

Bureau International des Poids et Mesures

Consultative Committee for Units (CCU)

Report of the 26th meeting
(9-10 April 2024)

to the International Committee for Weights and Measures



Comité international des poids et mesures

LIST OF MEMBERS OF THE CONSULTATIVE COMMITTEE FOR UNITS

as of 9 April 2024

Chair of the 26th meeting of the CCU

Prof. R. J. C. Brown, National Physical Laboratory [NPL]

Executive Secretary

Dr M. Stock, International Bureau of Weights and Measures [BIPM]

Members

Centro Español de Metrología [CEM], Madrid

Federal Agency on Technical Regulating and Metrology [Rosstandart], Moscow

Federal Institute of Metrology METAS [METAS], Bern-Wabern

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

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

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 Metrology Institute of Japan, AIST [NMIJ/AIST], Tsukuba

National Physical Laboratory [NPL], Teddington

National Research Council of Canada [NRC], Ottawa

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

Physikalisch-Technische Bundesanstalt [PTB], Braunschweig

Prof. M. Himbert, personal member

Dr T.J. Quinn CBE FRS, personal member

The Director of the International Bureau of Weights and Measures [BIPM], *ex officio* member

Liaisons

Committee on Data for Science and Technology [CODATA Task Group on Fundamental Constants]

International Astronomical Union [IAU]

International Commission on Illumination [CIE]

International Commission on Radiation Units and Measurements [ICRU]

International Electrotechnical Commission [IEC]

International Federation of Clinical Chemistry and Laboratory Medicine [IFCC]

International Mathematical Union [IMU]

International Organization for Standardization [ISO]

International Organization of Legal Metrology [OIML]

International Union of Pure and Applied Chemistry [IUPAC]

International Union of Pure and Applied Physics [IUPAP]

1. **OPENING OF THE MEETING; APPOINTMENT OF THE RAPPORTEUR; APPROVAL OF THE AGENDA**

The twenty-sixth meeting of the Consultative Committee for Units (CCU) was held at the International Bureau of Weights and Measures (BIPM) headquarters, at Sèvres, and online, from 9 to 10 April 2024.

The following attended (* indicates online participation):

Members: A. Balsamo (INRIM), S. Bize (LNE-SYRTE), P. Blattner (METAS), M. Brown (NRC), R.J.C. Brown (NPL, Chair of the 26th meeting of the CCU), R. Caballero Santos (CEM)*, M. Chambon (LNE), D. del Campo Maldonado (CEM, CIPM, CCT President)*, F. Fang (NIM)*, D. Flater (NIST)*, K. Hosaka (NMIJ/AIST), E. Korzinin (VNIIM), I.D. Leroux (NRC)*, A. Lewis (NPL), H. Margolis (NPL)*, E. Massa (INRIM), J. Meija (NRC, IUPAC), M.J.T. Milton (BIPM Director), P. Mohr (NIST), A. Oldershaw (NRC)*, W. Phillips (NIST)*, J. Qu (NIM, CIPM)*, K. Shirono (NMIJ/AIST)*, V. Skliarov (NSC IM)*, M. Thomas (LNE), S. Ulbricht (PTB), I. Yang (KRISS), M. Yasuda (NMIJ/AIST)*, D.-H. Yu (KRISS), J. Zhang (NIM)*.

Liaisons: N. Capitaine (IAU), T. Carlsson (ISO)*, H. Holden (IMU)*, D.-H. Lee (CIE)*, D. Newell (CODATA-TGFC), K. Pachucki (CODATA-TGFC), P. Sebellin (IEC), E. Shirley (IUPAP), A. Sperling (CIE).

Personal members: M. Himbert (LNE-LCM/Cnam)*, T.J. Quinn (BIPM Emeritus Director).

CIPM members and Consultative Committees Presidents: V.G. Achanta*, N. Dimarcq (CCTF President), G. Macdonald (CCM President)*, J. Olthoff*, M.L. Rastello (CCPR President)*.

Representatives from Member States invited to attend as Observer: R. Alyousefi (SASO-NMCC).

Invited guests: C.D. Ehrlich (JCGM-WG2 Convener)*, S. Karshenboim (LMU, MPQ), L. Mari (IEC), C. Salomon (LKB, Académie des Sciences)*, J. Ullrich (CCU Former President).

Also present from the BIPM: V. Gressier (CCRI Executive Secretary), J. Miles (Digital Transformation), G. Panfilo (FORUM-MD, CCAUV and CCL Executive Secretary), M. Stock (CCU and CCEM Executive Secretary), P. Tavella (CCTF Executive Secretary), F. Meynadier (SI Reference Point).

The meeting was opened at 14:00 on 9th April 2024.

R. Brown began the 26th meeting of the CCU by explaining why he was chairing the meeting. At Session III of the 112th meeting of the CIPM (October 2023), J. Ullrich confirmed that he was resigning from the CIPM and would step down as CCU President at Session I of the 113th meeting of the CIPM in March 2024. The CIPM agreed that R. Brown would be invited to chair the next CCU meeting in April 2024. R. Brown thanked J. Ullrich for his prior service as CCU President over the last 11 years on behalf of the CCU and noted J. Ullrich's many important contributions to the CCU over the years, including steering the CCU through the significant revision of the SI in 2019.

Pertaining to the CCU President, R. Brown noted that the CIPM decided in March 2024 to invite expressions of interest for the position of President of the CCU with the aim to elect a new President by June 2024. The CIPM also confirmed that R. Brown would oversee the implementation of any actions from the 26th meeting of the CCU with the help of the CCU Executive Secretary, M. Stock.

The CCU Terms of Reference were briefly reviewed to set the context and the framework for the meeting. These are:

- The development and improvement of the International System of Units (SI)
- The preparation of successive editions of the SI Brochure and supporting documents, and

- any other summaries relevant for metrology institutes, industry, academia and schools, etc
- Providing advice to the CIPM about units of measurement in general, overall consistency and harmonization
- Providing information and advice on units and their use to a wide range of stakeholders

R. Brown continued by presenting some important statements he had received regarding the impact of the CCU and its decisions on the broader metrology community and how the CCU must always think carefully before making changes to the SI that would have far reaching effects. R. Brown noted that the stakeholder base for the SI is ever growing. In particular this was exemplified by the NASA Artemis project, supported by UNESCO, that aimed to deposit a long-term stable capsule on the lunar surface, including information about humanity, and the plan was to include the SI logo amongst this information.

R. Brown celebrated the fact that the CCU is now 60 years old, having been established in 1964, to replace the “Commission for the System of Units”, set up by the CIPM in 1954. The 26th meeting of the CCU was its first hybrid meeting.

R. Brown presented the agenda [CCU/2024-01]. The agenda was accepted without any comment.

R. Brown remembered those colleagues who had died since the last meeting and whose contributions to the CCU were significant: Prof. Christian Bordé (President of CGPM 1999 – 2011), Prof. Pavel Neyezhnikov (CIPM member 2018 – 2023), and Prof. Ian Mills (CCU President 1995 – 2013). A moment of silence was observed in their honour.

