM has bioanalytical measurands of dimension 1 that they want to better distinguish, and a TG of CCQM is working on harmonizing these cases. While recognizing that they are outside the SI, they are exploring localized usage and potential standardization. CCT could do similarly.

The CCT President commented that she was involved in the discussion with CCU and appreciated the importance of it.

Dr Peruzzi asked Dr Abe why the CCT-K6.2021 key comparison, formally initiated in 2021, is still in the phase of protocol preparation and whether the protocol foresees a specific timeline for the comparison. Dr Abe replied that, having learnt the lesson from CCT-K8, they have decided to include in the protocol analytical methods, and this required time. There is already a first version of the protocol. Dr Peruzzi asked if this first version foresees a specific completion year. Dr Abe replied that it does not. Dr Bell added that the protocol indicates that the measurements are scheduled to take one year only and one of the factors determining the starting date is the availability of the transfer standard, because the top-level hygrometer market has changed a lot recently. Dr Abe added that the CCT-K8 measurements took only one year. The CCT President commented that the cause of the delay in CCT-K8 was not the measurements but the analysis of the results and expressed the hope that the new guide on the analysis of KC results, being prepared by the WG-KC, will alleviate such a problem in the future.

Dr Merlone commented on the choice of the unit symbol for relative humidity: he reminded that all units usually derive from ancient Latin or Greek languages, while %rh would use a modern language (English). However, in ancient Latin humidity is humiditas, so there was no problem with this proposal.

Dr Yang asked whether a recommendation from a CCT WG to the CCT will have any impact, since documents undergoing internal NMI review might be rejected if they follow the advice in this recommendation instead of what is printed in the SI Brochure. Dr Bell replied that the current recommendation to the CCT is a first step, and the hope is to eventually get this unit symbol recognized in the SI Brochure.

The CCT President suggested that the CCT could endorse the recommendation, and task the WG-Hu with further efforts and coordination with the relevant CCQM TG to try to eventually get this unit symbol into the SI Brochure.

Dr Vito Fernicola fully supported the WG-Hu proposal, remembering that Dr Bell has been working on it for many years, and asked the CCT President to support such a proposal. The CCT President confirmed her support and formally asked for CCT approval of the WG-HU recommendation to use %rh as unit symbol for relative humidity. The CCT unanimously approved it.

7.7. Highlights of CCT Working Group for Thermophysical Quantities (CCT-WG-ThQ)

Dr Jean-Remy Filtz reported on the activities of the WG-ThQ. For full details, see document CCT/2026-WG01. Dr Filtz informed that this will be his last CCT meeting, since he will soon retire.

Concerning the CCT supplementary comparisons, CCT-S1 (emissivity) and CCT-S2 (thermal conductivity) final reports have already been published in the KCDB, while CCT-S3 (thermal diffusivity) Draft B is currently being revised to address the WG-KC comments. The pilot (NMIJ) will submit the revised Draft B to the WG-KC in September 2027. CMCs for emissivity and thermal diffusivity can already be submitted.

During the WG-ThQ meeting, the digitalization of calibration certificates for thermophysical quantities was discussed, with reference to the hard work already performed by PTB (Christian Monte). This task is challenging given the large number of thermophysical quantities measured. During the TEMPMEKO Symposium in 2025, the WG decided to initially limit their scope to emissivity quantities, with the goal of harmonizing machine-readable calibration certificates, standardizing emissivity measurands and metadata, harmonizing with reflectance and transmittance measurements of CCPR and aligning with DCC schema and CCT-WG-Dig. Some questions still remain open and will be addressed in the future: which quantities define the emissivity measurand, which parameters should be reported as influence conditions, and what should be the minimum interoperable emissivity dataset. A closer collaboration on this topic with the chair of the new TG on Distributed Thermal Measurement Systems (Dr Shahin Tabandeh) will be needed.

EURAMET project 1516 on the determination of thermophysical quantity measurement capabilities beyond EURAMET has been completed. Its goal was to create a database gathering laboratories and institutes from outside the EURAMET community that have capabilities in the field.

A new EURAMET technical guide on high-temperature thermal diffusivity measurements has been created and published (see Technical Guide n. 5 on the EURAMET website, where it can be downloaded).

During the WG-ThQ meeting, the members unanimously elected Dr Bruno Hay as new WG-ThQ Chair. The CCT President, not having received any objection, officially ratified the election of Dr Hay as new WG-ThQ Chair and congratulated him.
The CCT President thanked Dr Filtz for his invaluable contribution to the CCT over the past 25 years. Dr Filtz thanked all CCT members for their consideration, discussion and collaboration over the years.

7.8. Highlights of CCT Working Group for Environment (CCT-WG-Env)

Dr Andrea Merlone reported on the activities of the WG-Env. For full details, see document CCT/2026-WG07.

Dr Merlone related that the WG-Env and the TG-AirT convened jointly earlier in the week (28 members + eight invited experts, including three WMO representatives). Recently the WG has become increasingly involved with WMO by the membership, and even chairmanship, of WG-Env members in WMO working groups, and by contributing to the preparation of several guidelines.

A certified online training course on calibration has just been produced by the WMO with substantial contributions from WG-Env.

INRIM was recently nominated WMO Measurement Lead Centre for Traceability and Field Metrology and makes its facilities available for climate and meteorology calibrations. An intercomparison of thermometers, shields and loggers will be performed for the GCOS Surface Reference Network. The WG runs the MMC conference, the next of which will be held in 2027 in Greece. JV is also very involved (Dr Age Andreas Falnes Olsen is the chair of the TG-AirT) both with laboratory and on-site activities to support the surface reference network stations. KRISS is very experienced in upper air (radiosondes) and contributed substantially to ISO guides and to the GRUAN Upper Air Network. INTiBS is engaged with different universities and institutes, NMIA is active in air temperature issues, CEM is engaged with GCOS-AOPC and WMO, NMIJ has developed a calibration system for deep ocean thermometers, NPL is contributing a lot to air temperature and humidity, CMI is engaged on several project of environmental measurements, SMU is coordinating a new project to improve our capabilities in measuring air temperature, VNIIM is realizing transportable devices for calibration of meteorological thermometers and hygrometers, LMK is coordinating a WMO intercomparison in temperature, humidity and pressure.

TG-AirT, chaired by Dr Age Andreas Falnes Olsen, is undertaking a significant part of the WG work. The TG is divided into three sub-groups: SG1, led by Dr Bell, on the definition of air temperature, SG2, led by Prof. Davor Zvizdic, on uncertainty evaluation in air temperature measurements, and SG3, led by Dr Peter Pavlasek (replacing Dr Yong-Gyoo Kim) on the development of guidelines:

> **SG1:** A definition of temperature is needed that specifies air composition, pressure, whether steady air or at what wind speed, no radiation or at what radiation, and water vapour content. Moreover, although we are used to saying that a thermometer measures the temperature of the air, in fact a contact thermometer gives an indication of its heat equilibrium at that time in that place and under those conditions. This thermodynamic equilibrium is influenced by a multitude of parameters, some of them related to the sensor, others to the environment. A paper on a proposed definition of air temperature is being drafted.
>
> **SG2:** Regarding uncertainties, it was decided to adopt the WMO approach to divide the uncertainties in groups of components and focus only on the group of uncertainties related to the system (the traceable calibration of the sensor in the lab). In other words, leave the issue of the representativeness of the measurement for the air outside the weather-station screen and even a wider local area to the WMO.
>
> **SG3:** Comparison of methods for calibrating air temperature thermometers using sub-chamber in liquid baths.

The CIPM-STG-CENV requested the formation of a CCT subgroup on Capacity Building related to environmental measurements. This was created during the CCT-WG-Env meeting on 19 May 2026, at which time it was decided to have at least one representative from each RMO in the SG. The scope of work is to survey the connections between NMIs and the National Meteorological and Hydrological Services to establish traceability for ECVs.

Dr Merlone concluded that there is a growing interest in metrology for climate and environment, increased participation, improved cooperation with the WMO and the GCOS, increased activities (no longer limited to specific funded projects), more staff in metrology for meteorology and climate, an extensive scientific production, and a capacity building initiative.

Dr Merlone asked whether it is possible to consider having a WMO representative in the CCT, since WMO signed the MRA and there are already WMO representatives acting as invited experts in the WG-Env. The CCT President commented that the new rules and procedures of the CGPM contemplate the possibility of liaison organizations attending the CGPM as observers. The BIPM Director, Dr Annette Koo, confirmed that observer status will be available to organizations if this resolution is passed at the CGPM, but membership in the CCs is still reserved to full Member States, not even to Associate States. Signing the MRA, even in the case of an NMI, does not automatically guarantee the NMI can become a member of the CCT. The ability to influence the direction of the organization is a right reserved to full

Member States. However, the voice of the WMO is very important to the BIPM, we have an MoU with the WMO, and they are very welcome to participate in the activities of the CCs and to be invited to attend CCT and WG meetings.

8. Approval of the updated CCT Strategy

The CCT President recalled that the CCT Strategy document (see document CCT/2026-02) responds to the CIPM request to update the CC strategies in view of the upcoming 2026 CGPM meeting. The strategy has been prepared by the members of the WG-SP with the help of Dr Stéphane Solve and was circulated by Dr Solve some weeks before the CCT meeting.

The document follows the main lines of the CIPM Strategy itself: a review of the different stakeholder needs was made, the achievements from 2021 to 2025 and a future scan from 2025 to 2030 are summarized in a table, a summary of the status and the needs of key comparisons is provided, and a list of all the guides published in 2022-2025 is included in the Annex.

The CCT President, having not received any comments on this document, and keeping in mind that this is a living document, asked for formal approval. The CCT unanimously approved.

9. Report from the CIPM Forum on Metrology and Digitalization (FORUM-MD)

Dr Patrick Rourke reported on the activities of the CIPM Forum on Metrology and Digitalization (FORUM-MD). For full details, see document CCT/2026-09.

Dr Rourke recalled that FORUM-MD follows the rules of a CC but advised the CIPM on the digital transformation rather than on a specific area of metrology. He stated that, out of the six FORUM-MD TGs and three WGs, CCT-WG-Dig are active in the FORUM-MD TG on Harmonizing DCC and DRMC, the TG on Sensor Networks, and the WG for coordination between Consultative Committees.

He reported on the FORUM-MD technical workshop ("Emerging Topics of Digitalization in Metrology") and plenary meeting held in February 2025, where much of the focus was on sensor networks. He also reported on the FORUM-MD technical workshop ("AI in a metrological context: AI for metrology and metrology for AI") and plenary meeting held in March 2026, with key findings for development and NMI validation of AI systems.

Dr Rourke related discussions with the President of the CCU at the March 2026 meeting of the FORUM-MD WG for coordination between Consultative Committees, regarding the request to use "%rh" in the SI Digital Framework. He concluded that, at present, the unit "%rh" cannot be used in the SI Reference Point, because it is a direct implementation of the SI Brochure and "%rh" is not currently in the SI Brochure. However, the broader SI Digital Framework is more flexible, and should be able to accommodate "%rh" as a quantity. He noted that further meetings may be held on this topic.

Lastly, Dr Rourke drew attention to the CGPM Draft Resolution E: *On the further digital transformation of the global metrology system*. He noted that this resolution encourages the CIPM to further intensify and expand its strong engagement in ensuring that the Metre Convention becomes fully accessible for all in the digital era, and highlighted the goals to extend the SI Reference Point to allow machine-actionable conversion between the SI and other systems of units, to standardize data exchange formats, to advance digital metrology for AI and complex systems, and to enable reliable integration and quality assurance of large-scale sensor networks.

10. Digitalization progress with the *BIPM SI Reference Point*

Mr Cristhian Paredes reported on the SI Reference Point (SIRP), which is the core response of the BIPM to the CIPM and CGPM mandate to extend the role of the Metre Convention into the digital era. The Metre Convention is the document that structures the worldwide metrological system, and is implemented around the International System of Units, specified in the SI Brochure. The extension to the digital era is done through the SI Reference Point, which is a digital representation of units of measurement.

Mr Paredes indicated the example of the kelvin from the SI Brochure: in the SIRP a Persistent Identifier (PID) is provided with a URL (https://si-digital-framework.org/SI/units/kelvin) for this unit, and there is also a PID for the Boltzmann Constant (https://si-digital-framework.org/constants/BoltzmannConstant). He said that these URLs will be used in machine-actionable documents, digital calibration certificates, databases, data analysis workflows and quality management documents. A big advantage of the SIRP is that it can be linked to anchor other digital representation units of measurement (DRUMs) to the authoritative definitions.

