

**International Committee
for Weights and Measures**

Proceedings of Session II

of the 108th meeting

(15-16 October 2019)

Executive Summary

Session II of the 108th meeting of the CIPM (15-16 October 2019)

Independence and responsibilities of CIPM members

The CIPM discussed issues related to the independence and responsibilities of its members.

CCU Working Group on Core Metrological Terms (CMT)

The CIPM approved the establishment of the CCU Working Group on Core Metrological Terms (CMT).

CIPM Task Group on the Digital SI

The CIPM established a CIPM Task Group on the Digital SI to explore and establish liaisons with relevant stakeholders to agree an authoritative document on a meta-data format for SI-based data transfer.

CIPM Working Group on Data

The CIPM decided to establish a CIPM Working group on Data (formerly the *ad hoc* Working Group on the Reproducibility of Research Data and Related Topics).

Expanded terms of reference for the CIPM Sub Committee on Strategy

The CIPM decided to expand the terms of reference of the CIPM Sub Committee on Strategy to include advice to the CIPM on wider strategic directions of metrology.

Member States and Associates in arrears

The CIPM discussed issues of with Member States and Associates in arrears, including difficulties with banking.

Honorary membership

The CIPM bestowed honorary membership on Dr Barry Inglis in recognition of his accomplishments as the President of the CIPM.

Mutual relationship between the BIPM and the CTBTO

The CIPM requested preparation of a MoU between the BIPM and the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) to collaborate on the metrological traceability of measurements of infrasound, seismic activity and radioactivity.

CIPM task group to support the preparation of the CIPM for the WRC 2023

The CIPM asked the CCTF President and the Director of the BIPM Time Department to establish a CIPM task group to support the preparation of the CIPM for the World Radiocommunication Conference in 2023.

Proliferation of international reference time scales

The CIPM decided to support the IGS and ICG to explore the capacity of GNSS providers to ensure multi-GNSS interoperability, based on UTC, with the final goal of avoiding the proliferation of international reference time scales.

CCAUV and CCRI Presidents

The CIPM appointed Dr Laiz as the President of the CCAUV and Dr Sené as the President of the CCRI.

**MEMBERS OF THE
INTERNATIONAL COMMITTEE FOR WEIGHTS AND MEASURES**

As of 15 October 2019

President

W. Louw, South Africa.

Secretary

T. Usuda, Japan.

Members

F. Bulygin, Russian Federation.

D. del Campo Maldonado, Spain.

I. Castelazo, Mexico.

N. Dimarcq, France.

Y. Duan, China.

H. Laíz, Argentina.

T. Liew, Singapore.

P. Neyezhnikov, Ukraine.

J. Olthoff, United States of America. *CIPM Vice-President.*

S.-R. Park, South Korea.

M.L. Rastello, Italy.

P. Richard, Switzerland.

G. Rietveld, the Netherlands.

M. Sené, United Kingdom.

A. Steele, Canada.

J. Ullrich, Germany. *CIPM Vice-President.*

Honorary members

W.R. Blevin, Berry, Australia.

L.M. Branscomb, La Jolla, United States of America.

E.O. Göbel, Braunschweig, Germany.

K. Iizuka, Tokyo, Japan.

R. Kaarls, Zoeterwoude, the Netherlands.

J. Skákala, Bratislava, Slovakia.

Agenda

1. Opening of the session, approval of the agenda, review of actions from the last session
2. Confirmation of the decisions taken by correspondence since the last session
3. Report on the work of the CIPM bureau by the CIPM Secretary
4. Independence and responsibilities of CIPM members
5. Reports from the CIPM Sub-Committees
6. Addressing Resolution 5 of the 26th meeting of the CGPM (2018)
7. Review of progress with the OIML and review of the proposals for a joint task group
8. Other CIPM governance topics
9. Discussion on strategy and governance
10. Discussion of criteria for honorary membership of the CIPM
11. Report from the BIPM Director
12. Reports from the BIPM Physical Metrology Department, CCEM, CCM, CCPR and CCU
13. Reports from the BIPM Ionizing Radiation Department, CCRI, CCAUV and CCT
14. Reports from the BIPM Chemistry Department, CCQM, JCTLM and proposal for a re-drafted JCTLM Declaration of Cooperation
15. Reports from the BIPM Time Department, CCL, CCTF and review of the IGC recommendation on GNSS time scales
16. Elections (including Presidents of the CCAUV and CCRI) and applications for membership and observership of the CCs
17. Miscellaneous reports
18. Reports from the CIPM Sub-Committees
19. Adjustment of the value of the point for salaries and the pension point
20. Report on *Metrologia* and the renewal of the BIPM website
21. Schedule of meetings for 2020-2022
22. Depository of the metric prototypes
23. Any other business

1. **OPENING OF THE SESSION; QUORUM; AGENDA**

The International Committee for Weights and Measures (CIPM) held Session II of its 108th meeting on Tuesday 15 and Wednesday 16 October 2019 in the Pavillon de Mail.

Present: F. Bulygin, D. del Campo Maldonado, I. Castelazo, N. Dimarcq, Y. Duan, H. Laiz, T. Liew, W. Louw, M.J.T. Milton (Director of the BIPM), P. Neyezhnikov, J. Olthoff, S.-R. Park, M.L. Rastello, P. Richard, G. Rietveld, M. Sené, A. Steele, J. Ullrich and T. Usuda.

Also attending the meeting were: C. Fellag Ariouet (Personal Assistant to the Director and Head of the Secretariat and Housekeeping Office), C. Planche (Librarian and Drafting Officer), F. Rojas Ceballos (Legal Adviser) and R. Sitton (Publications Officer).

The following were in attendance for parts of the meeting:

H. Fang (Mass - Kibble balance; Executive Secretary of the CCM), R. Guliyeva (International Liaison Assistant), A. Henson (Director of the International Liaison and Communication Department), S. Judge (Director of the Ionizing Radiation Department), C. Kuanbayev (International Liaison Assistant), J. Miles (Editor), S. Picard (KCDB Coordinator; Executive Secretary of the CCT), M. Stock (Director of the Physical Metrology Department), P. Tavella (Director of the Time Department and Executive Secretary of the CCTF), J. Viallon (Gas programme; Executive Secretary of the CCPR) and R. Wielgosz (Director of the Chemistry Department).

With 17 members present at the start of the meeting (Dr Castelazo arrived at 09:45) the quorum was satisfied according to Article 12 of the Regulations annexed to the Metre Convention.

The President asked if there were any changes or additions to the draft agenda. He confirmed that item 6 on “Addressing Resolution 5 of the 26th meeting of the CGPM (2018)” was intended to include any broader discussions on outcomes from the CGPM. There were no additional changes and the agenda was adopted.

2. **CONFIRMATION OF THE DECISIONS TAKEN BY CORRESPONDENCE SINCE THE LAST SESSION**

The minutes of session I of the 108th meeting (2019) had been approved by correspondence and were accepted as a true record.

Decision CIPM/108-21 The CIPM accepted the minutes of the first session of the 108th meeting of the CIPM as a true record.

The BIPM Director recalled that the CIPM had made a decision by correspondence in August 2018 that had not been confirmed at its previous session:

Decision CIPM/108-22 The CIPM confirmed the decision launched by correspondence on 23 August 2018 to approve the Joint Declaration on Metrological Traceability with the OIML, ILAC and ISO.

It had also made one decision by correspondence since its previous session:

Decision CIPM/108-23 The CIPM confirmed the decision adopted by correspondence on 1 October 2019 to approve the Memorandum of Understanding with the IUPAC.

3. REPORT ON THE WORK OF THE CIPM BUREAU BY THE CIPM SECRETARY

Dr Usuda, Secretary of the CIPM, gave his report (see Appendix 1) on the bureau meetings held on 22 March, 17-18 June and 14 October 2019. The following questions and comments refer to the content of this report.

Dr Richard asked if the President of the International Committee of Legal Metrology (CIML) had been informed officially about Decision CIPM/108-05 and what actions had been taken in respect of this decision since Session I of the 108th meeting in March 2019. Dr Louw replied that the CIML President had been informed and described the background information outlined in §10 “Proposal from the CIML President to form a Task Group with the OIML” in the report of Session I. The current situation is that the BIPM and OIML will continue to meet annually in March and at the next meeting in 2020 the issue of establishing a Joint Task Group at an operational level will be discussed further. Dr Olthoff added that the bilateral meeting between the BIPM and OIML in March 2020 will attempt to clarify this.

The process for preparing for meetings such as the annual bilateral meeting between the BIPM and OIML was questioned, particularly the issue of how a collective view is reached in advance of this and other similar bilateral and quadripartite meetings. Dr Louw said this will be addressed later in the agenda when the strategy regarding liaisons is discussed.

A concern was raised about online voting being carried out without a discussion in advance of the vote, with reference to the email ballot for the International Union of Pure and Applied Chemistry (IUPAC) Memorandum of Understanding. The assumption is that if the CIPM is to move towards using more email voting (or voting by correspondence), discussions on issues subject to a vote will have been completed in advance, and then followed by the vote. The vote for the IUPAC MoU had received one negative vote and one abstention, as reported by the CIPM Secretary; the reasons behind these negative votes had not been discussed. Dr Louw replied that the process used for the IUPAC MoU vote will be reflected upon. Dr Milton added that the documentation relating to the MoU vote had been circulated to the CIPM in March 2019 for comment. The resulting comments had been dealt with by bilateral exchanges and the commented document had been sent to IUPAC. Dr Louw reminded the CIPM that the Metre Convention (ART.13 (1875)) mentions that in the interval between sessions, the Committee has the right to deliberate by correspondence. In this case, for a decision to be valid, all members of the Committee must have been invited to express their opinion.

The President recalled that the Secretary had reported on the outstanding contributions and subscriptions and that this was the first time that this information had been reported so early. He congratulated the BIPM Executive and Meetings Office and the Finance Office for the work they had undertaken to improve the timeliness of this report.

The President said that the terms of reference (ToR) for the Working Group of Member State representatives had not been finalized. He suggested that the Working Group should develop its own ToR and decide among its members what will be discussed at the meeting, scheduled for Friday 18 October 2019. It was noted that the CIPM had sent the Working Group suggestions for discussion topics.

The President noted that one expression of interest had been received for the vacant Chair of the CIPM Sub-Committee on Finance.

4. INDEPENDENCE AND RESPONSIBILITIES OF THE CIPM MEMBERS

The President presented a one-page summary document CIPM/19-II-04 “The independence of CIPM Members”. The document detailed that CIPM members are independent from Member States according to the Metre Convention and annexed regulations, and with the position expressed by Member States. It highlights that the CIPM is the organ that exercises the exclusive direction and supervision of the BIPM and it is placed under the authority of the CGPM (Member States) as per Article 3 of the Metre Convention. The document covers: the relationship of CIPM members to their governments; the possibility for absent CIPM members to delegate their votes to members present during CIPM meetings; and how membership of the CIPM is reserved for individuals, considered by their peers to be renowned scientists or scholars.

The independence of CIPM members was alluded to at the 17th meeting of the CGPM (1983) when it was mentioned that the preferred option was that candidates [to become a CIPM member], if elected, would remain “acceptable” to his or her government, rather than each CIPM member nomination being approved by their respective government. This view was reaffirmed at the 21st meeting of the CGPM (1999), in which it was “recommended that no change should be made in the constitution of the CIPM either in respect of the number of seats or in the independence of the members, who remain individual members and not delegates of their governments”. The document CIPM/19-II-04 also makes reference to the preamble of the “Criteria and Process for Election of CIPM Members” (revised in 2018), which states “members of the CIPM (...) act within the framework decided by the CGPM and not on behalf of their own governments” and that although they “are elected on the basis of personal merit, it is important that they have some connection to the national measurement systems in their respective States, and have the support of their governments to serve in this capacity”. Moreover, it was noted that the “Compendium of main rules and practices applicable to the BIPM” provides a brief analysis of the role of the CIPM, its composition and attributions.

The President summarized the presentation by saying that a CIPM member is elected by the CGPM to oversee the execution of its decisions. A CIPM member in the execution of the tasks delegated by the CGPM should act on behalf of the General Conference and should apply scientific and other skills in the service of the Organization. He further recalled that article 7 of the Annexed Regulations allows CIPM members to be nominated as delegates of their governments at the CGPM, and therefore act on behalf of that State. The President stressed that when CIPM members attend meetings of NMI Directors and State Representatives, they should bear in mind that they should act in the interests of the BIPM. As such, when attending these meetings, CIPM members should act beyond the powers they have been conferred by the General Conference.

The President proposed that new members of the CIPM should receive a short induction, which would include information about the role, as well as practical issues. It was suggested that the one-page summary document CIPM/19-II-04 and the Compendium should, in the future, be included in the information package for new members of the CIPM. A concern was raised that the “Criteria and Process for Election of CIPM Members” focuses on the scientific abilities of candidates rather than policy and institutional skills, which are becoming increasingly important to international metrology. Proposals to modernize the International Organization should reflect the fact that knowledge of policy and institutional matters are now a significant component of the work of the CIPM.