R. Brown proposed to the CCU that M. Brown (NRC) should be the Rapporteur for the meeting. This was unanimously agreed.

There were 23 on-line participants, and 35 in-person at the first day of the meeting. Everyone introduced themselves, starting with in-person participants.

2. NEWS FROM THE CIPM AND THE BIPM

J. Ullrich presented the news from the CIPM. The following Decisions were highlighted as being either directly or indirectly relevant to the CCU:

- CIPM/110-20: The CIPM received the report from the CCU on the Core Metrological Terms and noted that consensus could not be reached on the matter of three definitions (quantity, quantity value and unit). The CIPM requests the CIPM Task Group on the Digital SI (CIPM TG DSI) to review the “machine actionability” of the three definitions under discussion and to report to the meeting of the CIPM in March 2022.
- CIPM/110-21: The CIPM accepted membership of CCU for NSC-IM (Ukraine).
- CIPM/112-36: The CIPM noted that the President of the Consultative Committee for Units (CCU) will step down at Session I of the 113th meeting of the CIPM in March 2024. The CIPM expressed its appreciation for the work carried out by J. Ullrich as CCU President. The CIPM decided to defer the election of the CCU President to its meeting in March 2024. R. Brown (NPL) will be invited to chair the next CCU meeting in April 2024.
- CIPM/113-05: The CIPM appointed C. Denz as the Chair of the Forum on Metrology and Digitalization, confirmed G. Macdonald as the Vice-chair and appointed H. Laiz as a second Vice-chair.
- CIPM/113-06: The CIPM appointed H.A. Frøystein as the BIPM representative to the Joint Committee for Guides in Metrology (JCGM).
- CIPM/113-07: The CIPM appointed V.G. Achanta as the BIPM representative to CODATA.
- CIPM/113-09: The CIPM decided to invite expressions of interest for the Presidency of the Consultative Committee for Units (CCU) with the aim to elect a new President by June 2024, and confirmed that R. Brown (NPL) will oversee the implementation of the actions from the April 2024 meeting.

It was also noted that three new members have been elected to the CIPM: C. Denz (Germany), Q. Jifeng (China), and H.A. Frøystein (Norway).

The following Resolutions of the 27th CGPM (2022) were noted as being directly or indirectly relevant to the CCU:

- Resolution 1, On the report prepared by the International Committee for Weights and Measures on the “Evolving Needs In Metrology”.
- Resolution 2, On the global digital transformation and the International System of Units.
- Resolution 3, On the extension of the range of SI prefixes.
- Resolution 4, On the use and future development of UTC.
- Resolution 5, On the future redefinition of the second.

It was noted that the topics relating to these resolutions would be discussed later in the agenda. There were no questions on the report from the CIPM.

M. Milton gave an update from the BIPM. The presentation began by summarizing the state of the organization. There are 64 Member States and 36 Associates of the CGPM. Currently 251 institutes participate in the CIPM MRA. M. Milton went on to present two news items.

The first, in large part due to the work of P. Tavella, was the agreement with the ITU at the WRC-2023 (World Radiocommunication Conference, Dubai) to move to a continuous UTC. The CGPM at its 27th meeting (2022) decided that the maximum value for the difference UT1-UTC (UT1, mean solar time) will be increased above the present value (nominally one second) in or before 2035. The challenge for the BIPM was to get the community to agree to acknowledge the decision of the CGPM. The BIPM worked closely with the ITU, being involved in their publications and meetings. P. Tavella worked closely with key players in industry, technology companies, and in telecommunications, and was able to marshal support at the WRC to approve the following resolution (Resolution 655 (REV.WRC-23)): (a) that the ITU is responsible for setting standards for the content and structure of time signals to be disseminated via radiocommunication signals, but, (b) that the BIPM is responsible for establishing and maintaining the second of the SI and the reference time scale UTC with the SI second as its scale unit. Most importantly it resolved that ITU cooperate further with BIPM, CIPM and CGPM in response to the consultation in order to define a new maximum value for the difference between UT1 and UTC and to agree the implementation date for continuous UTC.

The second, were the plans of the BIPM to celebrate the 150th anniversary of the signing of the Metre Convention, which took place on 20 May 1875. A dedicated website will be made available with full details of the planned activities, <https://www.bipm.org/en/committees/ot/bipm-ws/wg/150th-anniversary-metre-convention/2025-05-19>. The presentation continued by mentioning another ongoing project of the BIPM to develop a vision from young metrologists for what metrology might be like in 2050 and beyond, the Young Metrologists’ 2050+ vision. This project is designed to complement the CIPM Strategy 2030+ with visionary ideas in collaboration with young metrologists from the Regional Metrology Organizations (RMOs). The presentation concluded by mentioning that 20 May 2024 is the first World Metrology Day celebrated under the auspices of UNESCO. An event will take place at the UNESCO headquarters in celebration.

W. Phillips (online) asked M. Milton to elaborate on the transition to continuous UTC. In particular, was it decided that in 2035 we will no longer have leap seconds, and if so, what would be the recommended new value and how much difference would be allowed. W. Phillips continued by noting the projections for the possible negative leap second and how this may be affected because of accelerated global warming and melting of the polar ice caps. Do these latest projections mean that we will not need one before we stop having leap seconds in 2035? M. Milton replied by noting that W. Phillips had correctly identified two parameters that are the subject of ongoing discussions, the date for the new system (for which the BIPM is strongly arguing that it should not be after 2035), and the range of tolerance. M. Milton asked that P. Tavella comment on these questions. P. Tavella (in her capacity as Consultative Committee for Time and Frequency (CCTF) Executive Secretary) noted

that the CCTF has formed a task group that is working toward a draft resolution for the 28th meeting of the CGPM (2026) and that this task group needs to decide what the new tolerance (currently one second) should be: perhaps one minute, one hour, or no limit at all. P. Tavella went on to communicate that the task group will also need to decide how often this decision must be revisited by the CGPM. P. Tavella noted, in relation to W. Phillips' question, that there is a risk associated with a negative leap second because the rotation of the earth was speeding up such that in future one second may have to be removed from atomic time and this would be unprecedented. Unfortunately, however, the models and the predictions on the earth's rotation are not accurate enough at the moment to be able to say if, and when, a negative leap second will be necessary. It could be that the effects of climate change, such as the melting polar ice caps, may further delay this negative leap second. P. Tavella concluded by noting that 2035 is a compromise date that has been agreed to by taking into account the timescale for updates to the technological systems involved.