Mr Paredes explained that users accessing a PID URL using a web browser will land on a web page that gives information mirroring the SI Brochure. On the other hand, software accessing the PID URL will be provided with the machine-readable format of the definition, which points to the corresponding defining constant and the corresponding CGPM resolution; this can be done in a variety of formats (JSON, XML). Moreover, the SI Reference Point provides machine actionability, which adds a powerful interoperability layer, with a variety of formats (JSON-LD, TTL), and underpinned by a knowledge graph. Machines can operate on these data without human intervention. It also enables FAIR measurement data. This is limited only to units, because the SI Brochure defines the units, not the quantities. It works also for compound units (for example, the unit of heat capacity): the system can produce the corresponding PID, so that every compound unit has a PID, and a machine-actionable definition that will link the compound unit to its base units. He elaborated that the digital representations of quantities are focused on categories of CMCs in the KCDB. He also noted that this work is described in a paper that has been submitted to *Metrologia* by the members of the FORUM-MD TG on SI-digital Framework (FORUM-MD-TG-SIDF).

Mr Paredes thanked the CCT for its contributions to the SIRP, which resulted in a better alignment of the knowledge graph with the metrological expertise in thermometry. He also mentioned that the CCT APIs are an excellent showcase of how the SIRP can be used.

The next BIPM action will be the release of the first stable version of the Knowledge Model. Further activities will include a Survey of NMIs/DIs on digital transformation and BIPM digital services, making the web services more accessible to metrologists, and providing workshops and practical examples in the framework of Knowledge Transfer and Capacity Building.

Finally, Mr Paredes invited everyone to visit the website and test the APIs, including the public repository releasing the TTL-serialized knowledge graphs, and engage with the ongoing discussions.

Dr Yoon asked how we can provide the link to thermodynamic temperature when calibrations are traceable to the ITS-90. Mr Paredes replied that an API is under development providing the equations for the difference $T - T_{90}$ and its uncertainty. As this API is underpinned by the knowledge graph, it will offer a link between ITS-90 temperature and thermodynamic temperature. The CCT President clarified that Dr Yoon's question was related to the fact that, currently, when a calibration certificate is issued in terms of ITS-90 temperature, its unit kelvin is not directly traceable to the kelvin of the SI Reference Point. Mr Paredes added that, in his opinion, the unit should not be used to specify the quantity being measured. For example, for the quantity thermodynamic temperature, both the kelvin or degree Celsius can be used as the unit. The CCT President further clarified that, if we include in our ITS-90-based calibration certificate a link to the kelvin PID of the SI Reference Points, we are misguiding the users, because the thermodynamic temperature kelvin is not the same kelvin of the ITS-90.
Dr Rourke said that there are PIDs for both units and quantities, and the quantities are made to match the CMC service categories. If the CMC entry has T_{90} unit, then in the SI Digital Framework there is a quantity for T_{90}. The CCT President reiterated that, however, the T_{90} unit should not be linked to the SI kelvin, which is the unit of T. Mr Paredes made the example of torque, the unit N·m can be expressed as J, but this is not done with torque, because the quantity is independent from the unit. The CCT President insisted that this is not the case for T and T_{90}, because the units of T and T_{90} are not exactly the same. Strictly speaking, the SI unit kelvin is the unit of T and not of T_{90}. The same applies to T_{2000}. Dr Rourke added that, in the SI Brochure, it is stated that the ITS-90 temperature is an approximation to thermodynamic temperature and uses the kelvin (and °C) as the unit so, according to the SI Brochure, the kelvin used as unit by the ITS-90 is the same as the SI unit kelvin. Dr Peruzzi stated that indeed they are now, but they are not guaranteed to be so in the future.

The CCT President asked if the SI Digital Framework could be the place to include %rh as the unit for relative humidity. Mr Paredes replied that the CCU has been working on the list of non-SI units for inclusion in a revised version of the SI Brochure, and the list is not exhaustive, so there could be room to include %rh in the future.

Dr Tabandeh asked if the conversions between units will be integrated in this work, and if there is any timeline for that, since unit conversions would probably be the most useful part of the digital framework. Mr Paredes confirmed that this is planned but there is still no timeline for it, as the conversions are not straightforward to implement; for example, conversion between kelvin and degrees Celsius is different for absolute temperature and temperature differences. He mentioned that the M-layer could be a potential solution. Dr Tabandeh suggested that a good starting point should be the implementation of the prefixes.

11. Celebratory seminar of 100 years of temperature scales

Prof. Machin recalled that the decision to hold this seminar was taken a few months ago in the WG-SP, when he proposed to celebrate the fact that it is nearly 100 years since defined temperature scales were introduced. He introduced the five speakers and their talks.

11.1. The emergence of temperature scales: from pre-1600s to ITS-90, Prof. Graham Machin

For full details of Prof. Machin's presentation, see document CCT/2026-WORKSHOP01.

Prof. Machin first reviewed the emergence of reliable thermometry: from the thermoscope to the thermometer to practical temperature scales. Then, in the second part of his talk, he spoke about how a physical understanding of temperature started to emerge in the XIX century, leading to classical thermodynamics, primary thermometry and defined temperature scales.

In the last part of his talk, Prof. Machin spoke about how the framework for establishing an internationally agreed defined scale was laid by Chappuis at BIPM with the normal hydrogen scale (1887), carried by mercury-in-glass thermometers, and by Callendar proposing a scale based on platinum resistance thermometers calibrated at a number of fixed points of known temperature (1899). Finally, Prof. Machin spoke about the first defined international temperature scale - ITS-27 (1927) - and all its revisions until the ITS-90 (1990), each time increasingly converging to thermodynamic temperature values.

Prof. Machin concluded that we have come a long way and asked what the next 100 years will hold.

11.2. The run-up to the ITS-90, Dr Richard Rusby

For full details of Dr Rusby's presentation, see document CCT/2026-WORKSHOP02.

Dr Rusby remarked that his own temperature at birth must have been measured on the ITS-27, and he recalled that, when he first joined NPL, meetings were taking place to work on the IPTS-68. Looking back at all of the International Temperature Scales, Dr Rusby said that each of them was a big step forward in the art and science of temperature measurement even if, in the end, the practitioners became dissatisfied with them and they had to be revised to accommodate new developments and wider temperature ranges. He reminded the attendees that the ITS-90 was born out of dissatisfaction towards the IPTS-68, a dissatisfaction which increased throughout the 1970s and 1980s. He explained that the most significant objective in revising the IPTS-68 was to remove Type S thermocouples, with the initial plan being to extend the range of platinum resistance thermometers up to the Au point. However, at a conference in Beijing in 1986, this goal was assessed as too ambitious and a decision was taken to restrict high-temperature platinum SPRTs to the Ag point and below.

Dr Rusby recalled that the participants at the CCT meeting in 1987 were informed that the CIPM wanted to introduce new definitions of the Josephson and von Klitzing constants in electrical metrology on the first of January 1990, and they wanted to introduce a new ITS on that same date. He observed that the CCEM was informed of the reverse, and both communities set to work.

He summarized the flurry of scale features, issues and decisions during the 1987-1989 period:

- Removal of the Type S thermocouple and extension of SPRTs to the Ag point.
- Decision that radiation thermometry would be referenced to a blackbody at the Ag, Au or Cu point. The Au point had traditionally been used for this purpose, the Ag point was the new end point of the contact thermometry range, and the Cu point was added as a less expensive option. New values for the freezing points of Ag and Au had been determined by radiation thermometry relative to a blackbody at 760 K by Fischer and Jung at PTB. Dr Rusby recalled asking Dr Jung whether it would be wise to check the Ag-Au interval directly, to which Dr Jung replied “yes, but if I ask Fischer to do this, he would kill me!” Therefore such a check was not performed.
- Derivation of new SPRT reference functions above the triple point of water, using HTSPRTs calibrated at PTB. The thermodynamic correction to T_{68} was predominantly based on the NBS constant-volume gas thermometry measurements of Guildner and Edsinger (1976) and Edsinger and Schooley (1989). The discrepancy between the two sets of measurements (30 mK at 730 K) was solved by drawing a line in between the two sets of data, as there was no reason to prefer one or the other. Dr Rusby noted that, as consequence, the creators of the ITS-90 did not have good thermodynamic values for the Sn and Zn points.
- Combination of constant-volume gas thermometry experiments of Kemp, of Astrov, and of Steur and Durieux with total radiation thermometry experiments of Quinn and Martin to set the thermodynamic basis of the ITS-90 below TPW. These measurements indicated that $T - T_{68}$ reached a peak of about 13 mK +/- 5 mK at about 150 K, then plummeted to negative and oscillatory differences below about 60 K. Dr Rusby explained that the ITS-90 was defined just before the innovative spherical acoustic resonator measurements of Moldover and Ewing and Trusler became available, which showed $T - T_{68}$ peaking much less. He related that it was very disappointing to be told in the immediate aftermath of introducing the ITS-90 that the thermodynamic assignments in the scale were not accurate.
- Development and validation of cryogenic sealed triple point cells for H_2, Ne, O_2, N_2, Ar, Kr, Xe and CO_2 by Dr Pavese at IMGC and Dr Bonnier at INM. These were recognized as very precise tools for realizing the new scale.

- Exploration of many possible scale interpolation schemes, with different functions and sets of fixed points, using the Ward and Compton international comparison data set of 30 CSPRTs between 13.8 K and 273.16 K. Dr Rusby related that there was a huge number of such results, by Ward and Rusby at NPL, by Kemp in Australia, by Hill at NRC, and doubtless many others.
- Generation of the low temperature reference function using a chosen reference thermometer, whose α-value, essentially the slope at the triple point of water, was compatible with that of the HTSPRT used for the high-temperature reference function. Dr Rusby noted that since the interpolations above and below TPW depend on the particular SPRT used, there remains some risk of discontinuity, because the SPRTs suffer from non-uniqueness.
- Decision to introduce parallel subranges, arising from the decision to extend the SPRT range to the Ag point. This was deemed preferable to defining the scale in discrete piecewise steps (which had not been successful in the IPTS-68 below TPW), though with the risk of introducing subrange inconsistency (SRI). SRI was extensively tested where data allowed, but this was not always possible using the new potential fixed points Xe, Hg, Ga and In.
- Decision on the fixed points to include in the scale. Ga and In were added. The then CCT President Dr Preston-Thomas requested an additional point between TPW and the triple point of Ar, specifically the triple point of Xenon, which was well placed. However, there had been only few realizations of it, with mixed success (1-2 mK), and not with LSPRTs. Eventually the Hg point was chosen, but that was not immediately obvious until the final CCT meeting. The boiling point of water was removed and was therefore no longer pinned to exactly 100 °C, leading to news reports that “scientists say water does not boil at 100 °C!”
- Provision of new SPRT interpolations above and below the TPW. should be as mutually consistent as possible, and minimize non-uniqueness, but very limited data was, and still is, available for such things like Type 3 non-uniqueness for long-stem SPRTs above the TPW. Below the TPW, the main remaining issues were Xe vs Hg; and the Ne subrange, which did not meet the WG3 target of < 0.5 mK interpolation accuracy.

Dr Rusby explained that the process of building the ITS-90, from 1987 to 1989, was that Drs. Quinn and Preston-Thomas met quarterly with WG1 (Bloembergen), and in several occasions were assisted by Dr Crovini (WG3), Dr Jung from PTB, Dr Hudson (WG4) and Dr Rusby. In between, telex messages and faxes exchanged, and successive drafts of the scale text were circulated to the CCT for comment.

Dr Rusby described the events of the 17th meeting of the CCT (12-14 September 1989), during which the ITS-90 was finalized. He began by showing a photograph of a small group he called “the guilty men” and mentioned that he is glad that the CCT is now more inclusive, both in terms of geography and representatives. He mentioned that Durieux was appointed rapporteur, new members were welcomed, the death of a former CCT President was noted, but the meeting had no written agenda: just reports of the WGs, ITS-90, and any other business.

He related that Terry Quinn then quoted from Shakespeare's Julius Caesar and continued that the CCT as a whole must take the responsibility for the ITS-90 (meaning: unlike the IPTS-68). The final text of the ITS-90 needed to be ready to be recommended for adoption by the CIPM and CGPM the following month.

Dr Rusby mentioned that WG3, Crovini's group, presented the SPRT reference function. Dr Bedford then contacted Ken Hill at NRC to check the numerical validity and consistency of particular SPRT interpolations: Hill worked on these calculations overnight, and the CCT returned each morning and see what he had found.