There was a further concern related to the update or approval of the Compendium of main rules and practices applicable to the BIPM, distributed to delegates at the 26th meeting of the CGPM, and developed by the BIPM Legal Adviser. The President said that this document will be updated to reflect the outcomes of the CIPM Sub-Committee on Strategy and the Working Group of Member State Representatives. It is important to note that the “Criteria and Process for Election of CIPM Members” and the Compendium can be amended, if required. The Director reminded the CIPM that the Compendium had been developed in response to a request by the *ad hoc* Working Group on the role, mission, objectives, long-term financial stability, strategic direction and governance of the BIPM, which had been formed in 2012. This Working Group requested a single repository for all the rules and practices of the Organization. As a result, the requested Compendium was developed by

the then Legal Adviser and was made available on the BIPM website. It reflects practices and decisions of the CGPM and of the CIPM. A printed copy was made available to delegates at the 26th meeting of the CGPM to improve its visibility.

The BIPM Legal Adviser confirmed that the Compendium is indeed a living document, which is constantly updated. Moreover, this document includes a disclaimer stating that it has been developed by the BIPM's Legal Adviser, that it is not exhaustive, meaning that it can be revised and updated. Finally he stressed that the Compendium is not a normative document, and therefore has no legal standing with respect to the legal norms of the Organization (Treaties, Conventions, CGPM Resolutions, CIPM Decisions, etc.) The Compendium is simply a user-friendly compilation of the main rules and practices of the BIPM since 1875.

5. REPORTS FROM THE CIPM SUB-COMMITTEES

CIPM Task Group on “Unit” (Prof. Ullrich)

Prof. Ullrich presented the background to the CIPM Task Group on “unit”, formed following Decisions CIPM/107-12 and CIPM/107-13. Decision CIPM/108-13 confirmed the establishment of the Task Group, which held its first meeting on 20 June 2019 at the BIPM. He drew the attention of the CIPM to Decision CIPM/107-25, which noted the letter from the Chair of the JCGM Working Group on the VIM (WG2) about the proposed broader definition of the term “measurement” to include ordinal and nominal properties. Prof. Ullrich noted that the Task Group had concluded that terms such as “unit”, “measurement” and “traceability” are needed in CGPM Resolutions and even legislation in Member States, and that therefore these terms should be discussed by the CIPM, with the aim of reaching a coordinated view that can be fed back to the JCGM.

The recommendation from the CIPM Task Group on “unit” to the CIPM was that the CIPM should mandate the CCU to establish a CCU Working Group dedicated to examine the definition of selected metrological terms. This Working Group would report to the CCU plenary meeting: the CCU would then make a recommendation to the CIPM on the position to be presented to the JCGM WG2 meeting regarding core terminology. A letter of mandate with some terms of reference, a preliminary list of relevant metrological terms and a defined scope for the Working Group should be addressed by the CIPM to the CCU. The Working Group should be composed mainly of NMI representatives, although outside expertise will be welcomed.

Prof. Ullrich informed the CIPM that a recommendation had been discussed at the CCU meeting on 8-9 October 2019, with the outcome that it should be presented to the CIPM for discussion. During the CCU meeting, the CIPM President had tasked Prof Ullrich, in his role as CCU President, to make preparations for the establishment of a CCU Working Group on “units” to examine the definition of selected metrological terms. Draft terms of reference for the proposed CCU Working Group were presented to the CIPM. In addition, the CIPM Task Group on “unit” recommended that the CIPM should also appoint the Chair of the new Working Group to represent it at meetings of the JCGM WG2 in order to present a position that had been previously agreed by the CIPM, based on advice from the CCU. A proposed list of members of the CCU Working Group was presented.

Prof. Ullrich noted that the CCU had decided that the CCU Working Group on “units” should make a proposal to the CCU on the definition of “unit”, “quantity” and “value of quantity” by the end of September 2020, with a possible extension of its scope to be discussed by the CIPM. The proposed extension of scope will allow the CCU Working Group on “units” to consider core metrological terms (CMTs), particularly terms that enter CGPM Resolutions and national legislation. The proposed terms of reference, which will extend those of the CCU Working Group on “units” to cover CMTs were presented. Prof. Ullrich suggested that if the CIPM agrees to the creation of a CCU Working Group on “CMTs” and endorses the extended terms of reference he could inform the CCU of the extended scope.

The President reminded the CIPM that document CIPM-D-01 “Rules of procedure for the Consultative Committees (CCs), CC working groups and CC workshops” includes the following advice on the establishment of Working Groups “*The CC decides on the establishment of CC working groups, defines their membership, scope and terms of reference. These details are available from the CC President or Executive Secretary and are submitted to the CIPM for subsequent approval.*” He added that delegating the task of reviewing terminology to a CCU Working Group will allow the CIPM to make use of the expertise that exists within that community. The final approval of any outcomes from the Working Group will require CIPM approval. He asked for comments and questions.

It was suggested that if the CCU Working Group on “CMTs” is approved, the CIPM Task Group on “unit” can be closed, as it will have completed its work. Prof. Ullrich agreed that this is the case. The scope of what constitutes core metrological terms was questioned. The CCU Working Group on “CMTs” needs a clear definition of the scope so that it knows exactly which terms it should focus on. Prof. Ullrich replied that the CIPM Task Group on “unit” had discussed this, with the outcome that the CIPM should write to Prof. Ullrich to define what constitutes core metrological terms. This list will be developed in association with the International Organization of Legal Metrology (OIML). He added that one of the first tasks of the CCU Working Group on “CMTs” will be to identify the terms that will be discussed: the aim is to focus on the most important terms. The CIPM should have an opportunity to review the list and to carry out a final check before the Working Group begins its work. The duration of the CCU Working Group on “CMTs” was questioned, particularly whether it is intended as a permanent Working Group or if it will be closed after CMTs are addressed. Prof. Ullrich anticipated a quasi-permanent status as issues will continually arise with terminology.

Following a discussion it was agreed that the Working Group would be called the CCU Working Group on Core Metrological Terms.

The Director recalled that Prof. Ullrich had commented during his presentation that the OIML would be consulted to determine what constitutes a core metrological term. He added that this should be reflected in the terms of reference for clarity. Prof. Ullrich replied that the CIPM Task Group on “unit” had recommended that the OIML should be consulted to determine its views on terminology before the CCU Working Group on “CMTs” is established. The Director reiterated that there is a difference between consulting the OIML on the initial determination of what constitutes a core metrological term and any subsequent consultation to find consensus definitions; this should be reflected in the terms of reference. The need to explicitly mention the OIML in the terms of reference was questioned, particularly why it was mentioned whereas other organizations were not. Prof. Ullrich replied that the OIML, like the Metre Convention, operates as an Intergovernmental Organization in the field of metrology, and as such, has a more important status in defining metrological terms than other non-governmental organizations and the terminology it uses should be aligned with the BIPM. The Director added that the OIML uses its terminology within the scope of national legislation and it has a detailed perspective on metrological terms in this context. Following a discussion, it was agreed that it was not necessary to include a reference to the OIML in the first bullet point of the terms of reference for the CCU Working Group. The CIPM agreed the following decisions.

Decision CIPM/108-24 The CIPM decided to close the CIPM Task Group on “unit” because it has successfully completed its tasks.

Decision CIPM/108-25 The CIPM approved the establishment of the CCU Working Group on Core Metrological Terms (CMT) and endorsed the terms of reference suggested by the CCU President and as communicated previously to the CCU.

The CIPM welcomed the fact that the Chair of the CCU Working Group on Core Metrological Terms (CMT) is also the CIPM Representative at the JCGM.

Prof. Ullrich continued by presenting the recommendation from the CIPM Task Group on “unit” that he should

draft a letter to the Chair of the JCGM, to be sent by the CIPM President, to propose that the JCGM member organizations join the CIPM leadership in establishing machine-readable SI documents. This could start with the SI Brochure and follow up with the VIM, GUM and other metrological guidelines as necessary. He stressed that this action is needed urgently, particularly on a metadata format for measurement data based on the SI and on an ontology and hierarchy of core metrological terms. This issue had been discussed in the CCU meeting on 8-9 October 2019, which agreed that action is needed. Prof. Ullrich added that many other organizations are already involved in digitization and recommended that the organs of the Metre Convention should take a leadership role in developing machine-readable SI documents and to give guidance to other organizations on the subject. He presented a draft decision for the establishment of a CIPM Task Group on the Digital SI, which included suggested members and terms of reference.

The President thanked Prof. Ullrich and asked the CIPM if they agreed that a letter should be sent to the Chair of the JCGM to invite its member organizations to join the endeavour to produce a machine-readable SI, with the CIPM taking a leadership role. He asked if a formal document will be produced for presentation to the 27th meeting of the CGPM (2022). It was noted that many of the JCGM member organizations, and other organizations, are already developing machine-readable versions of their internal documents and that the BIPM and JCGM have yet to develop any machine-readable documents. Although the CIPM is starting late, it was not considered to be too late; although it was stressed that compatibility will be required with the formats that are already being developed. It was thought that a formal report on the development of a digital SI to the 27th meeting of the CGPM (2022) should not be required since it is within the authority of the CIPM to publish the SI Brochure and to collaborate with partners in the JCGM to produce the VIM and the GUM. The development of a digital SI can commence quickly and the CGPM will be informed of the progress. It was queried whether a specific format should be agreed to make the machine-readable SI Brochure compatible with other formats that are currently under development. Prof. Ullrich replied that guidance on the metadata format for transferring metrological data is needed. Whether developing machine-readable SI documents is the responsibility of the CCU, or the proposed CIPM Task Group on the Digital SI, and if sufficient expertise existed in either group to carry out the task was discussed. It was recommended that the proposed CIPM Task Group on the Digital SI should include an Expert Group recruited from NMIs, with support from the BIPM International Liaison and Communication Department. It was suggested that the CIPM Task Group on the Digital SI should identify what documents are being digitized by other organizations prior to beginning work. Prof. Ullrich agreed that work should be coordinated with organizations such as ISO, IEC, ILAC and the OIML. He concluded his presentation with the objectives of the proposed CIPM Task Group on the Digital SI. After a discussion the following decision was made.

Decision CIPM/108-28 The CIPM decided to establish a CIPM Task Group on the Digital SI to explore and establish suitable liaisons with all relevant stakeholders aiming at agreeing an authoritative document on a meta-data format for SI-based data transfer as well as for machine-interpretable unambiguous digital representation of metrological information and factual data in general.

The members of the Task Group are Dr Castelazo, Dr Liew, Dr Milton, Dr Olthoff, Dr Steele and Prof. Ullrich (Chair).

It is recommended that it establishes an Expert Group recruited from NMIs. The Task Group is supported by the BIPM International Liaison and Communication Department.

Terms of Reference:

- To develop and establish a world-wide uniform, unambiguous and secure data exchange format for use in IoT networks based on the International System of Units (SI) described in the current SI Brochure.
- To coordinate this effort with all relevant stakeholders by exploring and/or establishing suitable liaisons.
- To propose suitable actions towards making the SI Brochure machine readable.

CIPM *ad hoc* Working Group on the Reproducibility of Research Data and Related Topics (Dr Liew)

Dr Liew gave an update on the CIPM *ad hoc* Working Group on the Reproducibility of Research Data and Related Topics. He said that the Working Group had met in March and June 2019. He proposed that it is renamed the CIPM *ad hoc* Working Group on Metrology and Reproducibility in the Digitalized World to reflect its broader scope. The terms of reference had been developed at the meeting in March 2019. The terms of reference provide that the *ad hoc* Working Group should take stock of work in the areas of making metrological activities fit for the new digital world and of engaging with other communities and sectors to bring a metrological framework and thinking to areas that are impacted by the digital revolution, including specifically the issue of reproducibility of research results. They also noted that the *ad hoc* Working Group should identify and recommend priority digitalization activities to be undertaken by the BIPM, NMIs and other organizations such as the IEC, IEEE, ILAC, ISO and OIML.

Dr Liew said that a survey had been conducted to determine what the metrology community needs to do to ensure that its core activities are “fit” for the digital world. The survey asked for comments, via a series of questions, on how the digital revolution is challenging industry and governments to ensure that they have the confidence in information derived from measurements that the metrology community has carried out in the past and the fact that the scientific research community is facing serious issues with reproducibility of data. The results of the survey were presented. The CIPM *ad hoc* Working Group on the Reproducibility of Research Data and Related Topics had discussed the findings of the survey and made the following three recommendations:

Recommendation 1: Form a technical expert group to work on a digitalized SI Brochure and subsequently other documents such as the VIM etc.

Recommendation 2: Engage with other organizations such as the OIML, JCGM, ILAC, ISO, IEC, IEEE etc. to ensure the consistent roll out of digitalized SI Units.