3. CCU PRESIDENT'S REPORT

R. Brown presented an update on the CCU starting with a presentation of the CCU composition: thirteen Member Organizations, eleven Liaison Organizations, two Personal Members and one Ex-Officio Member. The CCU has received an application for membership from SASO-NMCC (Saudi Arabia) that would be considered in Agenda Item 14. The Decisions from the 25th meeting of the CCU were presented and the Actions from the 25th meeting of the CCU were noted as all being complete. Important resolutions from the 27th CGPM Meeting were again noted. The presentation concluded by briefly showing when the Working Groups (WGs), Task Groups (TGs) and Focus Groups (FGs) of the CCU had met over the last four years and noted some of their achievements and outputs, which would be presented in more detail later in the meeting.

There were no questions for R. Brown on the report.

4. COMMENTS ON THE REPORTS FROM THE CONSULTATIVE COMMITTEES AND CROSS-SECTIONAL ACTIVITIES

R. Brown communicated that within Agenda Item 4 there would be three presentations, one on the redefinition of the second, one on the consensus value of the kilogram, and finally a report on the Forum on Metrology and Digitalization.

4.1 REPORT ON THE STATUS OF THE PLANNED REDEFINITION OF THE SECOND

N. Dimarcq (CCTF President) presented the report from the CCTF on the status of the planned redefinition of the second. The presentation began by acknowledging P. Tavella and the BIPM Time department staff for the very high quality of the support they bring to CCTF activities. He continued by reminding the CCU of CGPM Resolution 5 (2022) – *On the Future Redefinition of the Second*. This resolution encouraged the CIPM to bring a proposal to the 28th meeting of the CGPM (2026) for the choice of preferred species with the base line that a new definition be adopted by the CGPM in 2030. In order to prepare this proposal, the CCTF requires consensus be established for: (1) which definition option is preferred (which individual transition, or set of transitions should be used), and (2) a clear, achievable and verifiable roadmap to satisfy the minimum mandatory criteria by 2029. Following the CGPM meeting in 2022, the CCTF re-organized the Task Force for the Redefinition of the Second into three subgroups that have broad membership to ensure all points of view are represented. These were:

- Subgroup 1, Redefinition options: dedicated to the analysis and comparison of the different redefinition options and possibilities;
- Subgroup 2, Criteria: a subgroup ensuring that the mandatory criteria established by CCTF are realized. Subgroup 2 is a cross-cutting subgroup as it will involve representatives of the

different CCTF working groups on frequency standards, on time and frequency transfer techniques, and on atomic time keeping skills;

- Subgroup 3, Education and Communication: a subgroup dedicated to ensuring the community is kept abreast of the CCTF's progress before, during and after redefinition.

The next significant meeting of the CCTF will be in 2025. If the CCTF is not ready at this point, a decision to postpone the redefinition beyond 2030 would likely be made. The schedule of the CCTF Task Force is such that the next meetings will occur virtually in November 2024, followed by an in-person meeting at the BIPM headquarters in September 2025.

The CCTF is not only concerned with the redefinition of the second but is also working on continuous UTC and leap seconds (both discussed earlier in the meeting), the traceability of GNSS signals to UTC, and on sharing of resources to improve national and international time keeping. While important, these topics were not covered in detail in this presentation.

The CCTF's overall action plan to be ready for the 2026 CGPM meeting was presented. Within this action plan an ensemble of documents have been prepared by the task force and by the different subgroups that present the possible redefinition options, the status of the redefinition candidates, the extent of fulfilment of the mandatory criteria and finally the progress with respect to educational activities. These documents are currently restricted to the CCTF community. In parallel selected documents are freely available on the BIPM website, and a public web page.

The presentation continued by showing the three options for the redefinition of the second under consideration by the CCTF. Option 1: one transition. Option 2: an ensemble of transitions. Option 3: fixing the value of a fundamental constant (mentioned only for reference as there is consensus that Option 3 is currently not viable). For each of the possible species and transitions, Subgroup 1 has prepared factsheets that contain the best reported uncertainties. These factsheets are being used to determine the level of maturity of the different species, transitions, and realizations as it relates to the established criteria to contribute to the redefinition of the second.

The presentation concluded by showing the mandatory criteria required to proceed with redefinition of the second. These include elements that concern frequency standards and contribution to atomic time scales, time and frequency comparison and dissemination techniques, and an important point related to the acceptability of the new definition. For example, if Option 1 above is selected for a specific atomic species, the CCTF acknowledges that a laboratory developing another species will not have a primary realization experiment (although this is not different to the current situation). If these mandatory criteria are fulfilled the CCTF is confident that the new definition will provide a lower uncertainty realization than is currently in place. Option 2 suffers from different issues as it would be very dissimilar to the current definition of the other SI base units and it remains unclear if realization would require all of the specified transitions, or only a subset of these.

R. Brown thanked N. Dimarcq for the presentation and asked what the limiting factor is in terms of bringing a proposal to the CGPM. Is it the ability to decide between the CCTF's various options, or is it the ability to meet the CCTF mandatory criteria? R. Brown noted that Option 1 is a special case of Option 2. N. Dimarcq replied that it is almost certain that the CCTF will present to the CGPM Option 1 with one, two or three candidates, and Option 2 with a preliminary ensemble of preferred species, noting that there is currently not consensus within the CCTF. The problem with Option 2 is that not everybody fully understands it. That is why the education part of the task force is so important. The personal opinion of N. Dimarcq is that, at present, the scientific community is not ready for Option 2 because it is too disruptive. It could be that Option 2 is a better long-term option. A problem with Option 1 is that there is no consensus on the species to be chosen, and that is why Option 2 may be better because it is not limited to a single transition. As of now the CCTF is not ready for Option 2, but it is perhaps the best long-term option.

W. Phillips complimented N. Dimarcq for the excellent and clear presentation and noted the concern with Option 1 for laboratories working on a particular species that, if this species is not chosen, they will not be part of the primary definition of the second. W. Phillips did not think this should be a major issue as there has been significant activity on rubidium over the years despite caesium being

defined as the reference for the SI second since 1967. W. Phillips went on to note his concerns related to how hard it will be to educate the community on Option 2 and that if we thought it was difficult to explain to people how you get a kilogram by fixing the numerical value of the Planck constant, just imagine how hard it is going to be to explain Option 2. W. Phillips continued that the general relativistic effect is such that, depending upon your altitude above sea level, there is a frequency change of about one part in 10^{16} per metre. With the new definition, we have atomic species that are accurate to a part in 10^{18} (corresponding to 1 cm) and laboratories have already demonstrated precision of better than a part in 10^{19} (corresponding to 1 mm). Given that the mass of the earth is constantly redistributing because of global climate change how will the *mise en pratique* address this? N. Dimarcq responded by acknowledging the importance of this question and explained that it is being considered within the mandatory criteria for redefinition established by the CCTF (section II.2, Knowledge of the Local Geopotential at the Proper Level). At present the CCTF views this issue as being under control, with a fulfilment level of 70 % - 90 %.