Dr Rusby explained that Ken Hill's results revealed that the subranges Hg-Ga and TPW-Ga were not consistent, and that the Hg point should be reduced by 2 mK. However, by that time the reference function of Kemp had been already accepted by the CCT. Dr Rusby noted NPL had supplied values for a capsule-type SPRT calibrated at Hg and, a couple of years later, when this SPRT was measured again, they found that the reference thermometer had changed with respect to its measurements taken prior to creation of the ITS-90, by perhaps 0.5 mK. So, the confusion at Hg could be the result of this unfortunate NPL value, and Dr Rusby offered his apologies for that. Calculations also indicated the SRI and Type 3 non-uniqueness targets had been met, except for the prospective Ne subrange.

Dr Rusby also mentioned the presentation of WG4, Hudson's WG, which focused on $T - T_{68}$ data and specifications of the interpolating constant-volume gas thermometer. Dr Rusby described discussions regarding possible inconsistency between Ag, Au and Cu fixed points for radiometry: Dr Jung considered that they agreed within approximately 10 mK, and were therefore good enough. Discussions were also held regarding the freezing point of In and, using data from IMGC and NIST, and the W_r-value of In was settled.

Dr Rusby related that, during the third morning of the CCT meeting, Dr Preston-Thomas asked Dr Crovini (WG3) if he recommended any further changes to the fixed-point values. Dr Crovini replied that, based on the available information, and confirmed by Hill, WG3 did not recommend any further changes. Dr Preston-Thomas, with due gravity, said "the time has now come when the question of the adoption of the ITS-90 can be put to the vote."

Dr Rusby said that Dr Pavese then interjected to ask whether a decision had been taken on whether or not the Ne subrange would be included in the scale.
Dr Preston-Thomas replied that he understood that this subrange did not meet the WG3 requirements and therefore would not be included. Crovini confirmed that in his role as WG3 Chair, he could not recommend inclusion of the Ne subrange.
Dr Pavese then argued that the Ne subrange should be included, to enable realization of the scale below 54 K without pressure measurements. The viewpoint of Dr Pavese was supported by Dr Bonnier, Dr Blanka, Dr Rusby and Dr Crovini in his role as IMGC representative. Dr Preston-Thomas then allowed a preliminary vote on this point, with the result that the inclusion of the Ne subrange was approved by 10 votes to 2 (NIST and NRC objecting), with Dr Astrov and Swenson abstaining.

Dr Rusby concluded that the 17th CCT meeting then proceeded with the unanimous approval of the final recommendation: “The CCT recommends that on 1 January 1990, the ITS-90 come into force and that from this same date the IPTS-68 and EPT-76 be abrogated.” He further noted that those in attendance did not at the time realize the importance of completing this task in the morning session: BIPM had put champagne on ice, and thus the CCT could not break for lunch until the vote had been passed.

11.3. The redefinition of the kelvin, Dr Christof Gaiser

For full details of Dr Gaiser’s presentation, see document CCT/2026-WORKSHOP03.

Dr Gaiser noted that the nature of temperature was understood in the late XIX century, with Waterson, Boltzmann and Maxwell. At the beginning of the XX century (1900), Planck, with his famous Planck’s law, understood immediately that the three constants in his equation could be used to establish the units of length, mass, time and temperature, independently of special artefacts or substances. Dr Gaiser asked why it then took more than 100 years to redefine the unit of temperature in terms of one of these constants. He explained that it was mainly because the determination of thermodynamic temperature is far more difficult than measuring platinum resistance thermometers in fixed point cells. Dr Gaiser recalled that gas thermometry and platinum resistance thermometry were both already practiced at the BIPM (Chappuis and Harker) in 1900 but, for the redefinition of the kelvin, absolute primary thermometry was needed, and that required 100 more years of research.

Dr Gaiser reminded about the 2005 a workshop was held at PTB on “New Ways to the Boltzmann Constant” where Dr Moldover was a prominent figure: he had already determined the Boltzmann Constant with an uncertainty of 1.8 ppm with his experiment of acoustic thermometry (AGT) in 1988. In Moldover’s original experiment, he measured the volume of the spherical resonator by pycnometry, filling it with mercury (3 litres!) with an uncertainty of 0.8 ppm. Nowadays, the volume is measured using microwave resonances (another idea of Moldover) with an uncertainty of 0.4 ppm.

Dr Gaiser reviewed the principle of measurement of dielectric constant gas thermometry (DCGT) and the advances achieved in measuring pressure and relative capacitance change, as required by this experiment. Again, Moldover was of great help by stimulating theorists to calculate the He polarizability, which was needed with an uncertainty of the level of 1 ppm. Dr Gaiser also reviewed a third primary method, absolute Johnson noise thermometry (JNT).

Dr Gaiser reminded the attendees that the CCT recommendation from 2014 required an overall uncertainty in the determination of the Boltzmann constant of less than 1 ppm, based on at least two fundamentally different methods, of which at least one for each should be better than 3 ppm. He showed the results included in the CODATA

Adjustment 2017 for the Boltzmann constant value, which led to the redefinition of the kelvin in 2019. He noted that, besides the primary thermometers used in the Boltzmann experiment (AGT, DCGT and JNT), the *Mise en Pratique for the definition of the kelvin in the SI* (*MeP*-K) also allows refractive index gas thermometry (RIGT which, together with DCGT is called polarizing gas thermometry, PGT) and primary radiometric thermometry, as well as the defined scales ITS-90 and PLTS-2000, so T and T_{90} coexist in the *MeP*-K.

Dr Gaiser explained that the set of Boltzmann experiments can be regarded as a comparison of thermodynamic temperature at the TPW. Further away from TPW, the agreement between T and T_{90} gets worse, with u(T_{90}) presently still lower than u(T), though $u(T)$ has been decreasing over the years.

Dr Gaiser mentioned the first steps to the direct realization and dissemination of T: the direct calibration of resistance thermometers by AGT between 10 K and 25 K, the EURAMET DireK-T project, and the improvement in $u(T - T_{90})$ in the range 4 K – 300 K. He explained that at high temperatures, there is still large $u(T-T_{90})$ and a severe lack of measurement data: the challenge for the future is to better estimate $T - T_{90}$ in the range 400 K – 1235 K. Recently, within the DireK-T project, NIM has performed measurements from 400 K to 1300 K using a combination of AGT and radiometric thermometry.

Dr Gaiser emphasized that platinum resistance thermometers are the scale carriers for dissemination of both T and T_{90} from 25 K to 1235 K, and he recalled the advantages and disadvantages of them. He highlighted the close interconnection between T, T_{ITS} and SPRTs. Concerning a new ITS, Dr Gaiser summarized what is needed from a scientific perspective and from a stakeholder perspective (referring to document CCT/2026-03).

The CCT President Dr del Campo asked whether, when the ITS-90 was developed, its creators expected it to last for 40 years. Dr Rusby replied that yes, each time a new scale is created it is intended to last forever, but that the creators of the ITS-90 received bad news about its thermodynamic accuracy soon after its creation.

11.4. The impact of changing temperature scales on the climate record, Dr Andrea Merlone

For full details of Dr Merlone's presentation, see document CCT/2026-WORKSHOP04.

Dr Merlone began his presentation with a spoiler: regarding the impact of changing temperature scales on the climate record… there is no impact.

The work presented by Dr Merlone is an output of the MeteoMet project and has been published in *Int. J. Climatol.* in 2015. He explained that this work is relevant to climatologists when they reconstruct the historical temperature data series which, in turn, is important for constraining models of the Earth's climate system, establishing long-term temperature trends, and validating proxies to extend the temperature record back in time.

Dr Merlone related that climatologists had tacitly assumed that the temperature scale was consistent across the whole historical temperature record. This is essentially true for temperatures close to the freezing point of water (0 °C), because this has been the anchor point to calibrate thermometers since the XVII century. However, he noted that the nonlinearity of different thermal properties used in thermometers (for example, thermal expansion of mercury, electrical resistance) implies that the choice of the instrument has a subtle effect on the temperature scale itself and introduces a bias in long temperature records. Fortunately, the thermometry community is aware of such effects and is able to advise the climatology community.

For temperatures close to 0 °C, Dr Merlone showed that a polynomial function can be used to describe the difference between different scales. He and his co-authors expressed t_{90} as the sum of the historically recorded temperature plus a polynomial correction. They found that the correction is very small (less than 6 mK) after 1968, but relevant (up to 20 mK at -25 °C) between 1927 and 1968. He continued that, as part of the work, a conversion program was developed to transform historical temperatures to t_{90}. He explained that this conversion was applied to the data of two centennial stations with uninterrupted records (Brera Observatory in Italy and Wasserkuppe in Germany): the result was that the correction is much smaller than the sensor uncertainty, and thus has a negligible impact. Nevertheless, Dr Merlone related that this work led to a deeper knowledge of historical thermometers used in meteorology, which proved useful when validating a high-temperature record made in Pakistan in 2017.

Dr Merlone explained that climate trend analyses are based on relative differences in the evolution of anomalies from baseline values in given periods. He showed that, for historical thermometers, the differences due to temperature scale changes are smaller than the ink marks on the thermometers. He concluded that climate change trends are reliable, and do not depend on changes of temperature scales or primary methods.

11.5. Future temperature traceability beyond ITS-90, part 1: Traceability considerations for T and T_{90}, Dr Jonathan Pearce

For full details of Dr Pearce's presentation, see document CCT/2026-WORKSHOP05.

Dr Pearce reported some of the outputs from the TG on Future Thermodynamic Temperature Traceability. He noted that thermodynamic temperature is already being disseminated by some NMIs, practical primary thermometers are being developed by NMIs and industry and are likely to be used soon. He continued that *in situ* traceability is also being developed through self-validating thermometers. He explained that the TG evaluated current and future temperature traceability in four case studies (primary relative radiometry, AGT, JNT, DBT); *in situ* self-validation; and, more widely, the impact of primary thermometry on low temperatures up to 300 K, above 300 K to the Ag point, and high temperatures above Ag.

Dr Pearce introduced self-validating techniques, whose key driver is the end-users' desire to mitigate calibration drift by implementing calibrations and traceability *in situ*. He explained that these techniques are based on phase changes of materials and come in different forms: some are integrated with a thermometer (though the thermometer is not typically immersed in the phase-change cell), while some are remotely located from the thermometer. They are broadly split into two categories: self-validating thermocouples (uncertainty about 1 °C) and high-precision devices predominantly built for space applications (uncertainty 5-10 mK). He noted that typical requirements for such self-validating systems are: knowledge of the dependence on thermal conditions, auto detection of melting plateaus, knowledge of the effect of impurities, and the ability to freeze the miniature ingot.

In addition, Dr Pearce described a new sensor network-based approach that has been successful, in which a thermocouple multiwire system (different Pt-Rh alloy wires joined at the tip) allows a single temperature point to be simultaneously measured by many thermocouples of different types.

Concerning the temperature range 25 K to 300 K, Dr Pearce suggested that the situation is straightforward (with possibly the exception of the Hg point), because the SPRT is both the ITS-90 interpolating and disseminating instrument, without any loss of accuracy. He noted that defined scale temperature realization and traceability below 25 K is currently complex and difficult, and therefore thermodynamic temperature dissemination could well be helpful in this range, by exploiting primary techniques such as JNT, RIGT, DCGT, AGT, pMFFT, and possibly second sound thermometry. He also mentioned that the use of the He-4 lambda-point transition could facilitate the use of relative primary thermometry at very low temperatures.

Between 300 K and the Ag point, Dr Pearce stated that the simplest and most practical traceability route is still the ITS-90. He explained that direct dissemination of thermodynamic temperature becomes more problematic in this range, because of increasing materials problems with AGTs and the higher uncertainties attainable by lower-temperature radiometry. He concluded that thermodynamic temperature traceability in this range is not likely to be feasible until the 2030s, though some promising results are being achieved by the EURAMET DireK-T and ThermoSI projects.

At temperatures above the Ag point, Dr Pearce pointed out that absolute primary radiometry is very challenging, but relative primary radiometry using physically-based interpolation and calibration is much simpler. He highlighted some very practical approaches using HTFPs based on eutectics as anchor points above the Cu point that have been published by Dr M. Sadli (LNE-Cnam) and Dr D. Lowe (NPL). He explained that this technique is now mature and the next step is to demonstrate equivalence and superiority to the ITS-90 approach. He noted that it is still not clear whether a formal CCT comparison of thermodynamic temperature traceability mediated by HTFPs is needed.

Dr Pearce drew attention to the fact that traceability for absolute primary thermometry is to multiple different units, while for relative primary thermometry it is always to the kelvin (via the reference temperature), and that relative primary thermometry is also more practical. He clarified that the TG defined a "practical primary thermometer" as something that can be put in a box, shipped to the customer/user, unpacked and then brought into service.