Recommendation 3: Organize a workshop in June 2020.

The President thanked Dr Liew and asked for clarification as to the difference between the proposed CIPM *ad hoc* Working Group on Metrology and Reproducibility in the Digitalized World and the CIPM Task Group on the Digital SI created by Decision CIPM/108-28. Dr Milton recalled that Dr Liew had started his presentation by suggesting a change of name for the *ad hoc* Working Group and had proposed terms of reference. Dr Milton recommended that the CIPM should consider both the name of the *ad hoc* Working Group and the ToR. This will allow the information to be made available on the CIPM webpages to raise the profile of the work of the *ad hoc* Working Group. He asked Dr Liew if the proposed ToR had been presented to the CIPM for discussion and approval. Dr Liew confirmed that this was the case. Dr Sené commented that there were three distinct issues that the group had considered and discussed at its meeting: Firstly, the issue of digitizing the SI is identical to a task that is now under the remit of the newly-created CIPM Task Group on the Digital SI, and as such, this does not need to be considered by the CIPM *ad hoc* Working Group on the Reproducibility of Research Data and Related Topics. Secondly, the significant global issue of reproducibility of data in scientific research, which led to the creation of the CIPM *ad hoc* Working Group on the Reproducibility of Research Data and Related Topics. On the issue he noted that there was a strong feeling within the Group that the metrological framework and concepts and the way in which measurements are approached has a significant impact on reproducibility. Thirdly, there is the larger issue of how the metrology community should respond to a world in which enormous amounts of data are being generated and then processed using complex algorithms and the application of Artificial Intelligence methods. The CIPM should consider if these issues are within the scope of one Working Group, or if each should be dealt with separately. Dr Sené reiterated that development of the proposed digital SI has been assigned to the CIPM Task Group on the Digital SI. The President commented on the overlap between the two groups and that possible ways

forward were either to ensure that the terms of reference of each group are made unique with no overlap, or for the two groups to discuss among themselves which topics that each will cover.

It was suggested that the proposed workshop in June 2020 should have a broad scope, which could go beyond topics such as machine-readability and reproducibility. At the end of the workshop, a panel discussion could decide how to address the various topics. Dr Rastello informed the CIPM that the CCPR is planning to hold a workshop on AI and “big data” in the field of Photometry and Radiometry. Dr Milton suggested that the workshop, proposed by Dr Liew and which will be discussed later in the agenda, should be scheduled for later in 2020. He added that the workshop could cover reproducibility of data in scientific research and that some NMIs have already expressed an interest in making proposals for a workshop on this topic. He proposed that the CIPM *ad hoc* Working Group on the Reproducibility of Research Data and Related Topics could make proposals for the content and scope of the workshop.

The President summarized by saying that the CIPM Task Group on the Digital SI, created by Decision CIPM/108-28, has a specific task, with well-defined terms of reference.

Following further discussion, it was agreed that the CIPM *ad hoc* Working Group on the Reproducibility of Research Data and Related Topics will be renamed the CIPM Working Group on Data. The terms of reference were discussed and agreed as shown in Decision CIPM/108-29.

Decision CIPM/108-29 The CIPM decided to establish a CIPM Working Group on Data (formerly the *ad hoc* Working Group on the Reproducibility of Research Data and Related Topics) with the following terms of reference:

- take stock of the metrology communities’ work in two areas:
 - making our core metrological activities fit for the new digital world
 - engaging with other communities/sectors to bring metrological framework/thinking to areas that are impacted by the digital revolution, including specifically the issue of reproducibility of research results.
- identify and recommend priority digitalization activities that might best be undertaken by:
 - the CIPM
 - the BIPM
 - the NMIs
 - and/or with other organizations that the CIPM should engage with on (this topic) such as OIML, ILAC, ISO, IEC, IEEE.
- establish deliverables and timeline for the activities.

CIPM Sub-Committee on Strategy (Dr Louw)

Dr Louw presented a summary of the work of the CIPM Sub-Committee on Strategy. Its meeting in June 2019 had been chaired by Dr Louw following Decision CIPM/108-30. The meeting had included a background discussion that reflected on the profound change to the SI in 2018. The current focus of the stakeholders in the SI, specifically the NMIs and DIs is to develop realizations of the units according to the defining constants.

He informed the CIPM that the discussions had started to develop a strategy for the long term. The topics under consideration were:

- What issues will scientific metrology have to address by 2030 and beyond?
- What disruptive technologies will shape our future?
- What will the organization look like in 2050 in order to address the landscape by that time?

Dr Louw said that the June 2019 meeting of the CIPM Sub-Committee on Strategy had discussed the broader strategy, including the Metre Convention in 2030 and beyond, and how to identify and report on the long-term requirements in metrology. The members of the Sub-Committee had mentioned that the role and constitution of the Metre Convention and the organs it had established is unique and its contributions to the world-wide harmonization of measurement cannot be overestimated. Other issues discussed included whether the BIPM/CIPM serves all economies/NMIs as effectively as it should. The other meeting had examined whether the BIPM liaises as efficiently as possible with other IGOs.

Dr Louw noted that the members of the CIPM Sub-Committee on Strategy had discussed whether the current strategy is closer to a “work plan” than a strategy. He noted that the Sub-Committee had agreed that both the strategy for the BIPM secretariat and laboratories and the strategy of the organization as a whole should be developed in parallel. He commented that clearly defined objectives and actions will be identified and developed, with a plan of how to meet these objectives. A work plan of how to develop the strategy was discussed, including a timetable to allow the updated strategy to be presented to the 27th meeting of the CGPM (2022). The CIPM Sub-Committee on Strategy met again on 14 October 2019 to finalize the outcomes of the June meeting, including five areas for the wider strategic direction, for which the Sub-Committee will provide the CIPM with advice and support. These five areas are included in the proposed expanded terms of reference for the CIPM Sub Committee on Strategy, which were presented. He commented that detailed discussion on the strategy will be possible later in the agenda under §9. The following decisions were agreed.

Decision CIPM/108-30 The CIPM appointed Dr Louw as Chair of the Sub-Committee on Strategy.

Decision CIPM/108-31 The CIPM decided to expand the terms of reference of the CIPM Sub Committee on Strategy to include advice to the CIPM on wider strategic directions of metrology as follows:

The CIPM Sub-Committee on Strategy will advise and support the CIPM on the following five areas:

1. responding to the evolving needs for metrology
2. addressing key scientific challenges to advance the global measurement system
3. strategy for deepening engagement with other international organizations on measurement science issues
4. reviewing the strategy for future membership of the organization
5. modernizing the operations of the organization

The outcome should focus on what the CIPM can do to address these issues, reflecting them in the operation of the BIPM staff and laboratories. Regular reports should be given to the CIPM, with a consolidated report to the 27th meeting of the CGPM.

CIPM Task Group set up in response to Decision CIPM/108-19 (Dr Louw)

A brief discussion took place on the outcomes of Decision CIPM/108-19, following which the CIPM had established a Task Group to propose terms of reference for a Working Group of Member State representatives. The Task Group had recommended that as a starting point towards the development of the terms of reference, the main topics for the Working Group of Member State representatives could be to:

- Examine the relationships between the organs of the Metre Convention to prepare a statement as to the role of each of these organs as defined by the Treaty.
- Consider whether and how best to distinguish the “Laboratory” and “Secretariat” aspects of the work done by the organization.
- Discuss principles of clarity, transparency and sustainability.

- Reflect on how strengths could be shared amongst Member States.
- Prepare and submit appropriate documented conclusions and recommendations to the 27th meeting of the CGPM (2022).

Dr Louw stressed that it was entirely up to the Working Group of Member State representatives to finalize the terms of reference. The Working Group was scheduled to meet on 18 October 2019. It was agreed that the CIPM Task Group had completed its work, as outlined in Decision CIPM/108-19, and that it could be closed.

Decision CIPM/108-32 The CIPM decided to close the CIPM Task Group established in response to discussions held before the adoption of Resolution 3 at the 26th meeting of the CGPM (see Decision CIPM/108-19) following the completion of its tasks.

6. ADDRESSING RESOLUTION 5 OF THE 26TH MEETING OF THE CGPM (2018)

The Director presented the Briefing Note: “Addressing the accumulation of arrears” (Document CIPM/19-II-06). The note had been written to address the requirements of Resolution 5 of the 26th meeting of the CGPM (2018) “On the financial arrears of Member States and the process of exclusion” and had been discussed in Session I of the 108th meeting of the CIPM (see §11 of the report of Session I). The Director commented that this is a major issue and that significant amounts of money are involved. He added that a number of options could be pursued to resolve this issue in advance of the 27th meeting of the CGPM (2022). Each of these options will need to be discussed by the CIPM. Any options to be pursued will need to be discussed in association with Member State representatives as soon as possible. The Briefing note includes a proposal to set up a CIPM *ad hoc* Working Group to investigate the issue of addressing the accumulation of arrears. Mr Henson said that the total arrears are close to 4 million €.

Following a discussion it was agreed to extend the terms of reference of the CIPM Sub-Committee on Finance to address the accumulation of arrears and to return to the point under item 8.

7. REVIEW OF PROGRESS WITH THE OIML AND THE PROPOSAL FOR A JOINT TASK GROUP

The President reminded the CIPM that a proposal to create a joint BIPM-OIML Task Group had been presented in §3 “Report on the work of the CIPM bureau by the CIPM Secretary.” Mr Henson said that the initial proposal for a joint task group had come from the CIML President at the 26th meeting of the CGPM (2018). He added that there is a great deal of ongoing collaborative work between the BIPM and OIML such as the World Metrology Day initiative. The President informed the CIPM that he had been invited to attend the 54th meeting of the CIML in Bratislava (Slovakia), where he had hoped to discuss the joint BIPM-OIML Task Group with Dr Schwartz, the CIML President. Unfortunately he will be unable to attend personally and asked whether any other CIPM members planned to attend the meeting. The Director confirmed that he will be attending, and he was asked, by the President, to discuss the proposed joint Task Group with Dr Schwartz informally.

Mr Henson remarked that a significant amount of collaborative work is being undertaken between the BIPM and OIML to update document OIML D 1 “Considerations for a Law on Metrology” (2012). The previous CIPM President had suggested in early 2017 that OIML D 1 should be a “joint document” between the BIPM and OIML now that it had evolved to the extent that the latest revision includes information relevant to scientific as well as legal metrology. Mr Henson said that he has been involved in the revision and has drafted several sections of the document, including those relating to NMIs. It was noted that the revision of OIML D 1 has progressed slowly for two years, but now there is some urgency to complete the process before October 2020. Mr Henson asked the CIPM to propose how to proceed with the project, and the level of governance they would like to impose.

The President asked the CIPM for volunteers to work with Mr Henson to progress the work. Mr Henson noted that Dr Olthoff had already given some guidance as he is increasingly advising the BIPM on liaison matters. Dr Laiz volunteered to become an additional contributor to the revision of OIML D 1. Dr Olthoff said that the immediate task was for himself, Mr Henson and Dr Laiz to propose a process by which the rest of the CIPM can become engaged in the approval of the document, and then to summarize this to the CIPM members. He commented that the options are either for the OIML to submit the finished D 1 document to the CIPM for approval or for the CIPM to get involved at an earlier stage to ensure that the document is not simply submitted as a *fait accompli*.

8. OTHER CIPM GOVERNANCE TOPICS

The Director briefed the CIPM on the visit of a delegation from Kosovo to the BIPM on 25 September 2019, with particular regard to its application to become an Associate of the CGPM. A presentation on the organization and recent technical developments within the Kosovo Metrology Agency (KMA) had been given during the visit. The Director had advised the delegation that there are two categories of Associate: Associate State or Associate Economy. He had explained that in order to calculate the contribution from an Associate State, the State would require a UN coefficient. At present Kosovo is not part of the UN and does not have a UN coefficient. The alternative would be to become an Associate Economy. An application as an Associate Economy would have to be referred to the Member States at a General Conference. The Director had informed the delegation from Kosovo that he would provide details of their visit to the CIPM. He stressed that the CIPM alone cannot make a decision with regard to Kosovo and cannot make any comments on statehood or political issues. The CIPM Secretary, who had been present during the visit, added that the status of the BIPM as a purely scientific organization had been stressed.

The President thanked the Director and the Secretary and agreed that informal discussions with Member States should start but that nothing can be done before the 27th meeting of the CGPM (2022). He added that no other action is required from the CIPM at the moment.

Following discussion, the BIPM Legal Adviser remarked that this is a sensitive issue. He stressed that the BIPM is a scientific and not a political organization. He stated that this issue could perhaps be discussed in a forum, such as the Working Group of Member State representatives. The President said that a suggestion would be made to the Working Group of Member State representatives that it may wish to discuss issues such as this.