J. Ullrich thanked N. Dimarcq for his report, for the progress that has been made at the CCTF, and asked the speaker to comment on the status of comparisons between optical clocks. N. Dimarcq replied that this is being considered within the mandatory criteria for redefinition established by the CCTF (section I.2, Validation of OFS (optical frequency standards) Accuracy Budgets – Frequency Ratios ($< 5 \times 10^{-18}$)). Transportable optical clocks are being developed for comparisons between regions where no optical fibre links exist, in particular for intercontinental comparisons.

4.2 REPORT ON THE STATUS OF THE CONSENSUS VALUE OF THE KILOGRAM

M. Stock gave a presentation on the dissemination of the kilogram from the consensus value. Discussions a few years ago suggested that one would no longer require traceability to the international prototype; in principle any NMI would be able to realize the kilogram. Unfortunately, the scientific consensus is not quite ready for this yet. Instead of the international prototype we have an international coordinated dissemination of the kilogram and this will remain until the dispersion between individual kilogram realizations becomes compatible with the realization uncertainties. M. Stock spoke on the calculation of the consensus value and its uncertainty. The uncertainty is chosen as the expected uncertainty from future realization experiments: 20 μg . The second key comparison of kilogram realizations was completed in late 2022 and a second consensus value was implemented on 1 March 2023. The discrepancy between the participants with the smallest uncertainties increased in this second key comparison. As a result of this comparison, an adjustment of $-7 \mu\text{g}$ with respect to mass values traceable to the IPK (or $-5 \mu\text{g}$ with respect to mass values traceable to the first consensus value) needs to be made. The Consultative Committee for Mass and Related Quantities (CCM) issued a note to its members and for calibration customers to inform them of the dissemination of this second consensus value. Calibration certificates should now clearly state that the results are traceable to the 2nd consensus value of the kilogram. The 3rd key comparison (CCM.M-K8.2024) is planned to start in late 2024, and is expected to be repeated every two or three years, piloted by the BIPM. Moving forward the consensus value will be calculated as the arithmetic mean of the key comparison reference values of the last three key comparisons in the form of a moving average. At one point the CCM may conclude that agreement between realization experiments is good enough to allow dissemination from independent realizations. A roadmap to resolve the lack of agreement is being established within the CCM.

R. Brown noted that there were projects planned to address the technical challenges in order to improve the results and this was a very positive development. A brief discussion ensued highlighting the significance of using the results of the three most recent comparisons to calculate the arithmetic mean consensus value.

W. Phillips asked whether there were any issues with making measurements in vacuum and in air. M. Stock replied that the related uncertainty is negligible compared to the uncertainties of the realization experiments. The typical mass change of the travelling standards due to adsorption is typically at the level of 3 μg - 4 μg , while typical realization uncertainties are at least 15 μg - 20 μg .

M. Brown asked if more laboratories will contribute to the consensus value in the future and M. Stock replied that he expects only a few more participants moving forward.

4.3 REPORT FROM THE FORUM ON METROLOGY AND DIGITALIZATION (FORUM-MD)

P. Blattner presented “Report from FORUM-MD to CCU”. Resolution 2 of the 27th CGPM had driven the formation of the FORUM-MD. The mission of the FORUM-MD is:

- to advise the CIPM on the SI digital framework;
- to harmonize internal processes related to digitalization between NMIs, CCs, RMOs, and BIPM headquarters, and;
- to act as a forum to exchange information and to create synergies and opportunities for collaboration in this field.

The first meeting of FORUM-MD was in March 2024. One outcome was the formation of eight task groups and working groups. Several of these groups have direct relevance for CCU activities, including Metrological Semantics, Coordination between CCs, and SI Digital Framework. Another outcome was the plan for two upcoming workshops, on Metrological Traceability and Complex Sensor Networks. The next meeting of the FORUM-MD is planned for February 2025.

L. Mari asked P. Blattner to comment on the concept of metrological semantics. P. Blattner noted the importance of discussing this topic and how language is used to effectively communicate.

R. Brown then asked for any comments related to submitted written reports from other Consultative Committees.

R. Brown noted that the CCT report contains descriptions of two scales for temperature; one associated with thermodynamic temperature and a second with the conventional ITS-90 scale. He thought that care was needed to ensure we do not have two independent scales causing confusion. D. del Campo replied that there was no other possibility at the moment and examples were shared as to why this is presently the case. In the medium- to longer-term it was to be expected that only the thermodynamic temperature scale would be used.

Related to the Consultative Committee for Photometry and Radiometry (CCPR) report, M. Chambon asked if it was provocative to suggest removing the candela as an SI base unit. R. Brown stated that he was not in favour of this proposal. A. Sperling also thought that the candela should remain a base unit because of its great importance in lighting. He added that there is currently no need to make any change to the definition of the candela. New work on cone fundamentals might prompt change in future but currently this work is not sufficiently advanced.

5. COMMENTS ON THE REPORTS FROM OTHER ORGANIZATIONS AND INSTITUTIONS: CIE, CODATA TGFC, IAU, ICRU, IEC, IFCC, IMU, ISO, IUPAC, IUPAP, OIML, ACADEMIE DES SCIENCES

E. Shirley noted that there has not been a lot of activity on IUPAP Commission 2 (C2) on Symbols, Units, Nomenclature, Atomic Masses and Fundamental Constants. The 2022 IUPAP-C2 SUNAMCO Senior Scientist Medal had been awarded to R. Brown for his various contribution to metrology over many years. E. Shirley congratulated R. Brown once again on this great honour.

R. Brown commented that the CIE report used micromoles per second for photon flux, and that he was in favour of this because the photon could justifiably be considered as an elementary entity. A. Sperling commented that in the field of horticultural lighting this special unit is used and has a long history that dates back to the 1960s.

N. Capitaine talked about the importance of the realization of UTC for the IAU because it is related to UT1, which is the time scale related to earth rotation. This was noted in the IAU report.

R. Brown asked D. Newell, representing the CODATA Task Group on Fundamental Constants, about likely new experiments that would contribute to CODATA's considerations. D. Newell replied that new results on the gravitational constant should be ready for the 2026 adjustment. K. Pachucki said that we should expect an updated Rydberg constant value in two to three years. D. Newell added that new spectroscopy measurements of molecules are under way that will contribute to calculations of magnetic moment ratios, so we can expect more magnetic moment data in the future. W. Phillips asked the CODATA team if it is of concern that quantum electrodynamic calculations of the g -factor of the muon disagree with measurements. K. Pachucki replied that the Fermi lab is repeating the measurements.

R. Brown asked P. Sebellin, representing IEC, if the standards that are being targeted for digitization are only future standards, or would existing standards be digitalized. P. Sebellin replied that digitalization is planned only for future standards with 50 projects ongoing using a new tool developed by ISO and IEC. When standards come up for revision, they will also be candidates for digitalization.