Dr Pearce recalled that, conventionally, the NMI/DIs maintain a primary realization of the kelvin, which is validated through the mechanism of key comparisons, fulfilling the demonstration of equivalence required by the CIPM MRA. He explained that primary thermometers are generally complex and, even when all non-temperature quantities are calibrated, validating their operation as a complete thermometer system is needed. However, looking to the future when primary thermometers are expected to be more widespread (including outside of NMIS/DIs), he noted that it would not be practical to do large, frequent key comparisons. He mentioned that this is not an issue for relative primary thermometry, since traceability is obtained from the used reference temperature(s), which could, for example, be ITS-90 fixed points.

Dr Pearce emphasized that it is even more important for T and T_{90} to be interchangeable with sufficiently low uncertainty. He summarized that, currently, $T - T_{90}$ is very well characterized up to 335 K, slightly less clear but probably still acceptable between 335 K and 505 K, and certainly not good enough above the Sn point.

Regarding on the co-existence of T and T_{90}, Dr Pearce remarked that, up to 25 K, direct traceability to T is expected to become increasingly widespread in the relatively near term. He continued that, from 25 K to the Cu point, traceability to T_{90} will likely remain widespread, with conversion to T via increasingly well-documented $T - T_{90}$ values, and longer-term progressive introduction of practical primary thermometers. Above the Cu point, he noted that there is already direct traceability to T and this will become more widespread going forward.

Dr Pearce concluded that, since $T - T_{90}$ values are available, it is important to be clear which values, T or T_{90}, are being presented in any given temperature measurement. He suggested that the risk of confusion is small, since SPRTs are generally used between 25 K and 660 °C, radiation thermometers are used from 1084 °C upwards, and cryogenic thermometers are used below 25 K. He also mentioned that the outputs of the TG have been published in the Royal Society Kelvin Workshop Proceedings.

Dr Yoon asked if there were any customers that would like to have T instead of T_{90}. Dr Pearce replied that scientists developing theory are working in T rather than T_{90}, and a number of industry sectors (nuclear waste storage and decommissioning, and heat treatment) are very interested in JNT because of its ability to mitigate sensor drift.

11.6. Future temperature traceability beyond ITS-90, part 2: Outline of a future International Temperature Scale, Dr Patrick Rourke

For full details of Dr Rourke's presentation, see document CCT/2026-WORKSHOP06.

Dr Rourke began by recalling that the paper by Burgess introducing the first International Temperature Scale indicated that the purpose of an ITS is to be a practical approximation of T, with Burgess stating that it is intended to be revised and amended over time. Dr Rourke then referred to the Preston-Thomas paper that introduced the ITS-90, which includes a summary of all scale improvements since ITS-27: thermodynamic accuracy, temperature range, interpolating instruments, fixed points and flexibility of implementation.

Dr Rourke recalled that the CCT had, earlier in the day, approved the recommendation establishing criteria for when to make a new ITS that would replace the ITS-90 (see document CCT/2026-03), and referred to the presentation of Dr Gaiser on this topic. Dr Rourke focused on four technical criteria: reducing the uncertainty of the consensus value of T - T_{90} to below twice the realization uncertainty of the ITS-90 over the whole temperature range (he pointed to the new TG under WG-NCTh being created to help address this criterion); solving the PLTS-2000 problem below 8 mK; improving the performance of high-temperature SPRTs; and establishing viable alternatives to the Hg point. Dr Rourke invited the attendees to imagine a future time in which, after much work by the thermometry community, all criteria were fulfilled: the criteria then become features of the new ITS-XX scale, in terms of thermodynamic accuracy, temperature range, interpolating instruments, and fixed points and flexibility.

Dr Rourke indicated that the large, shaded k = 1 uncertainty bands on CCT consensus values of T - T_{90} at high temperatures (> 400 K) need to be reduced before such thermodynamic knowledge is incorporated into a new scale, and that this will be a difficult task. However, he explained that it would lead to a new scale in which the temperatures, T_{XX}, are equivalent and interchangeable with T. He noted that such a new scale would need the SPRT reference function coefficients and fixed-point temperatures to be updated. He suggested that if the reference function would be updated anyway for thermodynamic reasons, the CCT should take the opportunity to correct the internal inconsistencies between SPRT reference resistance ratios, $W_{r,i}$, that are defined in the ITS-90 at the different fixed points, because these cause inconsistencies between temperatures realized on the different ITS-90 subranges. He showed that doing this in ITS-XX would eliminate subrange inconsistency and give consistent T_{XX} values from the different subranges.

Dr Rourke reminded the attendees that the PLTS-2000 is called "provisional" because it is based on two discrepant input data sets in the temperature range below 8 mK. He pointed to new T - T_{2000} measurements that almost reach this temperature range. He expressed that if further measurements could resolve the thermodynamic nature of the PLTS-2000 below 8 mK, then ITS-XX could be a unified temperature scale that combined PLTS-2000, PTB-2006 and ITS-90 into a single scale covering all temperatures down to 0.9 mK.

Dr Rourke noted that other speakers have already mentioned the need for SPRT performance improvements, especially at high temperatures, and that progress in this area would result in more reproducible scale use in ITS-XX.

Dr Rourke recalled the problems of the Hg point: health and environmental impacts (and resulting regulations); as well as poor temperature position too close to that of TPW for interpolation purposes. He summarized the advantages and disadvantages of the three leading potential Hg alternatives: SF_6, CO_2 and Xe. He suggested that, if these were established as viable alternatives to Hg, all of them should be included in ITS-XX, so that NMIs would be empowered to choose which option best suits their capabilities and clients. He emphasized that Hg should not be removed from the scale, so that NMIs could keep using their existing Hg cells if desired and expressed the expectation that use of Hg would naturally fade over time as the difficulty of obtaining high-quality Hg for new fixed points rises.

Dr Rourke then raised some additional new-temperature-scale issues that the CCT would need to address, beyond those deriving from the recommendation criteria. Regarding the balance between technical improvement and ease of adoption, he stated that the NRC position emphasizes ease of adoption: for backwards compatibility reasons, nothing should be removed from the scale (fixed points, subranges, etc.), but new options could be added in parallel. He expressed that the existing reference function and interpolation equations should be kept, only updating coefficients and assignments at fixed points, to make them as easy as possible to implement in device firmware updates. He acknowledged other viewpoints and possibilities for more significant technical improvements to the scale at the cost of more difficult adoption and concluded that the CCT would need to decide how to strike the balance.

Dr Rourke recapped the two main problems of radiometric thermometry in the ITS-90: the T_{90} values of the Ag, Au and Cu points used to anchor radiometric extrapolations differ from T and are not consistent with one another; and the $c_{2,90}$ constant defined in the scale is not equal to that defined in the SI (which is based on exact fundamental constants), when considering number of useful digits. He explained that these problems could be fixed relatively easily in a new scale, and new higher-temperature fixed points could be added, such as the eutectics which now have well-established thermodynamic temperature values. Dr Rourke laid out a different approach that the CCT could take, in which radiometric thermometry is removed from the scale entirely, such that dissemination would be only via direct (usually relative) primary radiometric realization of T. He explained that either approach could be chosen, but that it was essentially a philosophical question: both options would use the same equipment, Planck law equations, and anchoring fixed point temperatures; it would depend on whether the CCT wants the activity to formally remain within the scale or not.

Lastly, Dr Rourke asked how the CCT will handle requests from industry regarding temperature scale issues. He noted that many discussions at the CCT and its WGs involve what we think are in the best interests of our industrial partners and clients. He then recalled the 31st CCT meeting, in which the Chief Corporate Metrologist from a large metrology company delivered a presentation titled "The Benefits of a Potential Revision of ITS-90 for Industry". Dr Rourke reminded of the key points made to the CCT in that presentation: do not let the perfect get in the way of the better; industry does not like traceability through extrapolation; request to improve contact thermometry at the extremes of temperature, especially given that ITS-90 SPRTs are limited to the Ag point and below, but thermocouple and radiometric thermometry uncertainties are too high for industry; and suggested adding high-temperature eutectic fixed points to the scale, as well as additional fixed points below 373 K. However, Dr Rourke observed that these ideas have not gained traction within the CCT. He asked whether the CCT will ignore direct requests from industry like this or engage with them. And if the CCT would engage with such requests, he asked how this would be done: for example, how to improve contact thermometry up to the requested 1 673 K, noting that some work was done in this area many years ago, but not recently.

Dr Pearce commented on the slide concerning direct requests from industry that NPL is already offering thermocouple calibrations up to 1 500 °C using eutectic fixed points with an uncertainty of about 0.5 °C. Dr Rourke replied that his understanding of the industry request is that the thermocouple uncertainties are too high for them above the Ag point. Below the Ag point, they can still use SPRTs with satisfactorily low uncertainties but, above Ag, they need to use thermocouples with much larger uncertainties that are unsuitable for *e.g.* calibrating furnaces. This is why they are asking to extend the SPRT range above the Ag point. Dr Gaiser commented that it is interesting that the chief metrologist of a major SPRT manufacturer, which is supposed to be in charge of improving the SPRT performance, is asking the CCT to push up the SPRT temperature limit. Dr Rourke agreed with Dr Gaiser and suggested that this could be fed back to the manufacturer. Dr Rourke added that, SPRTs being the transfer artefact for both T and T_{90}, and having witnessed in recent years the deterioration of the quality of all types of SPRTs from multiple manufacturers, there could be the potential for a fruitful collaboration with industry.

Dr Sadli asked for a clarification on the slide concerning the radiometric thermometry, in the sense that the two options anticipated by Dr Rourke are in fact the same option. Dr Rourke confirmed that technically they are indeed the same, though philosophically different: essentially the difference is in the messaging from the CCT to the outside world about whether these radiometric thermometry activities are considered to be part of the defined scale. Dr Sadli also mentioned that adding eutectic fixed points could be good for industry, because this would support interpolation between fixed points rather than only extrapolation.

Dr Quelhas asked if, when replacing Hg with an alternative fixed point, the same interpolation function should be used, because this could create other problems. Dr Rourke replied that he would favour introducing multiple sub-ranges using different sets of fixed points, but using the same deviation function. For example, as alternative to Ar-Hg-H_2O, one could use Ar-CO_2-H_2O, Ar-SF_6-H_2O or Ar-Xe-H_2O, with the same interpolation function, and he has shown in a previous publication focusing on the Xe case that the same interpolation function works well. Beyond this, he noted that additional subranges could be introduced, for example Xe-H_2O with a linear interpolation function. It depends on how far you want to step from the ITS-90. His preference, however, would be to maintain all the original ITS-90 subranges and add any new ones in parallel.

Dr Yang asked about the amount of non-uniqueness that would be introduced by the new subranges. Dr Rourke replied that he has not completely worked out the answer to this question, but in his 2021 paper he showed that Type 3 non-uniqueness is significantly improved when Hg is replaced by Xe (that is also why they wanted to use Xe instead of Hg in the original ITS-90). He explained that it has a lot to do with the position of each alternative fixed point: SF_6 is better than Hg, CO_2 is better than SF_6, Xe is better than CO_2; and similarly for propagation of calibration uncertainties. He continued that for Type 1 non-uniqueness (subrange inconsistency), it comes down also to interpolation function: any linear interpolation would have a larger inconsistency than if using the existing interpolation equations. He further replied that if the same interpolation function is used as in the ITS-90 Ar-Hg-H_2O subrange, then subrange inconsistency is similar or smaller.

Dr Sparasci asked if the low-temperature issues at 17 K and 20 K have been considered. Dr Rourke replied that Preston-Thomas and Quinn published an International Temperature Symposium paper in 1992 showing the weaknesses of the ITS-90, and urging that these weaknesses be fixed in a new scale. He noted that vapour pressure points were one such weakness, and a suggested replacement was the deuterium triple point at 18.7 K. However, he expressed that the best way to go below the Ne point is by using primary thermometry, since realizations of the hydrogen vapour pressure points and interpolating constant volume gas thermometry are difficult. He pointed to a publication from INRIM that demonstrated hybrid SPRT calibrations combining ITS-90 fixed points with some thermodynamic measurements used in place of particular ITS-90 points that are hard to do. Dr Gaiser added that the use of platinum resistance thermometers is already not recommended below the Ne point, with rhodium-iron resistance thermometers being the preferred choice at those temperatures.