Mr Henson reported that there were payment issues with four States, all of which face possible exclusion on 1 January 2020 as a result. Of these States, Zimbabwe, which is an Associate, is three years in arrears with its subscription and will be excluded on 1 January 2020 unless at least one of the outstanding subscriptions is received before 31 December 2019. The other three States; Cuba, Syria and Iran have all attempted to pay their subscriptions (for Cuba and Syria) and contributions (for Iran) on numerous occasions but have had their payments into French banks blocked because of banking policy issues over sanctions. He noted that this situation had become worse over time. Mr Henson emphasized that the problem arises because the banks take a risk-based approach and choose not to handle payments from some countries.

Mr Henson said that guidance is needed from the CIPM on how to proceed. Following a discussion, Decision CIPM/108-35 was adopted. The President said that the situation regarding these payments will be monitored and the CIPM bureau will report back to the CIPM at future meetings.

Decision CIPM/108-35 The CIPM noted that some States have been unable to transfer their contributions or subscriptions successfully to the BIPM bank accounts in France due to the risk-averse policies of the French banks in the context of international sanction policies. The CIPM decided that such States shall not have their advantages and prerogatives suspended or be excluded, provided that genuine efforts have been made to pay their contributions or subscriptions, confirmed by refusal of acceptance by the banks holding the BIPM accounts. Such States should make the necessary arrangements to be in a position to transfer the due amounts as soon as it becomes possible.

In the context of the principles of Resolution 5 of the 26th meeting of the CGPM (2018) “On the financial arrears of Member States and the process of exclusion” the Director turned to the issue of those States that had paid debts beyond the first six years. Following a detailed discussion, the CIPM adopted Decision CIPM/108-33. The CIPM reflected on the special case where a Member State had default beyond six years, which will now be waived, and where that State had signed a rescheduling agreement and thus had not been excluded. In the interests of fair treatment, the CIPM instructed the BIPM to ensure that, in such circumstances, a re-engagement fee, equivalent to that which the State would have paid as a re-entry fee had it been excluded, must be included in the calculation. The CIPM requested that this instruction be recorded in the Minutes of the meeting.

My Henson noted that the adoption of Decision CIPM/108-33 meant that Iran no longer faced exclusion at the end of 2019.

Decisions CIPM/108-33 and CIPM/108-34 were discussed and agreed.

Decision CIPM/108-33 The CGPM in Resolution 5 adopted at its 26th meeting (2018) decided that the CIPM shall implement Article 6 paragraph 8 of the Annexed Regulations, and that the CIPM shall address the situation where historical practice has resulted in the accumulation of arrears. Pursuant to this resolution, the CIPM decided that the BIPM shall inform States that have previously been notified of accumulated arrears exceeding the six-year period, that the amounts due are those equal to the first six years of default.

The CIPM decided that any amounts paid by such States that constitute accumulated arrears exceeding the six-year period, may be considered when calculating their contribution, and entry contribution, following their re-engagement.

This decision does not address the associated advances made by Member States, which shall be considered separately by the CIPM in the context of Resolution 5.

Decision CIPM/108-34 In order to implement Resolution 5 adopted by the CGPM at its 26th meeting (2018) and further to Decision CIPM/108-33, the CIPM decided to extend the terms of reference of the CIPM Sub-Committee on Finance as follows:

- to review the associated financial data prepared by the BIPM staff
- to explore options to address the advances associated with the accumulated arrears in a way that will be acceptable to the Member States that made the advances and to the external auditors, and
- to report their recommendations on these two actions to the CIPM.

9. DISCUSSION ON STRATEGY AND GOVERNANCE

The President introduced the agenda point by saying that it was intended to allow the CIPM Sub-Committee on Strategy to exchange ideas with the entire CIPM to begin developing the strategy that will be presented to the 27th meeting of the CGPM (2022). He presented the five areas on which the CIPM Sub-Committee on Strategy will work that are listed in Decision CIPM/108-31. Following a brief discussion, it was agreed that the titles of the five areas are simply “placeholders” for wider concepts, rather than final names and that this is work in progress. More details were discussed for each of the five areas, including the name of a Convenor, CIPM members and BIPM staff who will work together to start developing each area. The output of the discussions will be fed back into the overall strategy for further discussion:

1. “Responding to the evolving needs for metrology”. The President said that this task will involve identifying the evolving needs of metrology, prioritizing these needs and confirming the findings with stakeholders. Appropriate actions will need to be decided and executed and it may be necessary to capture any thoughts in a report similar to the “Kaarls Report 2007”. Priorities could be identified by convening experts in particular subject areas at a series of workshops; this would allow NMIs and stakeholders to be brought together. (Dr Rietveld (Convenor), Dr Sené, Dr Liew and Dr Laiz).
2. “Addressing key scientific challenges to advance the global measurement system”. This area could include reviewing the implementation of the 2018 revision of the SI and considering possible future revisions of the SI. (Prof. Ullrich (Convenor), Dr del Campo Maldonado, Dr Dimarcq and Dr Rastello).
3. “Strategy for deepening engagement with other international organizations on measurement science issues”. This area could include a review of the international liaison “landscape”. The aim would be to optimize the impact from liaison activities. (Dr Olthoff (Convenor), Mr Henson and Dr Louw).
4. “Reviewing the strategy for future membership of the organization”. A strategy will be required to respond to past resolutions of the CGPM that encourage the CIPM to seek broader membership of the organization. Additionally, links with the RMOs will be deepened and the challenge of engaging with States that are not officially aligned with any RMO will be considered. (Dr Steele (Convenor), Mr Henson, Dr Louw and Dr Castelazo).
5. “Modernizing the operations of the organization”. Topics to be addressed include:
 - Addressing historic advances by Member States.
 - Developing “rules of procedure” for the CIPM.
 - Reviewing the role and operation of the CIPM bureau.
 - Reviewing future requirements for the work of the BIPM staff and laboratories.
 - Agreeing policies for the organization in line with best practice amongst International Organizations.
 - Improving exploitation of all available vehicles for stakeholder interaction.(Dr Richard (Convenor), Dr Milton, Mr Henson, Dr Louw, Dr Steele and Dr Usuda).

The President noted that the CIPM Sub-Committee on Strategy will report regularly to the CIPM and that its working documents will be made available on its web page for the whole CIPM. A “summary of the context” will be included in the introduction to the strategy and it will be made clear that the strategy is being developed by the CIPM to address issues that it has been mandated to carry out by the text of the Metre Convention and the General Conference. In parallel to the development of the strategy, the CIPM will develop a new financial model and a work programme for the BIPM staff, buildings, site and laboratories for the period 2024 to 2027.

The President said that there may be some strategic decisions that will require endorsement by the General Conference. Approval of major changes by the General Conference will require “early warning” of a major decision, prior to a proposal at the 27th meeting of the CGPM (2022). He added that agreement for the CIPM

to develop implementation plans may not require a decision by the General Conference.

The President recalled that the CIPM is facing a situation following the submission of a draft Resolution X “on the name of the intergovernmental organization created by the Metre Convention” to the 26th meeting of the CGPM (2018). He noted that this would be discussed by the Working Group of Member State Representatives. He presented a brief history of the BIPM, focusing on the development of its structure, different interpretations of the current structure. The President recalled that the BIPM Legal Adviser had put together a package of appropriate background information as requested in Session I (Decision CIPM/108-19) and that this had been made available to all CIPM members on the CIPM working documents page.

10. DISCUSSION OF CRITERIA FOR HONORARY MEMBERSHIP OF THE CIPM

The President stated that there had been a proposal during Session I that the retiring President of the CIPM should be made an honorary member. It was noted that, at the time, there was no formal criteria for bestowing honorary membership. The President remarked that subsequent discussions had resulted in the drafting of a set of criteria, which were presented. These criteria were accepted as Decision CIPM/108-36.

Decision CIPM/108-36 The CIPM decided that it would bestow honorary membership upon a limited number of former members for their distinguished service to the CIPM. Distinguished service could include, *inter alia*, carrying out one or more leadership positions within the CIPM that resulted in demonstrable accomplishments with impacts across the organization as a whole.

Each candidacy for honorary membership will be voted upon individually by the CIPM.

The CIPM discussed the contributions of Dr Barry Inglis to the work of the CIPM and decided unanimously that it would bestow honorary membership on him in Decision CIPM/108-37.

Decision CIPM/108-37 The CIPM decided that it would bestow honorary membership on Dr Barry Inglis in recognition of his accomplishments as the President of the CIPM with impact across the organization.

He served as President of the CIPM for 8 years during which time he led the organization through two meetings of the CGPM. He led the CIPM through the governance review and subsequent launch of the reform of its processes. His work in coordinating the work of the CIPM with its Consultative Committees and the global NMI community led to the successful adoption of revised definitions for the SI units in 2018. He always took a strategic and long-term view of the impact of the CIPM on world metrology.

11. REPORT FROM THE BIPM DIRECTOR

Dr Milton reported on activities since the Session I of the 108th meeting of the CIPM in March 2019.

He remarked that the BIPM has completed the calculation of the contributions for Member States for 2020. This was a significant task as the calculations had to take into account the new scale of contributions from the United Nations. The results have been shared with the CIPM President and Secretary, ready to be signed off. The information will be made available in the near future.

A number of large IT projects have been undertaken in 2019. The KCDB 2.0 is almost complete and will be presented later in the agenda. Renewal of the content management system for the website is under way and is

expected to go live in 2020. The design and functionality of the website will change at the same time and the technology behind the website will be modernized to encompass an “open source” system. The BIPM has started to adopt cloud storage and its financial accounting system is the first system for the BIPM to be fully cloud-based. The costs and benefits of moving to further cloud-based storage are being investigated.

The Human Resources Office has commissioned a salary survey and the report will be available in August 2020; both the CIPM *ad hoc* Working Group on Conditions of Employment and the Commission des conditions d’emploi (CCE) have been consulted.

The Director said that there was no news on the two ongoing cases at the Administrative Tribunal of the International Labour Organization (ILOAT). The cases are not scheduled to be heard in the next session. An update will be given when further information becomes available.

A new Chair of the Appeals Committee has been appointed following the retirement of the previous Chair who had completed two terms. Two names for a potential new Chair had been proposed by the Director and two by the Commission for Conditions of Employment; one name was common to both lists. At the time of the meeting, a contract was being agreed with this person.

The Director remarked that the report of the 26th meeting of the CGPM (2018) is complete and had been made available on an open-access area of the BIPM website for comment until the end of October 2019.

The Director concluded by saying that document CIPM/19-II-12.1 “Work Programme (2016-2019) – Progress report” gives details of the Work Programme in a format proposed by the CIPM. It presents the deliverables that were agreed in the programme and the work that has been carried out in the period 1 October 2018 to 30 June 2019. The document will be completed with a report of work undertaken from 1 July to 31 December 2019. He commented that the report includes very specific information about what has been achieved. The new work programme, approved by the 26th meeting of the CGPM (2018), includes activities, tasks and deliverables as well as an indication of the expected outcomes.

12. REPORTS FROM THE BIPM PHYSICAL METROLOGY DEPARTMENT, CCEM, CCM, CCPR AND CCU

BIPM Physical Metrology Department

Dr Stock, Director of the department, reported on progress made since March 2019. He said that core work in electricity had been the five ongoing bilateral comparisons and that he would focus on the two onsite comparisons of quantum Hall resistance standards and Josephson voltage standards. During 2019, two onsite quantum Hall resistance key comparisons (BIPM.EM-K12) have been carried out at NMC, A*Star (Singapore) and NIM (China) and one is planned at KRISS (Republic of Korea). He noted that these comparisons are a major logistical undertaking that require the shipment of 1.3 tonnes of equipment. The onsite quantum Hall resistance key comparisons are the only way to verify the intrinsic ppb-level accuracy of QHR systems and are mandatory for realization of the kilogram using Kibble balances with a target uncertainty of 20 ppb. The onsite Josephson voltage key comparisons (BIPM.EM-K10) have been running for many years and the latest is scheduled to be carried out at MIKES (Finland) in October 2019. These comparisons are the only way to verify the intrinsic sub-ppb-level accuracy of Josephson voltage standards and are also mandatory for realization of the kilogram using Kibble balances with a target uncertainty of 20 ppb.

In mass, the fabrication of prototype Number 112 has been completed and a purchase order for this prototype was received in September 2019. Fabrication of a further three prototypes (Numbers 113 to 115) are under way and several informal requests to purchase them have been received. Dr Stock recalled that so far in 2019 mass calibrations of Pt-Ir prototypes have been carried out for NIST (USA), SMD (Belgium), BEV (Austria) and SMU (Slovakia). Mass calibrations of stainless steel prototypes have been carried out for NSC (Ukraine),

LATU (Uruguay), SMD (Belgium), SMU (Slovakia) and BEV (Austria).