6. REPORT FROM THE WG-CMT (CORE METROLOGICAL TERMS)

6.1 RECOMMENDATION TO THE CIPM TO SUPPORT VIM4 CD1 AND/OR CD2

6.2 DISCUSSION AND POSSIBLE FUTURE WORK OF WG-CMT TOWARDS AN AXIOMATIC SYSTEM OF CMTS

J. Ullrich presented the report from the WG-CMT in memory of P. Neyezhnikov. The presentation started with the history of how and why the WG was formed. J. Ullrich explained the previous work of the CIPM TG Digital Framework related to the current WG-CMT. He noted the five levels of digitalization required to achieve machine-controllable content of the Smart Standards (ISO/IEC). Levels 3-5 are considered machine-actionable and relevant for the SI Digital Framework. Subsequently, decision CIPM/108-25 approved the creation of CCU WG-CMT. There were three meetings of the WG: July 2020, November 2020 and June 2021. No consensus on definitions for the terms "unit", "quantity" and "quantity value" were established at that time. A smaller focus group was established within WG-CMT with the idea of working on an axiomatic system for the definitions. They focused on the concepts and the relations between CMTs, instead of what CMTs actually 'are'. The same three CMTs as before were selected to start with. The focus group conclusions were consistent with both VIM4 CD1 and CD2, with a preference for CD1, since the distinction between "general quantity" and "instance of a quantity", introduced in VIM4 CD1, was seen as a useful development. The focus group highlighted as an advantage of their work that the "concepts" and "relations" can be translated into any language and a high precision mathematical language could be created, which could provide high-quality training material for machine learning.

J. Ullrich presented the following draft decisions from the CCU WG-CMT for discussion by the CCU:

- The CCU supports the definitions in VIM4 CD1 and CD2 concerning the terms "quantity", "measurement unit" and "value of a quantity" with a slight preference for the distinction between general and individual quantities (CD1).
- The CCU decides that the Working Group on Core Metrological Terms (WG-CMT) should continue its work as a Task Group (TG-CMT) focusing on how to move forward various aspects of ontology, logical and where possible mathematical descriptions, and machine readability. Detailed Terms of Reference will be drafted by the newly established Task Group.
- The CCU appoints L. Mari as Chair of the TG-CMT.
- The CCU appoints P. Blattner as its representative in the Forum on Metrology and Digitalization (Forum-MD).
- The CCU suggests to the CIPM that S. Ulbricht and R. Brown represent the BIPM in the JCGM WG2 (VIM).

- The CCU strongly supports a proposal in the framework of the EURAMET European Partnership on Metrology (EPM) call 2024 on digitalization related to the work of the Task Group on Core Metrological Terms TG-CMT.
- No recommendation on specific activities of Forum-MD at this stage, to be reviewed after its first meeting.

S. Karshenboim asked if the WG considered ChatGPT, and what ChatGPT uses as a definition of the CMTs. S. Ulbricht responded that the WG has to date only discussed a one parameter (scalar) quantity. All “versions” of quantity should be considered in the new terms of reference of the new Task Group. R. Brown noted that this work is in an early stage and we need to consider all options. J. Ullrich pointed out that we cannot forget the “human readable” part of the question.

M. Milton noted that the wording of the first draft decision is not very clear. What is “a slight preference”? J. Meija worried, as a representative from IUPAC, that CCU support of a document under development might cause problems if in the future the definitions changed. R. Brown commented that it was made clear to the VIM committee by P. Neyezhnikov and subsequently by R. Brown himself that the support from the CCU is for the existing drafts CD1 and CD2, but there might be future drafts which would require re-evaluation. R. Brown noted that the axiomatic system was not in contradiction with the VIM proposals. M. Milton pointed out that the commenting period on CD1 and CD2 is now closed and further J. Meija thought that CCU approving the above decision is premature. It was decided that the first draft decision would remain only an outcome of the WG-CMT, and would not become a decision of the full CCU. W. Phillips proposed that the CIPM and the BIPM have the ultimate responsibility to decide about these things and the CCU has to take the responsibility for the decisions being correct. Considering another example of an axiomatic system, Euclidean geometry, it might be possible to introduce some undefined terms. If relationships are clear maybe not everything has to be clearly defined. L. Mari noted that he has been working on the VIM for the last 15 years and that it is impossible to have everyone fully content with a revised definition. L. Mari noted that it is not even clear which terms the VIM should define. It even might not be possible to find an agreement for the term “quantity”. He considers the work of WG-CMT as a very important contribution because a formalization of the definitions is a way to avoid the ambiguities of national languages. R. Brown added that the JCGM is composed of eight member organizations, of which the BIPM is one, who have to find mutual consensus on the VIM.

C. Ehrlich provided clarification on CD1 and CD2. Around 1500 comments were received on CD1 and many were on the two entries for quantity. Because of this, CD2 contains only a single entry for quantity. He said that a mathematical language for the definition of the concepts would be helpful for the development of VIM4 and he was looking forward to the contributions of R. Brown and S. Ulbricht in JCGM-WG2:VIM. H. Holden said that an axiomatic system will necessarily contain undefined terms and that mathematicians should participate in this work to ensure a logically consistent system. E. Shirley highlighted the difficulties over the years with deciding who should define what. He felt that clarity was needed from the CIPM on the flow of definitions. P. Sebellin acknowledged the work of the WG-CMT and stated that the VIM is a higher level document and when IEC standards are written they need to use the VIM terminologies.

M. Milton commented that each CD was circulated to all NMIs. He clarified that all comments from all NMIs were sent to the JCGM. The CIPM did not review the comments received from NMIs in relation to the CD1 and CD2.

Following a group discussion R. Brown concluded that the first draft decision would be recorded as an outcome of the work of the WG-CMT, but not taken as a CCU decision. The last draft decision would not be needed either because the first meeting of the FORUM-MD had passed. There is an action on the CCU members to volunteer for the relevant FORUM-MD working groups and task groups, in particular those on the SI digital framework and on metrological semantics. M. Himbert commented online that members of the WG-CMT and the FG-CMT should move over automatically to the new Task Group.

With respect to the penultimate draft decision, M. Milton noted that it sits strangely that the BIPM

supports an issue related only to one RMO and in any event the deadline to provide a formal support letter has passed. It was decided within the CCU that support for this European proposal is solely an outcome of the CCU WG-CMT and its focus group, and not the full CCU. P. Blattner noted that it was useful for the CCU members to understand that participation in this proposal is possible even without receiving money from this programme.

E. Massa strongly supported proposals on digitalization from the WGs. He proposed that the WG consider removing the reference to European programmes. The penultimate draft decision of the CCU WG-CMTs was modified and agreed as: the CCU strongly supports project proposals on digitalization and encourages TG-CMT to coordinate its efforts with this work.

The other draft decisions were agreed without change. It is clear from the discussion that this remains a hot topic that needs a lot more work and discussions.