12. Highlights of CCT key comparisons

12.1. New CCT-K9

Dr Inseok Yang reported on the status of the new CCT-K9. Dr Yang recalled that in the previous CCT-K9 most of the participants completed their measurements in 2012, making the original CCT-K9 comparison already obsolete. He also noted that, in some cases, its results were not satisfactory due to drift of the SPRT artefacts. He related that initial discussions about a new CCT-K9 considered the possibility of using fixed-point cells as transfer artefacts, since cells are more stable than SPRTs, but that further reflection evidenced the many challenges in transporting fixed-point cells: since six defining fixed points are involved (Ar, Hg, Ga, In, Sn and Zn), a large number of cells would have to be transported, and hand-carrying all six cells is practically impossible. Moreover, the transport of Hg on aircraft is prohibited, Ga transport is restricted and Ar transport is very complicated (because the entire system, not just the cell, would have to be transported).

Dr Yang presented two options. The first option would be to use fixed-point cells as transfer artefacts. This would achieve lower comparison uncertainties but, assuming 12 participants, it would require the transport of 72 cells. The comparison would have to be divided into three separate groups, each with its own pilot laboratory and two fixed points. KRISS could pilot one group, but two additional pilot laboratories would be required to share the workload. The transportation issues for Ar, Hg and Ga remain unresolved, and In, Sn and Zn cells also have transportation issues, including potential breakage. The second option would be to revert to SPRTs as transfer artefacts. This would be the same approach as the past CCT-K3 and CCT-K9. In this case, KRISS can volunteer to serve as the pilot laboratory. The comparison would be relatively straightforward to implement, although SPRT drift may result in higher comparison uncertainty.

Dr Peruzzi added that it is important in the present discussion to gauge the interest of NMIs in a new CCT-K9 and which of the two options is preferred. Dr Pearce commented that, since NPL has just completed a bilateral K9 comparison, it feels compliant with CCT-K9 and is surprised to see that CCT-K9 is already considered obsolete. Moreover, Dr Pearce thought that the second option is the only realistic choice.

The CCT President agreed that the second option was the only realistic one. Dr Feng added that, because the Draft A report of APMP.T-K9 has just been completed and more than 80 % of the results are consistent with each other, APMP would prefer the second option. Dr Fernando Sparasci, pilot of EURAMET.T-K9, commented that the results obtained with SPRTs were not so unsatisfactory, so it is preferable to opt for the second option.

Dr Peruzzi acknowledged the preference for the second option and, having heard the concerns of Dr Pearce on the opportunity of starting a new K9 right away, asked what a preferred timeline for this KC would be. The CCT President noted that, if the decision is postponed to the next CCT meeting, it could mean waiting another 5 years before starting the measurements. She suggested asking the pilot (KRISS) to start developing the protocol now and to launch the measurements at the time of the next CCT meeting. Dr Pearce commented that starting with the measurements 5 years from now sounds reasonable, since some RMOs are still working on their regional extensions of K9. Dr Sadli supported the opinion of Dr Pearce. Dr Peruzzi noticed some understandable 'key comparison fatigue' from the RMOs and accepted the proposal of the RMOs. The CCT President concluded that the CCT decision on this matter is to launch the new K9 at the next CCT meeting. Dr Yang confirmed the availability of KRISS to act as pilot also on that occasion.

12.2. New CCT-K4

Dr Peruzzi introduced the subject of the new CCT-K4 comparison. He recalled that CCT-K4 was carried out 25 years ago, piloted by PTB. He noted that PTB was willing to act as pilot again and possesses excellent facilities to run it (six heat-pipe furnaces for high-temperature extra-long fixed-point cells – all six suitable for Al and four of them suitable for Ag cells, four 3-zone furnaces suitable for Al cells, gas handling for both 6N Ar and 6N He). He described a preliminary meeting that was held about one month prior, in which the major issues related to this new KC were discussed.

Dr Peruzzi related that the preferred topology was a collapsed star, using open or sealed cells as transfer artefacts (to be transported and assembled at the pilot's lab by each participant). He said it would be desirable to split the comparison into two parts (first Al then Ag), to reduce the time spent by the cells of each participant at the pilot's lab. He continued that HTSPRTs should be used by the pilot to compare the cells, with preliminary tests and selection of the most stable devices. He presented the envisaged timeline for the comparison: preparation and approval of the protocol from June 2026 to December 2026, start of the measurements at the participants' labs in January 2027, and start of the measurements at the pilot's lab in June 2027.

Dr Peruzzi noted that he had preliminarily contacted the RMO chairs and asked them to discuss, internally to each respective RMO, the participation in this new KC. He related that interest in participating was expressed by: NMISA and NIS in AFRIMETS; KRISS, NIM, NMIJ/AIST, MSL and NMIA from APMP; NPL, PTB, VSL and maybe LNE-Cnam from EURAMET; INMETRO, NIST, NRC, INM and BNSI from SIM; and SASO from GULFMET.

Dr Peruzzi asked the CCT to take a formal decision on the pilot and on the participants. Dr Olsen recalled that participation in CIPM KCs should be limited to the highest-level laboratories and asked if this is the case for some of the non-CCT members that requested to take part in this KC. Dr Peruzzi replied that there is one constraint imposed by the pilot, which is a maximum number of 14 participants (last CCT-K4 had 12 participants) and indeed, only the highest-level labs should take part according to the CIPM MRA rules. It is reasonable to give priority to the CCT members (12 or 13 participants, depending on the decision of LNE-Cnam). Dr Peruzzi proposed to hear briefly from the non-CCT members that are interested in participating. The CCT President noted that, in the spirit of the CIPM MRA, the labs that take part in the KC commit themselves to extend the linkage to the KC in follow-up regional extensions (with the quality of the regional KCRV dissemination dependent of the uncertainties of the linking labs), and all RMOs should be represented, taking into account the number of NMIs of each region, so the RMO should decide which NMIs of the region should take part in it, based on their respective needs. The CCT President continued that, if three participants from SIM is enough and 3.5 participants from EURAMET is enough, then that is the important point, not whether participation in the KC benefits any individual NMI. Dr Sadli commented that EURAMET has not taken a final decision on three participants and they are still considering having four participants. The CCT President asked if the participation of non-CCT member is strictly necessary and if they are aware that they commit themselves to extend the linkage to the other NMIs of the region.

Dr Bojkovski recalled that the CIPM-MRA-G11 guide on KCs explicitly states that "participation in CIPM KCs is open to laboratories having the highest technical competence and experience, normally the members of the CC," so obviously priority has to be given to CCT members. However, he noted that the case of GULFMET could be different from the other RMOs, because GULFMET currently has no CCT members, and they would have the need of extending the linkage within their region. The CCT President agreed on the case of GULFMET and asked if one participant (NMISA) would be enough for AFRIMETS. Dr Ejigu (AFRIMETS Chair) said that this was exactly the reason for having a second non-CCT member taking part in the comparison: to help NMISA to extend the link to the region. The CCT President asked about SIM. Dr Peruzzi proposed to hear the SIM Chair, Dr Carolina Herrera. Dr Herrera commented that she needed to understand from the SIM CCT members if they can sustain the workload necessary to provide linkage to the rest of the region. The CCT President commented that participating in the KC commits those labs to further participate in regional comparisons (these NMIs are representing the regions at the KC, not themselves), even if they have a heavy workload, and a reflection on this point has not been yet completed by the RMOs. Dr Peruzzi clarified that only some RMOs still need to make this reflection and the constraint imposed by the pilot (14 participants) should be respected. The CCT President agreed on the importance of balancing the needs of the pilot and the needs of the regions; she discouraged RMOs bringing forward all possible KC volunteers to the CCT. Dr Machin expressed doubts on SIM members being fully aware of their commitments when requesting to participate. Dr Peruzzi clarified that this had been clearly communicated by the SIM Chair. Dr Yoon confirmed that NIST is aware of the responsibilities when taking part in a CIPM KC, that in this temperature range (Al and Ag) not all the SIM NMIs have capabilities, so requirements for regional comparisons are not heavy. He also noted the financial constraints required by participants to transport cells and assemble them at the pilot. He expressed the belief that even if another round of selection was made, the list would probably not change (with the possible exception of EURAMET). Dr Yang pointed out that SASO is also an associate APMP member, and has taken part in APMP comparisons before, so the GULFMET region can get linkage also from APMP when needed. Dr Peruzzi made a final proposal: to accept all CCT members as participants (12 or 13 participants, depending on LNE-Cnam participation) and additionally accept SASO participation, since GULFMET is a new RMO that is building up their capabilities and has no CCT members, and we want to give them the chance to demonstrate their capabilities and extend the traceability to the others in the region. He noted that this proposal is compatible with a maximum number of 14 participants. The pilot and all CCT members accepted this proposal.

12.3. New CCT-K2

Dr Gaiser could not see the reason why a new CCT-K2 is on the agenda. The CCT President replied that Dr Bojkovski brought to the CCT's attention the fact that CCT-K2 is a very old KC that has never been repeated but, after discussion within the WG-SP meeting, it is clear that there is no immediate need of a new CCT-K2. Dr Gaiser confirmed that there is no need of a new CCT-K2. Dr Peruzzi commented that the CCT Strategy document is very clear about this: no CCT-K2 in this decade, since the long-term stability of cryogenic fixed-point cells has been clearly demonstrated in the literature.

12.4. Final report of CCT-K8

Dr Robert Benyon reported on the completion of CCT-K8 key comparison of dew-point temperature of humid gas in the range 30 °C to 95 °C. He related that it was a complicated KC: in the end it was successful, though it was not an example of efficiency, and in the end many important lessons were learned. He explained that CCT-K8 was registered in the KCDB in 2008, but then a lot of preliminary work had to be carried out on the two transfer standards: annealing and testing of mirror PRTs (INTA), calibration of the final batch of ceramic encapsulated PRTs (INTA and NIST), their integration into the mirror (MBW), and measurements of new transfer standards (INTA). He said that the measurement phase began in October 2016 and was completed by the end of the next year (December 2017), and the final report was published in 2025. He listed the participants but, due to the geopolitical situation, COOMET results could not be included in the report.

Dr Benyon said that two transfer standards were circulated in two parallel loops, with simultaneous measurements at the pilot's laboratory and at the linking laboratory. He mentioned that an additional stop with extra measurements at INTA, which had not been initially planned, had to be made for reasons related to the ATA Carnet. He noted that this stop was later shown to be important, because it gave extra information about the stability of the transfer standards and on the agreement between the two loops. He also explained that the preparatory work performed on the stabilization of the transfer standards had been successful, since their influence on the comparison was minimal: the selected ceramic encapsulated PRT drift was ultimately insignificant (mK level). He mentioned that different types of humidity generators were used by the participants.

Dr Benyon related that the bilateral equivalence was obtained by linking the two loops using the link laboratories that simultaneously measured both transfer standards in parallel four times. He explained that, to calculate a single KCRV, a single loop (virtual loop) was created to represent a single virtual transfer standard, measured by all participants, and that this concept is also being used in CCT-K6.2021. He noted that the calculated degrees of equivalence (differences of individual participant from the KCRV) had extremely low expanded uncertainties (1 to 2 mK), the level of agreement between different labs was excellent, and he performance of the travelling standards was excellent. He stated that the expanded uncertainties declared by the participants ranged from 17 mK to 110 mK.

Dr Benyon highlighted that the delay in completing the analysis was exceptionally long, with the delay of Draft A mainly being due to the selection and development of the most suitable method for analysing the results. He stated that the analysis method was developed in close collaboration with PTB and BEV/E+E, plus a lot of discussions held by the participants, which led to five successive versions of the Draft

A report and thus a delay in obtaining the final report. He mentioned that, in the end, there was no need for complex analysis in the KC. He described many lessons learned: careful selection and annealing of the mirror PRTs can lead to excellent long-term stability; the measurement phase should be kept as short as possible; the analysis methodology should be included in the protocol and approved by the participants prior to any data processing; and the linking method designed to establish a single KCRV simplified the analysis (the same method could be extrapolated to more complex KCs). Dr Benyon thanked Mr Daniel Mutter (MBW), Dr Helmut Mitter (E+E), Dr Volker Ebert (PTB), Dr Regina Deschermeir (PTB), and Dr Jaime Gargia Gallegos (INTA) for their contribution to the success of the KC.

Dr Peruzzi thanked Dr Benyon and asked him how the lesson learnt, that the analysis method should be agreed already in the protocol, can be reconciled with the principle of the KC Guide being prepared (of which Dr Benyon is co-author, see document CCT/2026-04), that the analysis method cannot be decided before examining the results. Dr Benyon said that, based on his experience with ISO/IEC 17043, having the rules of the game up front in the protocol is fundamental and that maybe something could be learned from the rules of proficiency tests, though KCs are not proficiency tests. Dr Benyon emphasized that the analysis process for CCT-K8 was challenging, and that if, for example, the method of handling outliers is not agreed ahead of time, it is very difficult to work through that with the participants later. The CCT President congratulated Dr Benyon on the completion of this KC.