The hierarchy of BIPM Pt-Ir prototypes and working standards, introduced in 2015 following the last measurements of the IPK in 2014, was presented. There are 12 working standards that are accessible; six are for current use, three standards are for limited use (to check the previous six annually) and three prototypes are for exceptional use (every five years). The mass evolution of the six accessible working standards for current use, when compared against the three standards for annual use, was displayed. In 2019, the department compared the six accessible working standards for current use against the three prototypes for exceptional use for the first time. This allowed the modelling of mass evolution to be checked. It had been expected that contamination of the mass standards of 1 μg per year would have resulted in an increase of approximately 5.5 μg over the five-year period, as no correction had been applied for contamination. It was however found that the mass had increased by about 8 μg . This means that over the next five-year period, a correction of 1.5-1.6 μg per year will have to be applied. The calibration uncertainty is now dominated by the uncertainty of the IPK with respect to h , which amounts to 10 μg .

Dr Stock informed the CIPM that the department is preparing for the first key comparison of kilogram realizations (CCM.M-K8.2019) using Kibble balances and silicon spheres. The BIPM is the pilot laboratory and the condition for participation was that a NMI had to be able to realize the kilogram with an uncertainty of less than 200 ppb ($u_r(m) \leq 200$ ppb (200 μg)). Seven to nine institutes met the criteria: two using XRCD techniques (Si spheres) and five to seven using Kibble/joule balances. The Draft A report is expected in April 2020, with the first consensus value being ready in May 2020. The first travelling standards are expected to arrive during October 2019.

There has been significant progress with the Kibble balance since March 2019. An electrical grounding issue on the suspension was resolved during April-May 2019. In addition, the measurement sequence was optimized and data processing was refined during June-July. The latest Kibble balance measurement results show a standard deviation of 4×10^{-8} and a combined standard uncertainty of 6×10^{-8} . Dr Stock said that in order to carry out measurements on the Kibble balance it is necessary to know the value of local gravitational attraction. The BIPM Work Programme had included provision to buy a FG5 gravimeter, which would have required a staff member to operate the instrument. Instead, METAS (Switzerland) offered to carry out the gravitational measurements, which were completed in September 2019. The METAS measurement was 4.8 μgal , lower than the result obtained during the International Comparison of Absolute Gravimeters (ICAG) in 2009, with an uncertainty of about 5 μgal ; this is not considered to be a limiting factor in the Kibble balance uncertainty. Regular surveys of the absolute acceleration of gravity will be carried out in the future.

Dr Stock presented the provisional uncertainty budget for the BIPM Kibble balance, which is being finalized by additional measurements. He noted that the main contributor to the overall relative uncertainty budget of 58 ppb was alignment issues, with a relative uncertainty of 47 ppb.

He concluded by summarizing the next steps for the work on the Kibble balance. The data analysis and uncertainty evaluation will be finalized and the results will be published with an uncertainty of $\leq 6 \times 10^{-8}$. The BIPM Kibble balance will participate in the first key comparison of the kilogram realizations. Later on, the apparatus will be refined to reduce both type A and B uncertainties and a guiding mechanism will be developed to further reduce the type B uncertainty resulting from parasitic coil motion.

The President thanked Dr Stock and invited questions. Dr Laiz asked about progress with graphene-based quantum Hall resistance standards. Dr Stock replied that development of a graphene-based table-top system to replace the 1.3 tonnes of equipment that currently needs to be transported to each onsite quantum Hall resistance key comparison would be welcomed. However, metrology-grade graphene samples will be required before this can go ahead and at present this is not the case. Commercially available graphene would be required that is suitable for such comparisons at the highest level, to achieve an uncertainty of 10^{-9} , before table-top systems can be developed.

Consultative Committee for Electricity and Magnetism (CCEM)

Dr Rietveld, CCEM President, stated that the CCEM had held its 31st meeting in March 2019. This had been its first meeting since the CGPM decision to revise the SI, which brought the electrical standards ‘back into the SI’ from 20 May 2019. He said that the revision of the SI has allowed K_J and R_K to be calculated from fixed numerical values of h and e . However, because the conventional values K_{J-90} and R_{K-90} , which had been used since 1990 were not equal to the final values, there were step changes of around 0.1 ppm for voltage values and 0.02 ppm for resistance values from the implementation date for the revised SI of 20 May 2019. This step change is only visible to top-level users, such as NMIs, and will have minimal impact on industry. Two guidance documents were however produced by the CCEM Working Group on Proposed Modifications to the SI (CCEM-WGSI) to inform industry of the changes. These documents are the *Mise en pratique for the definition of the ampere and other electric units in the SI* and *CCEM Guidelines for Implementation of the ‘Revised SI’*.

Following the revision of the SI, it became possible to close two CCEM Working Groups: the CCEM Working Group on Proposed Modification to the SI (CCEM-WGSI) and the CCEM Working Group on Electrical Methods to Monitor the Stability of the Kilogram (CCEM-WGKG). Dr Rietveld remarked that future responsibility for the Kibble balance will come under the auspices of the mass community and the relevant CCEM Working Group and that technical discussions will continue to take place at Kibble Balance Technical Meetings (KBTM). Regular reports from the CCEM WG and the KBTM will be given at future CCEM meetings. He noted that electrical metrology is a “service provider” to Kibble balances and continues to play an important role there.

Dr Rietveld said that other business of note during the 31st meeting of the CCEM included the inauguration of a new joint CCRI-CCEM Task Group on Low Current Measurement in support of ionization radiation (activity) measurements and the appointment of two new Working Group Chairs: Dr Early, MSL (New Zealand) for the CCEM Working Group on Low-Frequency Quantities (CCEM-WGLF) and Mr Di Lillo, INTI (Argentina) for the CCEM Working Group for RMO Coordination (CCEM-WGRMO). He added that CMI (Czechia) had made a presentation at the CCEM meeting with regard to becoming a Member. This application was endorsed by the CCEM.

Dr Rietveld gave a summary of the improvements in the effectiveness of the implementation of the CIPM MRA within the CCEM. He said that the key comparison CCEM-K4 had been carried out by the BIPM using the “star approach”, which significantly reduced the overall effort and time required for the comparison. He thanked the BIPM for taking on the role of “star” laboratory in this comparison and mentioned that, stimulated by the success of this comparison, the CCEM has decided to use this approach in future CCEM comparisons where possible. The CCEM’s high-voltage CMC categories have been reviewed in response to industry developments, and small extensions are under way to cover developments like digital equipment and on-wafer RF and MW measurements. The CMC review process has been reviewed, with inter-RMO reviews being reduced from 400 % to 100 %, with part of the review (‘simple’ CMCs) performed by the CCEM WGRMO chair and the remainder (‘challenging’ CMCs) assigned by the WGRMO chair to the RMOs. Dr Rietveld explained that the role of the WGRMO chair is important, but not decisive: any RMO is still free to review any CMC they want to review. The present process is a compromise between fairness and simplicity and the current balance is considered to be close to optimal. This method of review is explained in the Report of the 31st meeting of the CCEM (2019).

Dr Rietveld concluded by giving brief details of the CCEM technical workshop on “Metrology for radiofrequencies and microwaves”, which was held at the BIPM on 27 March 2019.

The President thanked Dr Rietveld and invited questions and comments. Dr Milton asked if the CCEM’s effective approach to CMC review could be promoted to other CCs. Dr Rietveld replied that there are other good methods of CMC review being carried out within the CCs. He added that he has been invited to contribute to a workshop on the CCEM CMC review process at the “Optimizing the CIPM MRA - the KCDB

2.0” course, to be held at the BIPM on 4-8 November 2019. This will give him the opportunity to promote the CCEM’s methods.

Consultative Committee for Mass and Related Quantities (CCM)

Dr Richard, CCM President, informed the CIPM that it had held its 17th meeting in May 2019. He presented the CCM roadmap for a final time, commenting that the planning within the roadmap had worked very efficiently. The CCM meeting had included a technical workshop, Chaired by Dr Steele, on the subject of “New activities in the field of mass and related quantities”.

Dr Richard noted that the CCM had approved the final version of the “*mise en pratique* for the definition of the kilogram in the SI” in April 2018 and the “CCM detailed note on the dissemination process after the proposed redefinition of the kilogram” in May 2019. The CCM had also approved the creation of a single CCM Working Group on Mass (CCM-WGM) through the merger of the former CCM Working Group on the Dissemination of the Kilogram (CCM-WGD-kg) and CCM Working Group on the Realization of the Kilogram (CCM-WGR-kg) in May 2019. He added that members of the Kibble balance community are welcome to attend meetings of the CCM-WGM and that even though the CCEM had closed two Working Groups (CCEM-WGSI and CCEM-WGKG) an informal group will continue to meet to discuss technical matters related to the ongoing work with Kibble balances.

Dr Richard said that the BIPM had prepared a “Note on the impact of the redefinition of the kilogram on BIPM mass calibration uncertainties” and that following the redefinition, the CMCs for the present traceability to *h* through the IPK had been updated. He recalled that, as mentioned by Dr Stock, the first key comparison of kilogram realizations (CCM.M-K8) is scheduled to start in the near future, with completion scheduled for April 2020. Dr Richard congratulated the BIPM on the progress it has made with its Kibble balance.

He concluded his presentation by recommending that the CIPM accepts the applications by INMETRO (Brazil) and IPQ (Portugal) to become full members of the CCM. Both NMIs are currently observers and had made presentations to the last meeting of the CCM and its Working Group Chairs. He noted that there had been a number of changes to the Working Group Chairs at the 17th meeting of the CCM and that there are now Vice-Chairs for each Working Group.

Consultative Committee for Photometry and Radiometry (CCPR)

Dr Rastello, CCPR President, informed the CIPM that the CCPR had held its 24th meeting in September 2019; the Ukraine and Poland sent observers to the meeting for the first time. The structure of the CCPR Working Groups was presented and it was noted that a number of Task Groups had been closed following the completion of their work. A workshop on “Advancing the State of the Art in Measurement Science” had been held during the meeting, with six invited talks.

Dr Rastello mentioned that following the revision of the SI, three documents of relevance to the photometry and radiometry community had been published: “*Mise en pratique* for the definition of the candela in the SI”, “BIPM report 05/2019: Principles governing photometry” and “Appendix 3: Units for photochemical and photobiological quantities (in the 9th edition of the SI brochure)”.

The CCPR has six ongoing key comparisons, which are currently in their second round. The set of seven CCPR Guidelines for comparisons are complete and have been published on the CCPR webpage. Dr Rastello said that the CCPR is discussing how to link RMO and CC comparisons, with a matrix approach being considered. There is currently an issue over reference sources in key comparisons following the ban on incandescent lamps in Europe. LED-based reference sources are under development in many laboratories in the regions and the outcome of the work is awaited.

Dr Rastello noted that many NMIs realize the candela by radiometric methods. The primary realization of radiometric quantities (i.e. a cryogenic radiometer) is based on an electrical substitution method. The revised SI has changed the practical realization of the electrical power (W) by 2×10^{-7} , and the electrical current

by 9×10^{-8} ; the best uncertainties in radiometric measurements are of the order of 10^{-5} . The conclusion was that the redefinitions have had no detectable effect on radiometric measurements.

Dr Rastello said that the CCU had received a report on the impact of the redefinitions on CIE standard Illuminant A, which was defined in 1924 through an ideal blackbody radiator with a distribution temperature of $T_A = 2848$ K. All photometric devices are calibrated by referring to CIE standard illuminant A and are realized using specific incandescent lamps. The relative spectral distribution $S(\lambda)$ of a blackbody radiator, given by Planck's law, includes h , c , and k . To keep the spectral distribution unchanged the distribution temperature has to be changed each time the values of h , c , and k change. The last value was based on ITS-90: $T_A = 2855.542$ K, which was typically rounded to 2856 K. The revised SI changed the value by -46 mK: $T_A = 2855.496$ K, which should be rounded to 2855 K. The uncertainty of distribution temperature measurements is in the region of 5 K to 10 K so the CIE now recommends a value of 2855.5 K for practical realization. She commented that this issue will be resolved when standard incandescent lamps are replaced by LEDs.

Dr Rastello reminded the CIPM that when the revised SI was proposed, new routes for traceability were sought. She commented that there is a proposal from NIST to link optical power directly to the kilogram through photon momentum: $p = h / \lambda$. This would allow devices to be calibrated using lasers.

Dr Rastello concluded by presenting a timetable of forthcoming CCPR meetings.

The President thanked Dr Rastello and invited questions. Dr Milton commented that the talk given at the CCPR meeting by John Lehman about the work at NIST on "using photon momentum to measure high CW laser power and pulse energy" had been very interesting. This work could lead to use of the cryogenic radiometer as a way of calibrating very low masses or forces in the same way that the forces are used to measure laser power. It was asked to what extent the changes in h and k are being rationalized with the temperature community. If the temperature community does not adopt the new values of h and k in ITS-90, there could potentially be two different disseminations of radiation-based temperature measurement. Dr Rastello replied that there is a joint Working Group that will discuss this issue.