7. REPORT FROM THE TG-ADQSIB (ANGLES AND DIMENSIONLESS QUANTITIES IN THE SI BROCHURE)

7.1 REPORT ON THE WORK OF THE TG-ADQSIB

R. Brown presented the report from the TG-ADQSIB (CCU-2024-00_b). The TG reviewed the 9th edition of the SI brochure and highlighted the parts relevant to angle and dimensionless quantities with the objective to improve the text to aid understanding. The boundary conditions and fundamental considerations of the TG were highlighted. The TG working principles were to consider only the relevant parts of the SI Brochure, to make only the minimum changes required, to improve understanding and reduce confusion, to not propose a solution that is potentially worse than the original problem, and to seek consensus for any proposed changes. All proposed changes from the TG were presented to the CCU and documented in full in meeting paper CCU-24-07.2_b. The most significant changes were in Table 4 and the associated notes to Table 4. Table 6 was updated to have an analogous treatment to Table 4. The TG concluded the following:

- The process has achieved its aim to improve the text about angle and dimensionless quantities in the SI Brochure;
- The TG has not considered the status of angle within the SI (which was not part of the terms of reference);
- The TG proposes that the CCU accept the proposed edits to the SI Brochure and recommend to the CIPM that these are published as v3.01 of the 9th Edition;
- Minor adjustments to the Concise Summary of the SI would be required as a result and;
- The TG proposes to the CCU that the TG can now be disbanded.

W. Phillips started the questions and comments by noting that the presented conclusion is about as good as could be achieved within the terms of reference. With respect to the status of the radian within the SI, he felt further changes are still needed. The current situation leaves an outstanding question of dimension of an angle. R. Brown thanked W. Phillips for his comment and for his continued support of the TG, noting that angle would likely be discussed later in the meeting.

L. Mari commented that both CDs of VIM4 received a lot of feedback on “quantity with unit of one”. He added that the JCGM-WG2 is looking to the SI to provide guidance for the description of this term in the VIM4. S. Karshenboim noted that no member of the education community was involved. He stated that it was his belief that all stakeholders should be involved.

J. Meija noted the benefits of including permille (‰) in the SI Brochure. IUPAC had struggled giving advice on usage because there is no clear guidance in the SI Brochure. It falls in a similar category to percent (%). This needs to be investigated further. E. Massa thought the use of ppm and ppb could be removed in its entirety and explicit units should be used instead. R. Brown replied that advice to use explicit units is already provided the SI Brochure. W. Phillips noted the ambiguity of what billion means in different languages and also the potential for misunderstanding introduced by the use of

ppm or ppb to describe relative uncertainty.

There were no further comments on the suggested changes of the SI Brochure, and the proposals were accepted.

7.2 REPORT ON THE WORK OF THE TG-ADQSIB FOCUS GROUP ON COUNTING AND NUMBER QUANTITIES

R. Brown continued presenting on the work of the TG-ADQSIB Focus Group. A joint CCU/CCQM Workshop on “Quantities which can be counted” was held online on 28-30 March 2023. A report of the workshop is published in *Metrology* **2023**, 3(3), 309-324. The presentations are available on the BIPM website. Terms of reference of the Focus Group were mapped across from the TG-ADQSIB. The relevant points of consensus from the CCU/CCQM Workshop included (a) that counting is a measurement process, whereas number of entities is a measurement quantity, (b) that a count is the result of counting and does not have a direct equivalence to a number of entities, and (c) that there was no consensus on the characteristics of the ‘unit one’. All proposed changes to the SI Brochure were presented. As with the previous presentation the full proposed changes are contained in CCU-24-07.2_b in the CCU list of working documents. The largest proposed change comes from a new paragraph in Section 5.4.7, page 151, that strikes a compromise between recognizing that downstream of the SI there is common use of ‘pseudo-units’ or ‘quantity descriptors’, but being clear that this is not a practice the SI currently allows.

W. Phillips noted that he was not sure there is a clear and obvious difference between entities and counting. R. Brown replied that elementary entities are considered together as amount of substance, whereas counting is a measurement method. R. Brown asked A. Balsamo to give an example on quantity type versus measurement process that he presented at the CCU/CCQM workshop. The example given related to determining the number of balls in a defined volume. This could be done by counting the balls, or alternatively by knowing the weight of one ball and then dividing the weight of the entire set of balls by this value. S. Karshenboim asked if in hydrogen gas, the atoms or the molecules are to be considered as the elementary entities. S. Ulbricht reminded the CCU that in the workshop it was clearly stated that the elementary entity in questions must be identified. M. Milton also noted that ‘amount of substance’ is to do with thermodynamic considerations. A. Balsamo, returning to the example of hydrogen stated that, as elementary entities these could be considered thermodynamically. E. Shirley noted that there were no examples given to specify what a ‘pseudo unit’ or a ‘quantity descriptor’ might be. R. Brown was not in favour of this because we would need to define the specific ‘pseudo unit’. P. Blattner asked what the substance was when talking about photons. R. Brown replied that a photon can be considered as an elementary entity and so it is appropriate to refer to a mole of photons. P. Blatter would communicate this point of view to the CCPR. W. Phillips asked if the idea of elementary entity is related to the fact that they are indistinguishable. M. Milton responded that we never consider thermodynamics with an ensemble of tennis balls and this is why a mole of tennis balls is forbidden.

J. Meija did not think “such quantities [ratios of two quantities of the same kind] are simply numbers”, in section 2.3.3 is helpful. R. Brown noted that unfortunately no consensus could be reached on adding “dimensionally” to the sentence. R. Brown went on to note that subsequent paragraphs within the Brochure (that are not highlighted in this presentation because there were no proposed changes) make it very clear that one should use explicit units whenever possible. E. Massa commented that ‘unit 1’ should be replaced with ‘unit one’, slide 37, which was agreed. W. Phillips noted the fact that several different quantities have the same unit is not unique. For example, newton metre could be the unit for energy or torque, these are very different kinds of physical quantities, and we need to be able to deal with this. E. Shirley added that there is an editorial in *Nature* which points out that the unit of torque should formally be N m/rad.

From this debate the following was decided by the CCU:

- The CCU recommends to the CIPM to publish a new version of the 9th Edition of the SI Brochure (v3.01) incorporating the changes suggested by the CCU Task Group and Focus

Group considering angles, dimensionless quantities, counting and number quantities.

- The CCU decides to disband the TG-ADQSIB and its Focus Group as its work is now complete.

There were no objections to these two decisions. The small additional changes decided during the discussion will be made by M. Stock. CC Presidents and Executive Secretaries will be informed when the new version 3.01 of the SI Brochure has been approved by the CIPM and published.