13. Highlights of RMO activities

13.1. AFRIMETS, Dr Efrem Ejigu

Dr Ejigu presented the activities of the AFRIMETS TC-T in the last two years. For full details, see document CCT/2026-RMO-01.

The AFRIMETS TC-T met in July 2024 online and in July 2025 in hybrid mode in Accra (Ghana). AFRIMETS is a developing region, so one of the major activities is inter-comparisons to support the CMCs of the NMIs. Two AFRIMETS supplementary comparisons are currently running (AFRIMETS.T-S3 and AFRIMETS.TS7). Moreover, NMISA is participating in CCT-K9.3, CCT-K4.2, CCT-K11, APMP.T-K6.2013, APMP.K4.2, APMP.T-S11/S12, APMP.T-S16, APMP.T-S13 and APMP.T-S17. AFRIMETS had five CMCs published in 2024, seven CMCs published in 2025 and ten CMCs published in 2026, so that the total number of published AFRIMETS CMCs is currently 56.

Different AFRIMETS NMIs are engaged in the inter-RMO CMC review process and in several capacity building activities: training, workshops and technical support to other NMIs and universities.

Research and development are performed only by a few NMIs (NMISA and NIS), in the field of non-contact thermometry, thermocouples, humidity, low-temperature and medium temperature contact thermometry.

The challenges of the RMO are difficulties in the procurement of equipment, inter-laboratory comparison delays, limited number of available inter-comparisons, limited number of NMIs with the capability to pilot intercomparisons and to provide training, limited technical capabilities, and increasing thermometry calibration services. The RMO covers a large continent with limited resources and exposure.

The CCT President said that she is happy to see new AFRIMETS CMCs and invited all other RMOs to support AFRIMETS.

13.2. APMP, Dr Xiaojuan Feng

Dr Feng reported on the activities of APMP. For full details, see document CCT/2026-RMO-02.

An APMP TC-T workshop and meeting was held in New Delhi in November 2024, chaired by Dr Hisashi Abe. The workshop focused on CMC training and resulted in a better understanding of the CMC submission and review process. The TC-T meeting focused on WG reports, CMCs and coordination of comparisons. Another APMP workshop and meeting was held in November 2025 in Incheon (Republic of Korea), chaired by Dr Feng. This workshop focused on reports of CCT activities on contact and non-contact thermometry, and humidity. Moreover, five laboratories reported on their activities. Each APMP TC-T meeting results in a list of specific actions to be taken, with strict deadlines.

The TC-T is structured with a chair, a vice-chair and five Working Groups: SPRTs, FPs and TPW; radiation thermometry; humidity; industrial thermometers; and thermophysical properties. The vice-chair is the former chair, which helps support the new chair to become familiar with the chair's duties.

Dr Feng summarized the progress in APMP key comparisons and supplementary comparisons. Most of the supplementary comparisons are older than 5 years, but their pilots have now committed to progress them before the next APMP TC-T meeting. Four APMP comparisons are hybrid comparisons, and they have progressed (two of them to completion).

In APMP there are also collaborative research projects on different subjects: relative humidity, comparison of liquid-in-glass thermometers, Ag freezing point, CO_2 triple point, and black globe thermometers.

APMP completed 50 RMO CMC reviews and published 36 CMCs (seven different economies) in 2025. In 2025, APMP also performed a large number of inter-RMO CMC reviews (172 in total), with an excellent KPI score (100 %). This is due to the tradition of having three different deadlines: one for the reviewer, one for the WG chair and one for the TC-T chair.

Future APMP TC-T plans are a hybrid meeting on CO_2 triple point realization, the possible creation of a TG for digitalization and/or AI (they will look for help from CCT-WG-Dig and EURAMET TC-T), and the election of a new TC-T chair.

13.3. COOMET, Dr Sergei Kondratev

Dr Kondratev reported on the COOMET activities in 2024-2026. For full details, see document CCT/2026-RMO-03.

Two meetings were held in the past two years: in October 2024 in Tashkent (Uzbekistan), and in September 2025 in Minsk (Belarus). COOMET.T-K6.1, COOMET.T-S5 and COOMET.T-S6 comparisons were completed in 2026. COOMET.T-S7 and COOMET.T-K6.2 are close to completion. COOMET.T-S8 and COOMET.T-S9 measurements are in progress. Six new CMCs (Kazakhstan) were approved in the past two years.

During the last day of the 2025 TC-T meeting, a workshop on the development of thermometry and thermophysical quantities was held, with participation from standardization and metrology services from different countries, for a total of more than 80 participants. Presentations were given by BelGIM, NIM, SMU, VINIIFTRI and VNIIM in the workshop.

The CCT President said that she was glad to see Kazakhstan piloting comparisons and obtaining CMCs.

Dr Filtz asked about connections with VNIIOFI and status of comparisons, particularly in the area of radiation thermometry. Dr Kondratev replied that work is planned to start again, and reminded the CCT that there was a separation of non-contact thermometry standards between the two institutes.

13.4. GULFMET, Dr Nasser Aldawood

Dr Aldawood reported on the GULFMET activities in 2024-2026. For full details, see document CCT/2026-RMO-05.

GULFMET has seven Member States and seven Associate Members. The TC-T on Thermometry was established in 2015. Dr Aldawood summarized the calibration capabilities of the GULFMET members and listed the completed (or close to completed) comparisons (EURAMET.T-K7.4, GULFMET.T-K9, GULFMET.T-S1, GULFMET.T-S2 and GULFMET.T-S3). Four more comparisons are being initiated (GULFMET.T-S6, GULFMET.T-S4, GULFMET.Ts1.2024 and GULFMET.T-S5), and two are being planned (not yet registered). Two GULFMET NMIs have already published CMCs: SASO (10) and EMI (7).

There are four GULFMET running research projects: high-temperature black body design, construction and verification of performance (towards establishment of absolute scale); integrated miniature cells for highly accurate new absolute humidity measurements; best practices for calibrating infrared thermometers and related uncertainty calculations; and development/manufacturing of a new system for calibrating surface probe sensors and thermal conductivity based on controlled copper blocks and a machine-learning predictive model (AI module).

The CCT President expressed her appreciation that GULFMET is becoming more active, year by year. Dr Aldawood asked if their new comparison of blackbodies for infrared ear and forehead thermometers should be registered as supplementary or key comparison. Dr Peruzzi replied that it should be a supplementary comparison. Dr Fernicola asked for details about the miniature cells for humidity. Dr Aldawood replied that he does not have more details about this new project at present but can send information by e-mail later.

13.5. EURAMET, Dr Mohamed Sadli

Dr Sadli reported on the EURAMET activities. For full details, see document CCT/2026-RMO-04.

EURAMET has 37 NMIs, 82 DIs and 16 international liaison organizations. Georgia has been accepted as a new member, and Ukraine is a new associate. The 2025 meeting was held in April in Sarajevo. In that occasion, a workshop on the CMC review process and review protocols was also held. The 2026 meeting was held in April in Vienna, together with a workshop on disseminating the redefined kelvin. The EURAMET TC-T is structured in five WG/TGs: WG Strategy, WG Best Practice, WG Thermophysical Quantities, WG CMC Review, and TG Digitalization.

The new EURAMET comparisons are EURAMET.T-K7.202X of triple point of water cells (7 loops, 34 participants, piloted by VSL), and a comparison in low and medium temperature radiation thermometry (2 loops, 14 participants, piloted by JV).

Many of the EURAMET research projects (DireK-T, INFOTherm, MultiFixRad, ThermoSI, PhoQus-T, and many others) are funded by the European Partnership on Metrology, started in 2021.

EURAMET TC-T Calibration Guides and Technical Guides have been published on the EURAMET website and are frequently consulted worldwide. The most recent one, published this year, is the Technical Guide on High-Temperature Thermal Diffusivity Measurements by the Laser Flash Method. Other guides are under development (surface temperature calibrations, radiation thermometers calibration, dewpoint calibrations, and relative humidity calibrations), and others are planned (resistance thermometry, calibration of thermocouples, and relative radiation thermometry).

In September, the EURAMET TC-T Summer School on Thermophysical Quantities will take place in Paris and Trappes (France).

EURAMET has published 114 CMCs since 2024 and has reviewed more than 250 CMCs, including 84 inter-RMO CMCs (94 % of the CMCs received for review). The 2025 workshop helped reduce the number of “sleeping CMCs” from 23 to 1, and reduced the time between submission and publication.

13.6. SIM, Dr Carolina Herrera

Dr Herrera reported on the SIM activities in the past two years. For full details, see document CCT/2026-RMO-06.

After her election, Dr Herrera established two WGs: the WG for CMC Review and the WG for Strategy and Planning. The CMC Review WG has been divided into four expertise areas (Fixed points and SPRTs; Industrial Thermometers; Radiation thermometry; and Humidity) with three experts per area.

In the last year, the CMC Review Group has reviewed 79 CMCs. During the last year, the WG for Strategy and Planning, composed of nine experts, has advised the Chair on prioritizing the planned RMO comparisons and supported the Chair in streamlining the organization of the Technical Workshop at LACOMET (November 2025) and the CMC review process. In 2025-2026, SIM published 12 CMCs.

There is only one remaining hanging CMC, investigation of which has led to the identification of a potential improvement to the relative humidity CMC review protocol. The issue was escalated to the CCT-WG-KC and further to the CCT-WG-Hu. SIM MWG3 is still waiting for the feedback from CCT-WG-Hu.

Unsatisfactory results obtained by some SIM NMIs in the CCT-K9 comparison have been diligently addressed by the NMIs through various actions (additional bilateral comparison, internal investigations, training processes).

Dr Herrera reviewed the status and progress of SIM comparisons and listed the major future activities of the SIM MWG3: organization of a workshop on thermal imaging cameras, design of the next key comparison (SPRTs from Hg to Zn), and the next annual meeting.

In June 2025, with the support of NIST experts, a virtual workshop on ITS-90 coefficient calculation software validation was delivered, in which 45 SIM participants joined online. The workshop included a pre-recorded demonstration of the realization of the triple point of water.

On the occasion of the annual SIM-MWG3 meeting (November 2025, San Juan, Costa Rica), a Temperature and Humidity Workshop was held in hybrid format, enabling both onsite and virtual attendance. More than 200 participants joined online during the first day.

In 2025, several virtual meetings were held: another SIM-MWG3 meeting in May, three WG-CMC meetings to discuss the review of CMCs, three meetings to discuss a newly planned dew/frost point comparison, one WG-SP meeting, and more than five leadership meetings.

In 2026, there have already been several virtual meetings to discuss newly planned comparisons (dew/frost point and SPRTs at fixed points) and WG-SP meetings to plan the 2026 workshop and annual meeting.

14. Seminar on the definition of uncertainty

The BIPM Director, Dr Annette Koo, introduced the reason for having this seminar: a potential new definition of uncertainty has been developed by one of the WGs of the JCGM, but there is still diversity of opinion about the definition, so the Chairs of JCGM WG1 and WG2 would like to engage with our community about the definition, the reasons why a new definition has been proposed, potential pros and cons of changing this definition, and collect feedback about it. A series of presentations to the CCs and other organizations has been planned for the coming 18 months, to ensure there is a good understanding of the definition itself and its meaning for us in the future.

14.1. Measurement uncertainty – A proposed new definition, Dr Walter Bich, JCGM-WG1

Dr Bich recalled the history of this new definition. In fact, it was first published by A. Possolo, the author of this definition, in NIST Technical Note 1900 in 2015, and included in the NIST Quality Manual since 2016. In 2019, a joint WG1-WG2 Focus Group was established on the topic, which seemed to have come to an agreed definition. Nevertheless, in 2023, the VIM4 CD2 was circulated with the traditional definition. In 2025, the new "agreed" definition was presented in a joint webinar. In February 2026, the final voting draft of the VIM4 was circulated with essentially the traditional definition. The results of the webinar poll were 2/3 of the votes in favour of the new definition.