Consultative Committee for Units (CCU)

Prof. Ullrich, CCU President, said that the CCU had held its 24th meeting on 8-9 October 2019. The meeting had received presentations from INRIM (Italy) to become a member of the CCU and NSC "Institute of Metrology" (Ukraine) to become an observer. Both applications were supported by the CCU. The meeting included a half-day session devoted to the second, followed by the joint CCU-CCTF workshop on "Advanced Time and Frequency Transfer (ATFT): the ultimate frontier for remote comparison methods", which was held at the BIPM on 10 October 2019. He noted that this workshop discussed space-based optical clocks at $\sim 10^{-19}$ relative uncertainty, which could be used among others to improve geodesy from 1 cm to 1 μm , in the search for dark matter, Lorentz invariance and gravitational wave detection.

Prof. Ullrich stated that a questionnaire on the implementation of the revised SI has been developed by the CCU, which includes a question on implementation of the revised SI within national legal metrological frameworks. He commented that a discussion is needed within the CIPM and at the meeting of NMI Directors on the subject of the stakeholders to which it could be sent. This discussion should consider whether there needs to be coordination with the OIML over the question of legal implementation as well as Part C of the questionnaire, which is aimed at academic institutes.

Prof. Ullrich recalled the earlier discussions in §5 on extending the scope of the proposed CCU Working Group on "units" to consider core metrological terms (CMTs). (See Decision CIPM/108-25). He added that NMI members and liaison organizations to the CCU have been asked to bring an official opinion on the definition of "unit" and units for angles and frequencies to the next meeting of the CCU in 2021 to try and reach a consensus. The CCU meeting had included a discussion on the SI in the digital world with the outcome that an authoritative document on machine-interpretable, unambiguous digital representation of metrological information and factual data, i.e. for a metadata format for measurement data based on the SI and for an

ontology and hierarchy of core metrological terms, was recommended. He noted that this had been discussed in §5, with Decision CIPM/108-28 being agreed by the CIPM.

The CCU had also discussed prefixes at its meeting, which currently go up to 10^{24} (yotta) and 10^{-24} (yocto) in Table 7 of the 9th edition of the SI Brochure. It was proposed that new prefixes (with suggested names shown in brackets) are required for 10^{27} (ronna), 10^{30} (quecca), 10^{-27} (ronto) and 10^{-30} (quecto). The etymology behind the proposed prefixes was presented. Prof. Ullrich remarked that the need for these new prefixes is being driven by applications in information technology, particularly in data storage applications with the advent of quantum computing. He suggested that the CCU should draft a position paper that would identify the favoured course of action concerning the extension of prefixes, whether this is to use the suggested new prefixes or to take a different approach such as compound or double SI prefixes.

Prof. Ullrich concluded by saying that the CCU strategy had been presented and approved at its 24th meeting. The Secretary General of the International Mathematical Union (IMU) had attended the meeting as a guest. Prof. Ullrich observed that there should be a strong link between the CCU and the IMU to give the mathematics community a voice in subjects such as angles and proposed that liaison status for the IMU to the CCU should be established. Two draft decisions were presented to the CIPM for consideration. After a discussion, the decisions were adopted.

Decision CIPM/108-26 The CIPM invited the CCU to prepare a position paper that identifies a preferred course of action concerning the extension of the SI prefixes.

Decision CIPM/108-27 The CIPM welcomed the preparation of a questionnaire by the CCU on the implementation of the revised SI by stakeholders of the Metre Convention. It is recommended to send this questionnaire to all Member State NMIs with the request for them to further involve representative scientific academies as well as representatives of educational institutions of Member States.

The President thanked Prof. Ullrich and invited questions. It was asked if the CCU Working Group on Angles and Dimensionless Quantities had been closed. Prof. Ullrich confirmed that this was the case.

13. REPORTS FROM THE BIPM IONIZING RADIATION DEPARTMENT, CCRI, CCAUV AND CCT

Ionizing Radiation Department

Dr Judge presented highlights of the work in the Ionizing Radiation Department since March 2019. He noted that the department has three main aims: to provide comparison and calibration services that can be centralized in a cost-effective way; to coordinate research projects of international interest; and to organize capacity building and knowledge transfer activities.

Dr Judge commented that one part of the department's work is in radionuclide metrology, particularly in the fields of nuclear medicine and environmental protection. A brief overview was given of the existing capabilities for comparing primary standards of gamma-ray emitting radionuclides, the International Reference System (SIR) and the Transportable International Reference System (SIRTI). A recent development has been the launch of the new International Reference System for pure beta-emitting radionuclides (the Extended International Reference System (ESIR)), which was driven by an increased use of pure beta-emitters for radiopharmaceutical therapy. Recent improvements have been made to the data acquisition system, the design of the instrument and the source preparation facilities. Validation studies to determine the parameter to use, in order to achieve a robust response, have been completed and the new on-demand comparison service for beta emitters will be launched in 2020. A pilot comparison will be undertaken using a beta-gamma emitter (^{60}Co) to compare the ESIR to the SIR.

In the field of radiation dosimetry services, the Ionizing Radiation Department has participated in one of the most significant changes in ionizing radiation dosimetry in many years, following the publication of "ICRU

*Report 90, Key Data for Ionizing-Radiation Dosimetry: Measurement Standards and Applications*¹. The report includes new data that impact primary standards and changes have been made to standards and uncertainties. The BIPM has implemented the changes for its standards and services and the impact has been published in *Metrologia*². The department has worked with the CCRI to implement these changes throughout the radiation dosimetry community.

Dr Judge said that a number of short-term R&D projects have been undertaken to address specific issues. A project to investigate the traceability of dosimetry for radiotherapy using LINACs was undertaken in association with the NRC (Canada). Furthermore, projects to improve the correction factors for x-ray dosimetry in collaboration with the International Atomic Energy Agency (IAEA) and to improve the characterization of reference qualities for low-energy x-rays in collaboration with the VNIIM (Russian Federation) have been carried out.

Dr Judge commented that the Ionizing Radiation Department has participated in many knowledge transfer activities through its contributions to standards and dissemination, for example the IAEA SSDL handbook, and through presentations and participation in workshops and conferences, notably the EURAMET IR comparison workshop at the National Physical Laboratory (UK); the Varenna Metrology School (Italy); the 22nd International Conference on Radionuclide Metrology and its Applications (ICRM 2019), Salamanca (Spain); and the IAEA International Symposium on Standards, Applications and Quality Assurance in Medical Radiation Dosimetry (IDOS 2019), Vienna (Austria).

Dr Judge concluded by summarizing the secondments to the department since October 2018 and thanked the various institutes for sending staff to the BIPM.

Consultative Committee for Ionizing Radiation (CCRI)

Dr Louw, CCRI President, presented the structure of the CCRI in terms of quantities and units in ionizing radiation. He noted that it works with the International Commission on Radiological Protection (ICRP), which publishes recommendations and guidance on radiation protection and the International Commission on Radiation Units and Measurements (ICRU), which develops quantities and units for therapy, imaging and radiation protection. The CCRI is the implementation body that recommends quantities and units to the CIPM for approval for inclusion in the SI brochure and it coordinates the development, comparison and promulgation of national measurement standards. In addition, the CCRI works closely with the IAEA for dissemination of units.

Dr Louw added to the comments by Dr Judge on the ICRU Report 90 by recalling that the CCRI had also contributed to the development of the report. He thanked the members of the Ionizing Radiation Department for their input into the report.

The new user-community focused CCRI Strategy was presented and Dr Louw noted that it has been published on the BIPM website. Four key areas in the strategy are: digitizing data acquisition/analysis and new technologies for electrical current measurement; new cancer treatment modalities (proton therapy, radiopharmaceutical therapy); environmental radioactivity and decommissioning of legacy nuclear sites; and requirements for knowledge transfer to smaller NMIs/DIs.

Dr Louw said that discussions within the CCRI in terms of activities for CIPM MRA review over the last few years have focused on core quantity, range or matrix CMCs to improve efficiency. As an example he noted that in the past the CCRI has had individual CMCs that focused on discreet energies; it is more efficient to have one CMC with a range of energies. A driver has been EURAMET, which operates core-quantity CMCs. The CCRI has reached consensus on how this approach can be adopted and an interpretation document has

¹ International Commission on Radiation Units and Measurements 2016 Key data for ionizing-radiation dosimetry: measurement standards and applications vol 14 ICRU Report 90

² Burns D., Kessler C. Re-evaluation of the BIPM international dosimetry standards on adoption of the recommendations of ICRU Report 90. 2018, *Metrologia*, **55**, R21

been drafted on this approach for working with CMCs.

The CCRI and the CCEM have set up a CCRI-CCEM Task Group on Low Current Measurement to guide the introduction of new technologies for the measurement of low electrical current for ionization chambers used in the measurement of radionuclide standards. Dr Louw commented that radionuclide metrology relies on ionization chambers and there are issues with linearity and obsolete instrumentation. In addition, a new CCRI Working Group in the field of dosimetry for radiopharmaceutical therapy will be set up.

Dr Louw commented that as requested by the PTB, a CCRI strategy is needed on the joint use of large facilities such as cyclotrons and LINACs. The next generation of comparisons may need access to such large facilities and the first step is to establish a database on the shared use of facilities. Information for this database has been requested, with a deadline of late October 2019 for receipt of data.

He concluded by noting that applications for membership of the CCRI have been received from BEV (Austria), CMI (Czechia), METAS (Switzerland) and NMISA and iThemba LABS (South Africa). All of these applications have been endorsed by the CCRI.

Consultative Committee for Acoustics, Ultrasound and Vibration (CCAUV)

Dr Usuda, CCAUV President, said that it had held its 12th meeting on 24-27 September 2019. The meeting had included a workshop on “Diagnosis and inspection by AUV measurement” as well as meetings of all three CCAUV Working Groups. Decisions taken at the CCAUV meeting included welcoming the Ukraine to participate in the activities of the CCAUV in preparation for a future application for observer status. The CCAUV meeting had also confirmed that NMIs can submit CMCs in the AUV field in either tabular or matrix format.

Dr Usuda informed the CIPM that there had been a number of actions arising from the CCAUV meeting, including a recommendation that a liaison between the CCAUV and the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) should be proposed to the CIPM. The CCAUV had also discussed further monitoring of “hybrid comparisons” and that this concept should be presented to the Joint Committee of the Regional Metrology Organizations and the BIPM (JCRB) to consider the naming of such comparisons. Dr Usuda recalled that in his role as CCAUV President, he had been asked to re-iterate to the relevant CCs that they should examine the use of g_n , the physical constant for the standard acceleration of gravity defined in CODATA. The CCAUV had expressed its concern over the expanding use of g_n instead of the SI unit. He added that he had been requested to report to the CCU and CIPM about the need for systematic communication with ISO/TC 12 and IEC TC 25 for the future revision of relevant standards for units. This request had followed a number of problems that had been encountered during the move from the DIS to the FDIS stage for the revision of ISO 80000-8 – quantities and units – Part 8: Acoustics. Significant changes had been made during this stage and there had been knock-on effects for the revision of the SI Brochure.

Dr Usuda presented the new Chairpersons and Deputy Chairpersons for the three CCAUV Working Groups. The new Chairpersons are as follows: CCAUV Working Group for Key Comparisons (CCAUV-KCWG), Dr Ripper, INMETRO (Brazil); CCAUV Working Group for RMO Coordination (CCAUV-RMOWG), Dr Enyakov (Russian Federation); and CCAUV Working Group on Strategic Planning (CCAUV-SPWG), Dr Gaitan, NIST (USA).

He concluded by returning to the issue of the proposed liaison between the CCAUV and the CTBTO. The CTBTO has 184 Member States, 270 staff from more than 85 countries and is headquartered in Vienna (Austria). It operates the International Monitoring System (IMS), which consists of an extensive network of seismic, hydroacoustic and infrasound monitoring stations; it is the IMS Division that has been in contact with the CCAUV. The CTBTO has an active scientific programme, including a biannual conference on science and technology. The Science and Technology Conference (SnT 2019) in Vienna in June 2019, was attended by 1 000 participants from more than 120 countries. Dr Usuda noted that many of the technical areas that the

CTBTO is involved in, such as seismology, infrasound and hydroacoustics involve scientific studies that include metrology. Many of the areas that the IMS covers are not represented by current CMCs. The IMS infrasound monitoring range requires monitoring at very low pressures, the IMS seismic monitoring range is only covered by one CCAUV key comparison (CCAUV.V-K3,2016), and the IMS hydroacoustic monitoring range is not covered by any validated CMCs.

Dr Usuda gave a summary of the common goals that provide the basis for a mutually beneficial relationship with the CTBTO. In addition, some CCAUV member institutes have been collaborating with the relevant national IMS network institutes in the field of seismo-acoustic technologies. He proposed that a collaboration be established between the BIPM and CTBTO with a view to enhance cooperation in areas of common interest and that reciprocal representation at relevant meetings of the CCAUV and CTBTO should be set up. Information should be exchanged between the two organizations to recognize the state of the art for seismo-acoustic technologies and the needs in relevant fields so that the CCAUV strategic plan can be revised to accommodate the needs in these fields. He concluded by recommending that a memorandum of understanding should be developed between the CIPM/BIPM and the CTBTO.