8. INCLUSION OF NOMINAL PROPERTIES IN THE VIM4

8.1 DISCUSSION ON THE EXTENSION OF THE DEFINITION OF “METROLOGY”

C. Ehrlich gave an online presentation on the extension of the definition of ‘metrology’ (CCU-2024-00_b). The definition of metrology had changed in each version of the VIM (three versions to date) but always contained the word “measurement”. In VIM1 (1984) metrology was defined as “the field of knowledge concerned with measurement”. In VIM2 (1993) the definition was “science of measurement”. In VIM3 (2012) metrology is defined as “science of measurement and its application”. For the proposed VIM4, both 1CD (science of measurement and its application) and 2CD (science of measurement and examination, and their applications) had different proposals for the definition of ‘metrology’. There is a VIM4 3CD proposal that proposes moving the word ‘examination’ to a footnote that is appended to the definition of metrology. The definition in 3CD was likely to be “science of measurement and its application”, while the appended footnote reads, “The science of measurement and its application are understood to include all theoretical and practical aspects of measurement and examination of nominal properties, whatever the measurement uncertainty and examination reliability, and field of application may be”.

L. Mari noted the term nominal property was used for historical reasons, and is not ideal. So-called nominal properties have nothing to do with names. They could better be called classificatory properties. S. Ulbricht noted that there is a logical inconsistency in the 3CD in the note following the definition of metrology which is not in agreement with the definition of measurement. C. Ehrlich agreed that moving examination into a note allows for a simpler definition of metrology, but then requires a note. S. Ulbricht would prefer 1CD as the note leads to confusion. W. Phillips (online) wondered if it is understood that science is both pure and applied, therefore the delineation in the definition is not needed. C. Ehrlich noted that there is no clear consensus on this.

E. Massa noted that as a metrologist, the VIM is the textbook for definitions, but the general public look at definitions in a standard dictionary. He wondered if there could be better alignment between these two sources. C. Ehrlich replied that the VIM presents the viewpoint of the member organizations of the JCGM but that other communities are free to have their own vocabularies.

J. Ullrich supported going back to the VIM3 definition. He did not like the footnote. It does not help and provides a double definition for measurement. He believed measurement should not include subjective quantities, which would be dangerous. L. Mari noted that nominal properties – as considered by the VIM – can be defined in an objective way. The question was posed as to whether a concept such as ‘beauty’ could be considered as a nominal property? L. Mari did not think so. It could be excluded because there is not a scale with elements traceable to references. E. Shirley commented that using footnotes for definitions is not advisable. He favoured the 2CD over the 3CD in order to keep measurement and examination separated. L. Mari suggested that one possibility would be a change in the title of the vocabulary, for example to ‘International Vocabulary of Metrology and the Body of Knowledge related to Examination’.

J. Meija recommended defining metrology as in the VIM2. A separate discussion should be what the definition of measurement is. D. Newell suggested going back to the VIM2 but asked what the VIM2 defines as ‘science’. C. Ehrlich replied that ‘science’ is not defined in the VIM (it is considered as a primitive term). C. Ehrlich stated that the plan was to put out a third committee draft version of the document this year that hopefully might find a broader consensus.

8.2 RECOMMENDATIONS TO THE CIPM

Despite constructive discussion there was no clear consensus formed by the CCU on the preferred definition of ‘metrology’. The conclusion from the meeting was therefore that it was too early for the CCU to make a recommendation to the CIPM on this topic. Nonetheless, R. Brown, L. Mari and S. Ulbricht will take opinions and concerns of the CCU into account when they attend the JCGM WG2.

9. REPORT ON THE SI PREFIX EXTENSION AND PROGRESS UPDATE ON THE NEW BINARY PREFIXES IN IEC 80000-13

R. Brown gave a presentation on the recent SI prefix extension and a progress update on the new binary prefixes in IEC 80000-13 (CCU-2024-00_b). The new SI prefixes are ronna (10^{27}), ronto (10^{-27}), quetta (10^{30}) and quecto (10^{-30}). There was significant media coverage including mainstream media. The BIPM had updated the SI Brochure (to create version v2.01 of the 9th Edition) and the BIPM webpage to include the new SI prefixes. R. Brown concluded his presentation by explaining that IEC 80000-13 needs to be revised in order to document the analogous binary prefixes. This work has been initiated within IEC TC25 JWG2.

A discussion ensued with a couple of examples of legal cases related to the size of storage devices described (for example a dispute over the meaning of 1 GB, with the court eventually deciding that this did mean 10^9 bytes and not 2^{30} bytes). This illustrated the clear difference in meaning between the decimal and binary prefixes.

10. CONSIDERATIONS ABOUT NON-SI UNITS IN THE SI BROCHURE

R. Brown presented considerations about non-SI units in the SI Brochure (CCU-2024-00_b). He proposed that this was an emerging topic that has surfaced over the last few years and an area where more thought might be warranted. In the 9th Edition of the SI Brochure there is only one category of non-SI units accepted for use with the SI. It was proposed that it is important to ask what the criteria are for deciding on the non-SI units that should be part of the SI Brochure. An important stakeholder to consider here is the SI Reference Point, which needs unambiguous usage rules. The CCU also has responsibility for global comparability of measurements in general and a balance is needed between promoting the SI while acknowledging that there are non-SI units that are essential to other international organizations or used in international law. M. Milton noted that the CCU should consider in future the scope of the SI Brochure, and this should include the role of non-SI units, with a description about how the choice is made about which non-SI units to include in the SI Brochure.

11. CONSIDERATIONS ABOUT THE DISTINCTION BETWEEN BASE AND DERIVED UNITS IN THE SI BROCHURE

R. Brown presented considerations about the distinction between base and derived units in the SI Brochure (CCU-2024-00_b). The 9th Edition of the SI Brochure states that there is, in principle, no longer a requirement to distinguish between SI base and SI derived units. Nevertheless, the concept of base and derived units is maintained because it is useful and historically well established. The distinction between base and derived units has existed for over 60 years. R. Brown concluded his presentation by proposing that the CCU creates a Task Group on Key Topics in the SI Brochure (TG-KTSIB) to develop criteria for how the SI Brochure should address this topic, and the treatment of non-SI units, in the future.

A second presentation by P. Blattner explained his observations on the distinction between SI base

units and SI derived units. This presentation was the personal opinion of P. Blattner. He proposed that the distinction has lost some of its justification because both base and derived units can be directly linked to the defining constants. One of his conclusions was that metrology is a much wider subject than consideration of the SI base units alone, and that using this argument to give more weight to the derived units may help NMIs to better demonstrate the impact of their work in metrology.

P. Mohr gave the final presentation in the section on angles and phases in the SI. He argued for a change of the status of angle in the SI from being a dimensionless derived quantity to a dimensioned, independent base quantity. He suggested that the advantage of doing this was, for example, the prevention of 2π errors in equations with angle-dependent quantities. He proposed that adding a dimension for angles would eliminate a long-standing problem with angle units in the SI. He suggested that this should be considered in the 10th edition of the SI Brochure.