Dr Bich explained the reasons for a new definition. The current definition ('parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand') is ambiguously close to that of standard uncertainty, because the dispersion parameter of a distribution is nothing else than the standard deviation. From this comes the need for disambiguation. The second reason is that, in modern metrology, many measurements involve implicit and/or multivariate models, inverse problems, Bayesian inference, AI and so on. Hence the need for generalization. The proposed new definition of measurement uncertainty is: 'doubt about the value of the measurand that remains after making a measurement'. The word doubt has been debated a lot within the WG1, the alternative being 'uncertainty about the value…'. Dr Bich can accept the alternative formulation if considered preferable, because he does not believe the new definition should be rejected just for a word. From the Oxford Advanced Learner's Dictionary of Current English, 'doubt' means uncertainty of mind, 'uncertainty' means 'doubt', so the two terms are more or less synonyms. The change of paradigm of the new definition is that measurement uncertainty is a doubt and, as such, a subjective state of mind. Dr Bich quoted the distinguished statistician Dennis Lindley "Uncertainty is a personal matter, it is not 'the' uncertainty, it is 'your' uncertainty". Also, measurement uncertainty is the concept, not the value: it is the doubt about the value. Dr Bich explained that it is desired to restore the dignity of the true value of the measurand, which has been demonized for some time, but is still a key element of estimation theory, the cornerstone of data treatment, and strictly connected to the fact that we deal with real numbers. In several cases, the true value not only exists, but can be known exactly. The true value is unique, though its uniqueness is questioned in some quarters. A classical example is the thickness of a sheet of paper. It is considered an ill-defined measurand, because it depends on where you measure it. The same is for the distance from Rome to Paris, the air density of my laboratory, the atomic mass of carbon. All these specifications actually define populations of values, each with its own distribution. Then there are well-defined measurands, such as the average air density of my laboratory today or average thickness of a sheet of paper.

Dr Bich expressed that the doubt is about the measurand, given its estimate, not about the estimate. The estimate is not uncertain, it is the only sure datum at hand. Concerning 'after making a measurement,' here the word measurement has a broader meaning than that intended in the VIM (not just experimentally). Dr Bich explained also the three notes related to the new definition. Finally, the key takeaways of the new definition are: the concept is separate from its quantitative expressions, the definition is broader than the current one (measurement uncertainty is now an overarching concept that accommodate a variety of mathematical tools used to express it), and it is easily transferable to categorical data as examination uncertainty. The doubt can be expressed with standard uncertainties, coverage intervals (including expanded uncertainties), covariance matrices, probability distributions, and possibly more, exactly as we already do. The definition of all these quantitative expressions for measurement uncertainty are unchanged, so that there is no impact whatsoever on current laboratory practice: operationally, the new definition is the same as the old definition.

14.2. The definition of 'measurement uncertainty' in the VIM4: the rationale for retaining the established concept, Dr Chuck Ehrlich, JCGM-WG2

Dr Ehrlich recalled that the VIM4 Voting Draft has already been circulated, where the definition of measurement uncertainty remains essentially as it is in the VIM3. He said that the decision was not made lightly and the issue of the potential new definition of measurement uncertainty will be addressed in the VIM5. He explained that the focus of VIM4 was on new nominal properties entries (now accomplished) and it was felt that waiting for the resolution of the measurement uncertainty definition should not slow down the main new aspects of the VIM. Comments on the VIM4 Voting Draft are due back to JCGM by 12 September 2026.

Dr Ehrlich stated that the JCGM GUM (WG1) committee informally introduced the new definition of measurement uncertainty in 2023. Informally because, strictly, it is not in the form of a definition and also because at this point the GUM Committee was just offering the possibility to the JCGM VIM (WG2) committee to consider this new definition in the VIM4. With respect to the idea that the new definition is generalizing/broadening the existing definition, the VIM committee maintains that this is not the case, because the proposed new definition changes the fundamental aspect of the concept from being mathematical (a parameter), as it has been for over 30 years, to being non mathematical – a doubt – which is a psychological concept. Dr Ehrlich expressed that the two definitions are of different nature, and one does not the generalize or incorporate the other. He mentioned that one could argue that the newly proposed definition broadens the range of the options for expressing a measurement uncertainty but, as it will be shown later, the VIM committee also has a proposal for doing this. He stated that, in several senses, the new definition is actually more restrictive than the traditional one, and provides more room for interpretation than the traditional one.

Dr Ehrlich related that the WG1 and WG2 held joint meetings from 2022 to 2025 and, although consensus was achieved on definitions of related concepts, no consensus was achieved on the definition of measurement uncertainty. In the informal poll held during the Webinar (July 2025), there was no overwhelming majority either way, and former BIPM Director Dr Martin Milton suggested that it was worth continuing to provide additional information and justification desired by many people in order to make a decision. The seminar of today is one of the sessions being planned to provide this additional information to help people better understand the issue.

During the webinar, a basic question was the level of acceptance by the metrology community of the proposed change in the usage of the term ‘measurement uncertainty’. Dr Ehrlich explained that, after the webinar, several members of the VIM committee felt that the webinar had be presented in a biased way, and that their perspective had not been adequately provided. They wrote a paper about this – see *Metrologia* 62 (2025) 062101 – which is not an official VIM committee paper, but was significantly factored into the VIM committee consideration about retaining the established concept of measurement uncertainty in the VIM4. In the abstract of this communication, it is stated that the 1993 VIM definition is too narrow in its scope, mainly because ‘parameter’ is no longer considered an adequate primitive concept. However, the proposed new definition involves three radical changes that led the authors to conclude that the reasons for radically changing the fundamental concept of measurement uncertainty are not sufficient. The three radical changes are: 1) measurement uncertainty is treated as a psychological entity instead of a mathematical one. In the development of the VIM4, the VIM committee used two important documents for guidance (ISO 704 and ISO 10241-1), but the GUM committee is unencumbered by the need to adhere to or even consider these two documents. The tasks of the VIM and GUM committees are different, so it is not surprising that these JCGM committees feel differently about how to proceed with the definition of measurement uncertainty. Dr Ehrlich additionally noted that the VIM committee is also developing an ontology in collaboration with the Digital SI. 2) measurement uncertainty is treated as related to the doubt about a unique theoretical true value instead of to an operational dispersion of measured values. 3) measurement uncertainty is treated as only applicable to single-valued measurands instead of the more general and more useful case of measurands with non-zero definitional uncertainty. Dr Ehrlich offered a typical example of this: a doctor measures a patient’s body weight. Is there a unique true value of the patient’s body weight at the instant the measurement on the scale is performed? Dr Ehrlich explained that body weight for a given individual can vary, at the level of a quarter kg, depending on many things, such as when the patient last ate. He continued that the measurement is also influenced by other effects, such as whether the patient has removed their glasses. He concluded that there is no unique true value of the patient's weight, but rather a range of values that will be consistent with specifying the measurand as the patient's body weight. One could insist that, in order to make a proper measurement, further specifications are needed. But for the purpose shown it is not necessary, since it will not influence the doctor's analysis. He emphasized that this is one of the key points that those who oppose the new definition are concerned about: the new definition does not accommodate the many measurements made in the world for which there is no unique true value. He related that the VIM committee wants the VIM definition to be applicable for the great majority of the people in the world making measurements, not just for those making high-end or very stable measurements.

Dr Ehrlich said that both the VIM and GUM committees agree that the 1993 definition of measurement uncertainty is too restrictive. He noted that there are other suggestions in the 2025 *Metrologia* paper, and reminded that the VIM is the authoritative place for metrology definitions.

14.3. Discussion

Dr Tabandeh noted that Dr Bich considered the true value as the ground truth for the definition of measurement uncertainty, but in several machine-learning applications there are cases in which the ground truth itself is uncertain, so he asked if there is a potential problem in defining uncertainty in those cases. Dr Bich replied that the topic of measurement uncertainty in artificial intelligence is a different matter, because there is no parallelism between ground truth and true value. Dr Bich continued that, when speaking about a true value in a measurement, he can accept that it is an ideal concept in some cases, but he can demonstrate that it exists in a lot of situations and, even in the case of the patient on the scale, a measurement model can be established, and a true value can be attributed to the patient's weight at the moment the measurement is taken. He also noted that what the doctor is interested in is the average weight, that is, within a distribution of values. He said that he has no tools to quantify the definition of uncertainty, but he does have tools to quantify the parameter of the distribution of values.

Prof. Davor Zvizdic appreciated one of the definitions given during the presentations that specifies 'based on the information used,' because different people use different information. For example, when using the example of the patient's weight, you can use information on the weight of the glasses, on the buoyancy, and so on. Dr Bich commented that the idea of glasses on or off is a good one. He said he considers dispersion to be different than uncertainty and gave the example of the measurement uncertainty on the atomic weight of a specific specimen of carbon-12 being several times better than the dispersion taken over different specimens.

Dr Ehrlich clarified that WG2 believes in true values, the question is only about the uniqueness of the true value. He was glad to hear the comment about `based on the information used,' which is in the VIM definition. He noted that some WG2 members like that dispersion is not clearly defined in the present definition, because it gives some flexibility (that the new definition does not have).

Dr Bell noted that she saw many things she liked and many things she did not like in the two presentations and commented that, in the *Metrologia* short communication, the term “psychological entity” in the first radical change is not the best word. In her opinion, a better word is “concept.” Dr Ehrlich replied that the word concept has been used in different ways in the presentations. Psychological is not the preferred use, the VIM Committee would prefer to use mathematical, as opposed to non-mathematical definition. Both definitions have underlying concepts, but the concepts are different. Dr Bell replied that “psychological entity” is a bit awkward as it puts it in the same brackets as ego and schizophrenia. Dr Ehrlich agreed on this point and added that it should be meant in the sense that each individual could have their own uncertainty for a given set of data. Dr Bich commented that the doubt is subjective. However, the goal of the community is to arrive at a situation in which they all share the same doubt – an agreed uncertainty on the quantity, as in the case of the fundamental constants. Dr Ehrlich clarified that the fundamental constants are given a zero uncertainty only because they are used to define the units.

Dr Sadli asked about if it is now up to the community to decide which definition to adopt. He said he liked the first proposal in the 2025 *Metrologia* paper and asked whether it is still possible to introduce that definition as the new one in the VIM. The BIPM director replied that, at the moment, we are in the phase of socializing the idea and collecting feedback from the community (over the next 12-18 months). Every time WG1 and WG2 have prepared a draft, the formal process requires that the draft is shared with the community for feedback. The feedback will be considered by the WGs, since the underlying principle is consensus, so at the moment we are trying to converge to a consensus definition.

Dr Peruzzi expressed appreciation for the new definition, however he is concerned about the meaning that is given by the word ‘doubt’ to measurement uncertainty as a ‘subjective state of mind,’ which weakens our goal of achieving consistency/equivalence between measurements performed by different labs. If each person says “this is just my uncertainty, my state of mind,” then it no longer makes sense to look for consistency and equivalence. Dr Bich took as example an international comparison. The same measurand is measured by all laboratories and, at the end, each laboratory gives its value and its uncertainty, and they are all different. This does not prevent the calculation of a consensus value with a consensus uncertainty. But each lab has its own doubt, though it is based on objective data and methods to evaluate it. The idea of removing all subjectivity from a measurement remains an illusion. However, he clarified that the wording of ‘subjective’ state of mind is only in the presentation, not in the definition itself.

Dr Rourke asked about the future steps in the process. Currently, the VIM4 has been advanced as a draft with the traditional definition. Is the intention of these presentations and discussion that those CCT members who are convinced of the new definition should return to their NMIs and lobby to get that new definition inserted into VIM4? Or are the discussions instead intended to feed into VIM5? The BIPM Director replied that the latter option is preferred, because the work done on nominal properties needs to be published. However, if the community has a strong position on the go/no go of the measurement uncertainty definition, they are open to reconsider it.

Dr Merlone, with reference to the difficulties experienced with the meteorological and climatological communities when delivering the concept of uncertainty to them, suggested that the speakers prepare presentations tuned to a target audience that is broader than just members of the CCs.

The CCT President thanked Dr Bich and Dr Ehrlich for their interesting presentations. Drs. Bich and Ehrlich expressed that they are open to further discussions by e-mail.

15. Report on the activities of the STG-CENV

The CCT President reported on the 1st CIPM-STG-CENV stakeholder meeting, held on 16-18 September 2024 at the BIPM headquarters. Some figures of the meeting: 400 registered participants, 23 co-chairs, 14 sessions, 70 speakers and 81 posters. The President noted that the preparatory work, review and summary of presentations and posters made by the co-chairs was essential. The President explained that the structure of the meeting was identical to the previous workshop (held in 2022), with two main themes: the physical science basis for climate change and observation of greenhouse gas (GHG) emissions, each one subdivided into several main topics. The discussions on physical science generated many recommendations, while those on GHG emissions only a few.

The CCT President said that the conclusions and proposals from the meeting were that future STG-CENV stakeholder meetings should focus on: the number of CIPM CC Groups related to environment in operation, and their inputs; the number of regional/national/international organization groups related to environment with a demonstrable NMI Metrology input and their outputs; proposals to integrate new activities within the CCs or other CIPM structures; and case studies of impact on environmental issues through improved metrology.