The President thanked Dr Usuda and invited comments. Dr Sené noted that the CTBTO has an interest in ionizing radiation measurements and takes traceability to the SI. There is therefore a broader interest in collaboration with the CTBTO outside the CCAUV. Following a short discussion a decision on the preparation of a memorandum of understanding between the BIPM and the CTBTO was agreed.

Decision CIPM/108-38 The CIPM asked the CIPM Secretary, the CCAUV and CCRI Presidents and the BIPM International Liaison and Communication Department to prepare a memorandum of understanding between the BIPM and the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) to collaborate on the metrological traceability of measurements of infrasound, seismic activity and radioactivity.

Consultative Committee for Thermometry (CCT)

Dr Duan, CCT President, notified the CIPM that it had not met in 2019 and that its next meeting was scheduled for March 2020. He had attended the TEMPMEKO conference in Chengdu (China) in June 2019 where a talk was given on the redefinition of the kelvin. It was noted that the *mise en pratique* for the kelvin (*MeP-K*) is still under development. Dr Duan informed the CIPM that a number of primary methods have been developed to measure thermodynamic temperature including acoustic gas thermometry, radiometric thermometry, polarizing gas thermometry, dielectric constant gas thermometry, refractive index gas thermometry and Johnson noise thermometry. He commented that the thermometry community will have to overcome the problem of having to find a new fixed point in the *MeP-K* to replace the triple point of Hg in response to the Minamata Convention on Mercury, which will ban the use of mercury from 2020. The most likely replacement is CO₂.

Dr Duan commented that ITS-90 is still valid and no revision of the temperature scale is expected within the next 10 years. The CCT continues to contribute to the measurement of T-T90. With the development of the new fixed point, which will replace the triple point of Hg and progress with the measurement of (T-T90), a new interpolation formula needs to be found. Progress has been made in radiation thermometry with the measurement of the eutectic points in which the interpolation method with high temperature fixed points will replace the extrapolation method from the silver fixed point according to Planck's Law in the future.

He concluded by saying that there is increasing interest among the thermometry community for thermodynamic temperature measurements rather than a defined fixed scale. The President thanked Dr Duan and invited questions. Dr Stock recalled that a new interpolation formula had been proposed for the resistance

thermometry range. He asked if there would be an ITS-2020 or something equivalent and if so under which framework it would be published. Dr Duan replied that there is a need to replace the triple point of Hg so the interpolation equation for ITS-90 will be changed. There are ongoing efforts to measure T-T90 using an alternative fixed point; after this is achieved, a new formula can be developed for the SPRT range. Dr Duan added that although mercury is being banned in 2020, it will be phased out for the purposes required by the thermometry community in 2025.

14. REPORTS FROM THE BIPM CHEMISTRY DEPARTMENT, CCQM, JCTLM AND PROPOSAL FOR A RE-DRAFTED JCTLM DECLARATION OF COOPERATION

Chemistry Department

Dr Wielgosz gave an overview of the BIPM Chemistry Department programme and its staff. He noted that the department has 10.5 Full-time equivalents (FTEs) and has hosted an additional 47 visiting scientists from 23 countries during 2016-2019. These visiting scientists spent between 3 to 18 months at the BIPM, which is equivalent to an extra four FTEs. The visiting scientists are evenly split between programme delivery and those receiving training. The first training programme for GULFMET scientists will be carried out in late 2019 through a Metrology for Safe Food and Feed workshop.

Dr Wielgosz presented eight performance indicators for the Chemistry Department for 2019 and during 2016-2019. There have been 53 NMI participations in BIPM coordinated comparisons during 2019 and 292 for the period 2016-2019. Five BIPM key comparisons have been run in 2019 and 14 during 2016-2019, with three BIPM comparison reports published in 2019 and 22 for 2016-2019. There have been 14 visiting scientists on secondment to the department in 2019, with a total of 47 during 2016-2019. Of these visiting scientists, ten were either self-funded or funded by a third party in 2019 and 29 in 2016-2019. The department's extensive visiting scientist programme would not be possible without self-funding by NMIs or third party funding. He commented that the Chemistry Department has received donations for the JCTLM and to fund visiting scientists totalling 137 k€ in 2019 and 451 k€ in 2016-2019. The department's publishing output remains strong, with eight papers being published in peer-reviewed journals in 2019 and 19 during 2016-2019. In addition, five other publications were produced in 2019 and 11 in 2016-2019. A total of five workshops, Consultative Committee and Joint Committee meetings were organized in 2019 and eleven for 2016-2019.

Dr Wielgosz gave highlights of the greenhouse gas standards and monitoring programme. He remarked that in 2019, the key comparison CCQM-K120, organized by the CCQM Working Group on Gas Analysis (CCQM-GAWG) with comparative measurements performed at the BIPM, was completed at atmospheric CO₂ levels and the results were presented at the 20th WMO/IAEA Meeting on Carbon Dioxide, Other Greenhouse Gases, and Related Measurement Techniques (GGMT-2019), which was held in Jeju (Republic of Korea) from 2-5 September 2019. Dr Wielgosz added that a global CO₂ monitoring network is operated by the World Meteorological Organization Global Atmosphere Watch Programme (WMO-GAW) and the scale³ and standards used to underpin CO₂ measurements by this network are maintained by the WMO, which signed the CIPM MRA in 2010. In 2019, the WMO are updating the CO₂ scale (WMO-CO₂-X2019), the primary reference for the WMO-GAW monitoring network on which all global background observations of CO₂ is based. The scale is used by the WMO-GAW programme in its global monitoring network for tracking trends in the background CO₂ amount fraction in the atmosphere and the accuracy of the scale was demonstrated in CCQM-K120. The comparison was a substantial undertaking involving the analysis of the composition of 46 gas reference materials over one year and the reference value standard uncertainty was found to be 0.05 µmol/mol. This provides an accurate way of underpinning the annual measurements of atmospheric CO₂ levels.

³ Brewer P.J., Brown R.J.C., Tarasova O.A., Hall B., Rhoderick G.C., Wielgosz R.I., SI traceability and scales for underpinning atmospheric monitoring of greenhouse gases, *Metrologia*, 2018, **55**(5), S174-S181

Dr Wielgosz commented that the CCQM-K120 key comparison relied on many measurements being made at the BIPM over an extended time period. An alternative way of carrying out the comparison is to operate a primary facility at the BIPM, which can measure standards on an ongoing basis. The programme to develop this CO₂-PVT (pressure, volume and temperature) reference system has been under way for three years with support from visiting scientists from NIST (USA) and RISE (Sweden) and in 2020 from NMIJ (Japan). The facility measures the PVT of CO₂ extracted from air and this relationship is used to give a mole fraction. The measurements have been validated in pilot study (CCQM-P188) run in parallel to the key comparison and the results have been published⁴. It is expected that the CO₂-PVT reference system will be operational in the near future and that NMIs will be then be able to measure their CO₂ standards against a constant facility at any time, rather than having to wait for completion of a multiple standard comparison exercise, for which at least one year's measurement time is required. In addition, only negligible amounts of gas will be required, allowing the remainder of the gas standard to be used for other purposes by the NMI.

He remarked that the CO₂ monitoring community is not only interested in the amount of CO₂ in the atmosphere; it is also interested in where the CO₂ comes from. It is possible to measure the carbon isotope ratio in CO₂ (¹³C to ¹²C) to determine the source of the carbon in the CO₂ because emissions of CO₂ from fossil fuel sources are depleted in ¹³C and therefore have a different carbon signature to atmospheric CO₂. Scales and comparability of isotope ratio measurements are therefore important and the Chemistry Department has established a CO₂ isotope ratio standard comparison facility with assistance from visiting scientists from INRIM (Italy), NIM (China), NPL (UK) and VNIIM (Russian Federation). The facility is now operational and the comparison CCQM-P204 is under way with the IAEA. It is expected that this will be one of the largest comparisons operated by the department, with ~100 samples being circulated to 20 laboratories around the world. Dr Wielgosz said that a paper has been published on how to calibrate Fourier Transform Infrared (FTIR) and other isotope ratio infrared spectrometer instruments, and what standards are required to do this, for accurate CO₂ measurements in air⁵.

The department has gained expertise in many measurement techniques through the underpinning of comparisons. One area where it operates a particularly strong programme is Fourier Transform Infrared spectroscopy (FTIR). The department has been passing on the knowledge of how to use this technique to many NMIs, with 13 NMIs having received training so far. The NPL (UK) has sponsored six of the training places. In addition, the Chemistry Department will begin a training programme in dynamic gas standards in 2020, starting with NO₂ in collaboration with METAS (Switzerland).

Dr Wielgosz said that the department also works on primary standards for organic measurements in areas such as pharmaceuticals and diagnostics. He recalled that a NMR system was donated to the BIPM in 2014 as part of a programme with NMIJ (Japan) on the development of quantitative Nuclear Magnetic Resonance (qNMR) methods for organic purity analysis. Numerous comparisons have been run since then on a range of calibrants to investigate the value assignment of these pure primary standards. An additional output from the qNMR programme has been to produce reference data documents for the qNMR techniques used by the department. This data has been made available in a series of seven qNMR Internal Standard Reference Data (ISRD) documents that cover seven "universal calibrators" for qNMR⁶. These universal calibrators were identified by the NMIJ and the BIPM as being able to serve as a set of internal standards that will enable SI-traceable purity assignment measurements by qNMR for the vast majority of organic analyte/solvent combinations. The documents were developed as a key output from the BIPM-NMIJ collaboration undertaken at the BIPM together with visiting scientists from NIM (China), INMETRO (Brazil) and UME (Turkey). He remarked that INMETRO will start producing certified reference materials (CRMs) for four of the seven universal calibrators

⁴ Flores E., Viallon J., Choteau T., Moussay P., Idrees F., Wielgosz R.I., Meyer C., Rzesanke D., Report of the pilot study CCQM-P188 (in parallel with CCQM-K120.a and b), *Metrologia*, 2019, **56**, Tech. Suppl., 08012

⁵ Flores E., Viallon J., Moussay P., Griffith D.W.T., Wielgosz R.I., Calibration strategies for FT-IR and other isotope ratio infrared spectrometer instruments for accurate $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ measurements of CO₂ in air, *Anal. Chem.*, 2017, **89**(6), 3648-3655

⁶ Westwood S., Yamazaki T., Huang T., *et al.* Development and validation of a suite of standards for the purity assignment of organic compounds by quantitative NMR spectroscopy. *Metrologia*, 2019, **56**(6), 064001

in 2019 and that the work has come to the attention of Pharmacopoeias, which are interested in the method for value assignment of standards and for production of pure materials. The department was invited to give a presentation to the US Pharmacopeia's "5th International qNMR Summit" at Rockville (USA) on 2-3 October 2019.

Dr Wielgosz concluded by presenting the Chemistry Department's capacity building programmes. He focused on the "Metrology for food safety" programme, which has received visiting scientists from many countries, particularly in the area of mycotoxins. This programme has received strong support from NIM and the PTB has sponsored visiting scientists. The topic of mycotoxins was initially proposed by AFRIMETS and is of great concern to many countries. The visiting scientists were trained in how to produce calibration materials and standards and the first comparison (CCQM-K154.a – Zearalenone (ZEN)) has been run by the BIPM using mycotoxin calibrant standards produced by the trainees at their home institutes to demonstrate their competence and to show that the knowledge transfer was successful. The outcome of the comparison showed very good agreement and an additional benefit from the programme has been the production of new reference materials and the establishment of new services in the area of mycotoxin analysis by the NMIs that sent visiting scientists.

The President thanked Dr Wielgosz and invited questions. Dr Duan commented that NIM has been involved in the mycotoxin and other capacity building programmes in the Chemistry Department. He noted that NIM derives an added benefit from its involvement in terms of being able to develop its capabilities. In addition, he remarked that a major achievement of the department's capacity building programme is that the knowledge acquired by the visiting scientists is being transferred around the world: this is an excellent example of the way in which the BIPM laboratories could work in the future. The Director acknowledged that the support provided by NIM has been instrumental in establishing the BIPM's capacity building activities. He clarified the difference between capacity building and training; at the end of a capacity building placement, the participants are able to return to their laboratory with the knowledge acquired to produce reference materials themselves that can be sent back to the BIPM for successful validation. He recalled that Dr Inglis, the former CIPM President, had stated that training means nothing unless it is possible to prove that something has been achieved; the capacity building programme, based on the support of many Member States, has resulted in demonstrable evidence that NMIs have benefitted. The Director echoed the comments by Dr Duan that the capacity building model adopted by the Chemistry Department could be used by other BIPM departments. The President added that the CCRI is looking at developing a capacity building programme.