S. Karshenboim noted that base quantities have to be defined before base units and they are not related to fundamental constants. Base quantities should be described in the SI Brochure. He also noted that all textbooks would need to be changed if the radian were to be made a base unit. H. Holden made the argument that his scientific paper describing angle is mathematically sound and concluded that angle was a scalar dimensionless quantity. He added that just because there might be an error in a physics textbook is a very weak argument for changing the long-standing convention for angular measurements. Introducing an additional constant in equations related to angles makes no sense. R. Brown moved the discussion along by noting that there are differing and strongly polarized opinions on this topic within the CCU and in his opinion there was no prospect of consensus in the near future.

W. Phillips noted that unit analysis and dimensional analysis are not the same thing. A dimensional analysis does not guarantee that the units will come out correctly. He implored the CCU not to forget the convenience of “traditional base units” even if we do not call them that anymore. D. Newell commented that even experienced metrologists make calculation error by omitting 2π . He also suggested returning to the use of ‘traditional’ in describing the distinction between SI base and SI derived units, which was removed from a draft of the 9th edition of the SI Brochure during the publication process.

M. Himbert commented that in the past the marginal notes in the SI Brochure were considered useful for information which was not normative. P. Blattner thought it useful to distinguish between parts of the SI Brochure which are normative and those which are informative. M. Milton highlighted the need to establish criteria for including marginal notes, remarking that they are very difficult to characterize and reproduce in a digital version, and might show up inconsistently when the document is downloaded. He remarked that prior to the next edition of the SI Brochure a decision should be made on either keeping marginal notes or removing them entirely.

The draft terms of reference of the suggested TG-KTSIB were presented by R. Brown, these were:

- To review the current treatment of non-SI units, and base and derived units, in the 9th Edition of the SI Brochure;
- To review historical perspectives, existing authoritative documentation, and current stakeholder needs relating to these topics;
- To recommend criteria for how the SI Brochure should address these topics in future;
- To provide updates to CCU WG-S and present progress to the next CCU.

The CCU decided to create a new Task Group on the Key Topics in the SI Brochure (TG-KTSIB) chaired by the CCU President, and approved the draft terms of reference.

12. REPORT ON THE SI REFERENCE POINT

F. Meynadier (BIPM) presented the SI Reference Point as a machine-interpretable reference for the International System of Units. A comprehensive description of the six levels of digitalization was

shown. Work began at the BIPM by establishing a route to make the content of the SI brochure machine-readable, machine-interpretable and finally machine-controllable. The SI Reference Point is designed to be the digital counterpart of the SI Brochure. It contains the SI units, SI prefixes, defining constants, selected quantities and decisions concerning the SI. The information is encoded in knowledge graphs and is usable by humans and machines. In the future, the SI Brochure might be developed from the SI reference point. The beta-version is currently available at si-digital-framework.org. An online tour of the SI Reference Point was given. Only things already in the SI Brochure are contained in the SI Reference Point. A lot of effort had been necessary to get to this point.

The decision was made that P. Blattner will serve as the link between the SI Reference Point work and the Working Group on the SI Digital Framework of the FORUM-MD. Questions related to the SI and its interpretation will be relayed back to the CCU WG-S, and if needed, to the full CCU for resolution.

13. CCU STRATEGY FOR THE NEXT TEN YEARS

M. Stock presented the current CCU Strategy Document. The updated document was approved by the CCU WG-S in September 2023. It is available for review as working document CCU-24-13.

Some updates will be made after the CCU in order to include information on the newly created task groups and the new CCU President.

M. Stock will update the CCU Strategy Document and send it around to the WG-S for final approval before it is uploaded online for CCU members to access.

14. REVIEW OF MEMBERSHIP

14.1 REQUESTS FOR MEMBERSHIP OR OBSERVERSHIP OF CCU

SASO-NMCC, the NMI of Saudi Arabia, had expressed its interest in joining the CCU as a member. To provide further information about this application R. Alyousefi presented a report of the activities at Saudi Standards Metrology & Quality Organization National Measurement Calibration Centre (SASO-NMCC). Following the presentation R. Brown stated that he would ask the WG-S for their comments and review of the proposal prior to making a recommendation to the CIPM.

14.2 REVIEW OF MEMBERSHIP OF CCU WORKING GROUPS

R. Brown and M. Stock took an action to review and update the membership of the WG-S. R. Brown stated that in future the WG-S would be constituted of members holding positions of responsibility either within the CCU or in CCs relevant to the CCU's work.

It was agreed that M. Stock would send out an e-mail asking for expressions of interests to join the two new task groups (TG-CMT and TG-KTSIB).

15. ANY OTHER BUSINESS

M. Milton presented a couple of diagrams related to the possibility of a negative leap second. He showed latest data from the International Earth Rotation and Reference Systems Service (IERS) in Paris with an extrapolation forwards. It was not yet certain that the necessity to introduce a negative leap second would arise before 2035.

16. DATE OF THE NEXT CCU MEETING

The next CCU meeting will take place in 2027.

In the absence of further business, the meeting closed at 17:00 on 10 April.

Dr M. Brown

Rapporteur, 10 June 2024

17. DECISIONS AND ACTIONS FROM THE 26TH MEETING OF THE CCU

Decisions

- The CCU decided to appoint M. Brown (NRC) as Rapporteur
- The CCU decided that the Working Group on Core Metrological Terms (WG-CMT) should continue its work as a Task Group (TG-CMT) focusing on how to move forward various aspects of ontology, logical and where possible mathematical descriptions, and machine readability. Detailed Terms of Reference will be drafted by the newly established Task Group.
- The CCU decided to appoint L. Mari as the chair of TG-CMT
- The CCU strongly supports project proposals on digitalization and encourages TG-CMT to coordinate its efforts with this work
- The CCU decided to recommend to the CIPM that S. Ulbricht and R. Brown represent the BIPM in the JCGM-WG2:VIM
- The CCU decided that P. Blattner will represent CCU in the TG on SI digital framework of the FORUM-MD
- The CCU decided to recommend to the CIPM to publish a new version of the 9th Edition of the SI Brochure (v3.01) incorporating the changes suggested by the CCU Task Group and Focus Group considering angles, dimensionless quantities, counting and number quantities and the minor changes agreed at the meeting
- The CCU decided to create a Task Group on Key Topics in the SI Brochure TG-KTSIB, approving its draft terms of reference
- The CCU decided to disband TG-ADQSIB

Actions

- Recommend to CIPM that S. Ulbricht and R. Brown represent BIPM in JCGM-WG2, together with a third person chosen by the CIPM (R. Brown, M. Milton)
- Version 3.01 of SI Brochure to be finalized and submitted to CIPM for approval (M. Stock, R. Brown)
- P. Blattner to join TG on SI digital framework of Forum-MD as CCU liaison (P. Blattner)
- Ask members to volunteer for task groups on metrological semantics and on the SI digital framework of the Forum-MD (M. Stock)
- Strategy Document to be submitted to WG-S for approval (M. Stock)
- Renew membership of WG-S (R. Brown, M. Stock)
- Invite members to join TG-CMT and TG-KTSIB (M. Stock, L. Mari)
- Review application for CCU membership of SASO within WG-S (R. Brown)