The CCT President remarked that a small coordinating core group was the best structure to enable the TG to achieve its goals. The President mentioned that membership of the STG-CENV has been updated, drawing its members from three distinct groups: the metrology community (CCs and RMOs with active programmes in the area), international organizations with measurement programmes within the scope of the TG, and experts with competencies in the fields covered by the TG. The President reported that the activities foreseen for the period 2023-2027 are: reviewing recommendations from the BIPM-WMO 2022 workshop on Metrology for Climate Action and communicating those that can be addressed within existing BIPM/RMOs/WMO structures or considering whether they need the organization of new groups; organizing periodic meetings with stakeholders (next one in 2027) to report back on progress and identify new high priority activities to be addressed; encouraging technical meetings focused on environmental metrology challenges; liaising with the WMO Secretariat to coordinate communication and identification of experts to contribute to each other’s committees and to support new initiatives; and identifying other International Organizations with active Climate and Environment programmes that have requirements for metrology services, then developing liaisons with these organizations to promote access to such services and gather requirements for new initiatives.

16. SASO-NMCC presentation, Dr Nasser al Qahtani

Dr al Qahtani presented the thermometry activities at SASO-NMCC, in support of the request for SASO-NMCC to become a member of the CCT.

Dr al Qahtani noted that Saudi Arabia became a Member State and signed the CIPM MRA in 2011. In 2023, SASO appointed KACST as DI for ionizing radiation. The score of Saudi Arabia in the QI4SD (Quality Infrastructure readiness to support Sustainable Development goals) Index is 64.2, placing the country at the 20th position. SASO-NMCC has four major technical measurement departments: Physical, Electrical and Time, Chemical and Mechanical. The Physical Department has 12 specialized laboratories, including Temperature, Thermal Radiation and Humidity. Temperature, Thermal Radiation and Humidity have in total 12 staff (one PhD, one MSc, and eleven BSc). Dr al Qahtani mentioned the SASO-NMCC research programme and peer reviewed publications in international journals, with the work of Temperature, Thermal Radiation and Humidity focusing on advancing primary thermometry and radiation and humidity standards. He said that SASO has established a high level of competence through successful participation in international comparisons organized by the BIPM, the CCT and the RMOs.

Dr al Qahtani explained that the core infrastructure comprises a suite of fixed-point cells from Ar to Ag, primary humidity generators based on two-pressure-two-temperature generators, SPRTs (CSPRTs, LSPRTs, HTSPRTs), thermostat mediums, standard resistors in oil baths, high-stability blackbody sources, and chilled mirror hygrometers. Environmental conditions of the facilities are controlled to 0.1 °C and low-noise shielding is present in the labs.

Dr al Qahtani mentioned that 16 calibration services are already accredited by the national accreditation body (SAC), including contact thermometry, non-contact thermometry, and humidity services. He listed all the comparisons (completed and planned) in which SASO-NMCC is a participant and all published CMCs (11 CMCs). He said that SASO-NMCC participated in many international conferences (TEMPMEKO2025, CAFMET2024, and others) and published eleven papers in different journals (including *Metrologia* and *Measurement Sensors*).

Dr al Qahtani explained that SASO-NMCC has developed its capabilities and competencies through the exchange of expertise with advanced NMIs such as TUBITAK-UME, NMIJ, LNE-CETIAT and KRISS, and that they have provided training services to both private and public sectors within the domestic region, including countries such as Kuwait, Iraq, Sudan, Oman and Bahrain.

Lastly, Dr al Qahtani described the involvement of SASO-NMCC in a number of strategic projects, such as revising the 3rd version of the calibration and measurement national law; raising awareness in the field of measurement and calibration; enhancing NMCC's capabilities and services; strengthening cooperation and integration with partners; and the digital transformation of metrology.

Dr Peruzzi asked how many Al and Ag cells are operated by SASO-NMCC, since they requested to participate in the new CCT-K4. Dr al Qahtani replied that they have three cells of each.

Dr Yoon asked Dr al Qahtani what specific objectives SASO-NMCC has in becoming a full member of the CCT, as opposed to being an observer. Dr al Qahtani replied that SASO-NMCC will take part in the CCT activities irrespective of its status as observer or full member.

The CCT President proposed that all members should send their comments about SASO's request by email before the end of the following week. After that, the WG-SP will discuss the proposal and submit a recommendation to the CIPM, that will take the decision.

17. Outcome of TEMPMEKO ISHM 2025 Symposium

Dr Mohamed Sadli presented the key statistics of the recent TEMPMEKO ISHM 2025 Symposium, which was held in Reims (France) on 20-24 October 2025. The Symposium was organized by Cnam with support from LNE and CETIAT. The chairs of the International Programme Committee were Dr Xiaojuan Feng and Prof. Vito Fernicola. There were 392 registered attendees (301 older than 35, 81 younger than 35) and 24 exhibition booths. The most represented country was France (60 participants), followed by Germany (48), China (39), and the UK (38). Dr Sadli said that the audience enjoyed the very interesting and diverse plenary lectures and the opening session held by Dr Martin Milton. A total of 360 presentations were given, and 85 papers have been submitted for publication in the proceedings of the conference. Dr Sadli thanked the sponsor and announced the next TEMPMEKO ISHM, which will be organized by E+E (Austria) and will take place in Salzburg (Austria) on 23-27 October 2028.

18. Approval of open access documentation

The CCT President asked and received permission from all presenters to upload their presentations in the open access area of the BIPM website and reminded the six NMIs that have not submitted their reports to do so by the end of the following week.

19. Next CCT Meeting

The CCT President informed that, during the WG-SP meeting, the date of the next CCT meeting was discussed. Having considered the amount of work, the time required to complete it, and the fact that the TEMPMEKO 2028 Symposium will offer the possibility for interim WG meetings, the WG-SP proposes to have the next CCT meeting in May 2029. The CCT plenary approved this proposal, so the next CCT meeting will take place in May 2029.

20. Closure of the 32nd meeting of the CCT

The CCT President thanked all participants and officially closed the 32nd meeting of the CCT.

21. Decisions and actions arising from the 32nd meeting of the CCT

21.1. Decisions

The following decisions were taken unanimously:

CCT32/D1: Approval of creation of new Task Group on Distributed Thermal Measurement Systems under CCT-WG-Dig.

CCT32/D2: Approval of recommendation T 1 (2026) to the CIPM: "Criteria for the establishment of a new International Temperature Scale."

CCT32/D3: Approval of creation of new TG on "The feasibility of using non-contact thermometry to measure $T - T_{90}$ between Sn and Ag point with < 10 ppm" under CCT-WG-NCTh.

CCT32/D4: Approval of the recommendation from CCT-WG-Hu to the CCT endorsing the use of %rh as unit symbol for relative humidity.

CCT32/D5: Approval of the election of Dr Bruno Hay as new Chair of CCT-WG-ThQ.

CCT32/D6: Approval of the updated CCT 2025-2030+ Strategy document.

CCT32/D7: New CCT-K9 key comparison to be launched at the next CCT meeting (May 2029), with KRISS as pilot.

CCT32/D8: Participants of the new CCT-K4 key comparison to be all of the proposed CCT members (LNE-Cnam still to be confirmed) plus SASO (Saudi Arabia).

21.2. Actions

CCT32/A1: Prof. Bojkovski (WG-CMC Chair) and Dr Andrea Peruzzi (WG-KC Chair) to prepare a document on CCT policy concerning the validity of KCs in supporting CMCs, expiration and greying-out of CMCs.

CCT32/A2: All CCT members to send comments on the draft "Guide to the Analysis of CCT Key Comparisons" (document CCT/2026-04) within the two weeks following the CCT meeting. Dr Peruzzi to prepare a revised version of the document by September 2026. The document will finally be circulated by email for CCT approval.

CCT32/A3: Dr del Campo to formalize the establishment of a new TG on Distributed Thermal Measurement System within the WG-Dig.

CCT32/A4: Dr del Campo to submit to CIPM the recommendation T 1 (2026) "Criteria for the establishment of a new International Temperature Scale."

CCT32/A5: Dr del Campo to formalize the establishment of a new TG on "The feasibility of using non-contact thermometry to measure $T - T_{90}$ between Sn and Ag point with < 10 ppm" within the WG-NCTh.

CCT32/A6: CCT to recommend the use of %rh as unit symbol for relative humidity.

CCT32/A7: Dr Yang (KRISS) to the develop the technical protocol for the new CCT-K9 key comparison by the time of the next CCT meeting (May 2029).

CCT32/A8: Dr Buenger (PTB) to develop the technical protocol for the new CCT-K4 key comparison by the end of 2026.

CCT32/A9: EURAMET TC-T chair to confirm whether or not LNE-Cnam will participate in the new CCT-K4 key comparison.

CCT32/A10: Dr del Campo to continue the discussion within WG-SP about the admission of SASO (Saudi Arabia) as a member.

RECOMMENDATIONS OF THE CONSULTATIVE COMMITTEE FOR THERMOMETRY SUBMITTED TO THE INTERNATIONAL COMMITTEE FOR WEIGHTS AND MEASURES

RECOMMENDATION T 1 (2026):
Criteria for the establishment of a new International Temperature Scale

The Consultative Committee for Thermometry (CCT), at its 32nd meeting in 2026,

recalling

- the CCT Declaration on the 27th meeting in 2014 "Requirement for new determinations of thermodynamic temperature",
- the CCT Recommendation (T1, 2017) to the CIPM "on the new definition of the kelvin" where it stated "that Member State NMIs take full advantage of the opportunities for the realization and dissemination of thermodynamic temperature afforded by the kelvin redefinition and the *mise en pratique* for the definition of the kelvin",
- the CCT Recommendation (T1, 2021) to the CIPM "Requirement for new determinations of thermodynamic temperature above 400 K",

welcoming

- the Resolution 1 (2018) of the CGPM "On the revision of the International System of Units (SI)", which linked the unit of temperature to the Boltzmann constant,

considering

- the discussions held at the 30th, and 31st meetings of the CCT in 2022 and 2024; and meetings at the CCT-WG-CTh,
- that experimental progress has allowed the development of a *mise en pratique* for the realization of the kelvin (*MeP*-K), which has been extended to cover direct measurement of thermodynamic temperature, T, after the redefinition of the kelvin (in part putting into practice CCT recommendation T1 2017),

noting that

- in the last years, primary thermometry by acoustic gas thermometry, dielectric-constant gas thermometry, and refractive-index gas thermometry have yielded low uncertainty thermodynamic-temperature data and so improved considerably the knowledge of T-T_{90} below 400 K (T_{90} is the temperature according to the International Temperature Scale of 1990, ITS-90),
- above 1300 K the use of High Temperature Fixed Points (HTFPs), with designated thermodynamic temperatures, given in an *MeP*-K annex, have facilitated realization, and offer the possibility for, disseminating thermodynamic temperature with low uncertainties without recourse to a defined scale,
- above 400 K, there is still a dearth of accurate measurements of T, which are urgently required to facilitate implementation of the *MeP*-K by thermodynamic thermometry and to evaluate T-T_{90} in this important temperature region for a wide range of stakeholders,

recommends

- that CIPM ensures that there are new low-uncertainty evaluations of thermodynamic temperature above 400 K to bring T and any future T_{ITS} closer together fulfilling requirements concerning uncertainty, namely
    - the thermodynamic data should not be uncertain by more than a factor of two of the total uncertainty of the realization of the ITS-90 up to the freezing point of silver and
    - ensuring the reliability of primary thermometry (*i.e.* the data be based on at least two fundamentally different primary thermometry methods within the *MeP*-K, where at least one result for each should have a standard uncertainty not more than a factor of three of the total uncertainty of the realization of the ITS-90),
- that CIPM consult with key stakeholders so that a proper consideration of the cost of the introduction, implementation, and requirements of a new ITS be evaluated (*i.e.* a cost-benefit analysis be performed),
- that member state NMIs and DIs stimulate research

    - to solve the PLTS-2000 problem below 8 mK so that it could be considered for incorporation into a possible future ITS,
    - to improve the operating performance of high-temperature platinum resistance thermometers (where possible working with manufacturers) and
    - to demonstrate one or more viable alternatives to the triple point of mercury for the calibration of both capsule and long-stem platinum resistance thermometers,
- that, after the above items have been achieved, CCT perform a survey checking if primary thermometry is still only possible in very few NMIs and, therefore, not a practical way of realizing and disseminating thermodynamic temperature (which would justify a possible new ITS).

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