Consultative Committee for Amount of Substance: Metrology in Chemistry and Biology (CCQM)

Dr Park, CCQM President, recalled that the committee had celebrated its 25th anniversary at its meeting in April 2019. The CCQM has grown significantly since its inception to cover both chemistry and biology and its number of Working Groups has expanded from three to nine technical Working Groups, two oversight Working Groups (CCQM Strategic Planning Working Group (CCQM-SPWG) and CCQM WG on Key Comparisons and CMC Quality (CCQM-KCWG)) and one CCQM *ad hoc* Working Group on the Mole (CCQM-ah-WG-Mole). In addition, there are over 250 attendees during the week of the CCQM meetings. A focus issue of *Metrologia*, entitled "Focus on Advances in Metrology in Chemistry and Biology" was published to celebrate the 25th anniversary of the CCQM, containing 20 papers. A workshop on "Advances in Metrology in Chemistry and Biology" was held during the CCQM meeting to celebrate the anniversary, which received more than 90 abstracts.

Dr Park observed that the CCQM has a programme orientated to measurement challenges in a range of areas including advanced manufacturing, energy and environment, food safety, healthcare, medical devices, personalized medicine and forensics. Addressing these challenges will require creative and multidisciplinary research in order for the chemical metrology community to achieve a wider and more profound impact.

There have been changes to the Chairs and Vice-Chairs of eight of the CCQM Working Groups, details of which were presented. An extraordinary meeting of the CCQM Working Group on Strategic Planning (CCQM-SPWG) was held at INRIM, Turin (Italy) on 5-6 October 2019 for orientation of the new Working Group leaders. The meeting covered: the BIPM, the organization, its constituent organs and the Consultative Committees; the CCQM and its processes; the CCQM WG meetings and running them: successes and challenges; CCQM and WG strategy documents (2017-2026) and their revision; impact of RMO activities on CCQM strategy; and CCQM activities in the 4-year period April 2019 to April 2023. The CCQM-SPWG meeting also discussed the timeline for the revision of the CCQM strategy document.

Dr Park noted that development of the CCQM strategy addresses the significant number of key comparisons that it operates. In order to run its key comparison programme more efficiently, the CCQM is developing and implementing “Core Key Comparison” models across the CCQM technical areas. The strategic aim is to lessen the burden at the same time as enhancing the impact of the CCQM comparison programme. The CCQM is also developing broad-scope CMCs, whereby a number of current CMCs are replaced with a single broad-scope CMC. The guidelines for broad-scope CMCs are being harmonized among the Working Groups and the three categories being developed for CMCs within the CCQM Working Group on Organic Analysis (CCQM-OAWG) were presented.

Work has continued on the development of method defined measurands, with the final report of the CCQM Task Group having been approved. Four decision criteria for method defined measurands have been established and were presented. One such method defined measurand is ‘active’ surface area and volume determined by the BET method; it was noted that this measurand might be outside the scope of the CCQM and the CCL has been consulted for advice.

The CCQM has received two applications from NMIs: INTI (Argentina) and SE “Ukrmetrteststandard” (Ukraine). Supporting information was provided to the CCQM by both institutes and their applications have been endorsed for observer status.

Dr Park remarked that the CCQM has led an extensive consultation process on the redefinition of the mole with the international chemical community to ensure their requirements are met by the redefinition. The outcome is that there is agreement on the wording of the redefinition between IUPAC, the CCQM and the CCU. He concluded by recalling that some of the CCQM Working Group Chairs had asked if logos for the CCQM are available, noting that the logos of individual institutes are on occasion used on CCQM WG reports and presentations.

The President thanked Dr Park and invited questions and comments. It was noted that logos are under development for the Consultative Committees. The CCQM was congratulated on its 25th anniversary and the efforts to make its key comparison activities more efficient and to reduce the workload were welcomed. It was asked if similar efforts are being made to streamline the number of meetings now that the CCQM is becoming mature. Dr Park replied that Working Group meeting frequency was determined by the work load of each Working Group and that not all groups met with the same frequency; some modified their meeting frequency depending on activities that needed to be covered. It was noted that the CCQM’s work on method defined analytes may be of use to other Consultative Committees and Dr Park was asked if the corresponding document was freely available. Dr Park confirmed that it is an open-access document.

Joint Committee for Traceability in Laboratory Medicine (JCTLM)

Dr Wielgosz, Executive Secretary of the JCTLM, presented an overview and its history, traceability in laboratory medicine and BIPM activities in support of the JCTLM. He noted that Dr Liew and Dr Park are members of the JCTLM Executive Committee. It was recalled that an important driver for the establishment of the JCTLM had been the introduction of the European IVD Directive 98/79/EC of 27 October 1998 on *in vitro* diagnostic medical devices, which stated that “the traceability of values assigned to calibrators and/or control materials must be assured through available reference measurement procedures and/or available reference materials of a higher order...” (Annex I - Essential Requirements. Part A. General Requirements, Clause 3). Dr Wielgosz acknowledged the contribution of the International Federation of Clinical Chemistry and Laboratory Medicine (IFCC) to the operation of the JCTLM, which has made a donation of around 50 k€ per year to cover 50 % of the JCTLM Secretariat running costs since 2005.

Dr Wielgosz said that the JCTLM database contains approximately 700 entries; the number of materials in the database has stabilized (289 in 2018) and the number of methods and services is growing. A breakdown of the content of the JCTLM database in 2019 was presented. Of the 201 reference measurement methods, 34 % were developed by NMIs. There were 303 certified reference materials (CRMs) in the database and of the 13 producers, 12 were NMIs/DIs, amounting to 95 % of the CRMs listed being from NMIs/DIs. He noted that although the European Commission’s Joint Research Centre (JRC) is no longer in the KCDB, it is still represented in the JCTLM. In terms of reference measurement services listed in the database, the vast majority were from China (39 %) and Germany (36 %) in 2019. There are currently no laboratories represented in the reference measurement services area from the USA because the JCTLM criteria requires accreditation and the laboratories in the USA that cover these services are not accredited. The annual cycle of nominations for submission to the JCTLM database yielded 157 nominations for review in 2019.

Dr Wielgosz informed the CIPM that the next biennial JCTLM Stakeholder’s Workshop will be held at the BIPM on 2-3 December 2019.

Proposal for a redrafted JCTLM Declaration of Cooperation

Dr Wielgosz commented that the JCTLM had completed a strategic review of its structure and one of the issues recognized was that member bodies were seeking greater participation in the committee. He added that although traceability is a well-known approach for some stakeholders it is less well known for others, resulting in a requirement for wider participation in the JCTLM to include more manufacturers, laboratories and regulators. In addition, the JCTLM only covers around 300 analytes out of the estimated 4 000 or so that are measured; the remainder are under the umbrella of other communities that carry out standardization in their own fields.

He recalled that a revised Declaration of Cooperation was signed by the CIPM, IFCC and ILAC in 2016, which allowed further expansion of the membership of the JCTLM. At the same time it was anticipated that there would be new members of the JCTLM Executive Committee and the hope was that the revised Declaration of Cooperation would allow this. In 2017 discussions started with the International Council for Standardization in Haematology (ICSH), which has applied for membership of the JCTLM Executive Committee. A subsequent legal review of the 2016 Declaration of Cooperation decided that the organizations that established the JCTLM by signing the original Declaration of Cooperation (BIPM, IFCC and ILAC) should be separated from new members of the Executive Committee that help with the operation of the JCTLM. As a result, the JCTLM Declaration of Cooperation has been redrafted and the proposed new document differentiates between “parties” to the Declaration of Cooperation (BIPM, IFCC and ILAC) and Executive Committee members. The parties to the Declaration of Cooperation are the only members of the Executive Committee that have the right to terminate the JCTLM.

Dr Liew added that the JCTLM Secretariat has carried out a considerable amount of work to redraft the document to allow the ICSH to become a member of the Executive Committee and seeks agreement from all parties. The revised Declaration of Cooperation was sent to the IFCC and ILAC for review and approval and

this has been completed successfully and it is ready for approval by the CIPM so that it can be signed by the relevant parties.

The President thanked Dr Wielgosz and Dr Liew. The BIPM Director asked the CIPM if it was ready to approve the signing of the redrafted document. There were no objections and Decision CIPM/108-39 was agreed.

Decision CIPM/108-39 The CIPM agreed that the CIPM President and the BIPM Director should conclude the revised Declaration of Cooperation for the JCTLM.

15. REPORTS FROM THE BIPM TIME DEPARTMENT, CCL, CCTF AND REVIEW OF THE ICG RECOMMENDATION ON GNSS TIME SCALES

BIPM Time Department

Dr Tavella said that the most important task of the BIPM Time Department continues to be the calculation of Coordinated Universal Time (UTC) via the weekly solution Rapid UTC (UTC_r) and monthly with the definitive computation, which is published in BIPM *Circular T*. She remarked that the department's work has three main drivers: to calculate, disseminate and improve the world reference time scale; to study and support the implementation of novel time and frequency transfer techniques for the comparison of highly accurate optical standards; and to promote the importance and benefits to the international telecommunications, astronomy and earth science communities of UTC as unique reference time scale.

Dr Tavella gave an overview of the calculation of UTC. She noted that the accuracy of UTC is based on steering versus the primary realizations of the SI second. Primary realizations operated by the NMIs consist of ten caesium fountains with an accuracy of 10^{-16} and two traditional caesium beams with an accuracy of 10^{-14} . An additional six Cs fountains, as well as optical standards, are under development. Secondary representations of the second are also beginning to contribute to UTC. The SYRTE (France) Rb fountain has been contributing since July 2015 and the first measurements from the SYRTE strontium lattice standards began in March 2017. The NICT (Japan) and SYRTE strontium standards entered into UTC computation in December 2018 and the NIST ytterbium lattice standard in February 2019. In September 2019 the relative accuracy of UTC with respect to the SI second was $-0.08 \pm 0.13 \times 10^{-15}$. The two primary caesium beam frequency standards operated by the PTB (Germany) have been contributing to UTC continuously for more than 30 years.

Dr Tavella remarked that primary and secondary frequency standards (PSFS) need to be compared in order to enter into UTC. This is achieved via time and frequency transfer and it requires sub-nanosecond accuracy. Achieving nanosecond accuracy is complex due to many variable factors. She noted that the most important clock comparisons are centred on Two Way Satellite Time and Frequency Transfer (TWSTFT) techniques and GNSS, which are currently based on the existing systems GPS and GLONASS. The Time Department will also include in UTC computation the newly developed GNSS systems, Galileo and BeiDou. The Time Department's calibration scheme within the RMOs using its existing travelling standard was presented.

Dr Tavella presented details of the new BIPM travelling GNSS apparatus for generic calibration purposes. The apparatus has been designed to improve accuracy and for easier deployment. It requires a reduced number of operations onsite and most of its connections are fixed; the apparatus is undergoing final tests. The first onsite calibration using the BIPM travelling GNSS apparatus will be carried out on a TWSTFT link in Asia. It is hoped that the new travelling apparatus will allow sub-nanosecond accuracy.

The Time Department is collaborating with the European Space Agency (ESA) to carry out the absolute calibration of two reference GNSS chains. Dr Tavella said that the objective of this collaboration is to calibrate the reference chains to be used by the BIPM as the reference travelling receiver for the Galileo system and the reference station to be used by NIST (USA) to collect UTC disseminated by Galileo. The calibration exercise

has been completed and the reference chains have been returned to the BIPM; a calibration report has been issued.

Dr Tavella concluded her presentation by presenting the Time Department's proposed CBKT initiatives. She remarked that a number of laboratories that have recently started contributing to UTC have asked for support to improve the quality of their data. A secondee from NICT is helping the department to develop a CBKT initiative to address this requirement and funding is being sought.

The President thanked Dr Tavella and invited questions and comments. It was asked why the Cs fountain clocks operated by the NPL (UK) and NIST were no longer contributing to UTC. Dr Tavella replied that contributions are not continuous as the operation of a primary standard is quite complex and it may need important maintenance periods. Mr Henson commented that the next Work Programme starting in 2020 includes core capacity building initiatives to support the CIPM MRA. Ideologically, there is no difference between supporting the MRA and supporting the proposed Time Department initiative. If a new laboratory that participates in the CIPM MRA performs poorly, it affects all other laboratories. The same is true for the calculation of UTC; poor incoming data has a negative impact on the speed and quality of the generalized solution. The effective generation of UTC in terms of capacity building initiatives could be included in the Work Programme for 2024-2027.

Consultative Committee for Length (CCL)

Dr Castelazo, CCL President, said that the CCL had not met in 2019 and that its next meeting was scheduled for 2021. The CCL Working Group on Dimensional Nanometrology (CCL-WG-N) and the CCL Working Group on the CIPM MRA (CCL-WG-MRA) will hold meetings at the PTB (Germany) on 17-18 October 2019. He commented that a recent highlight from the CCL has been the publication of the *mise en pratique* (MeP) for the definition of the metre in the SI. The MeP was published in Appendix 2 of the 9th edition of the SI Brochure. Until this publication, the only method available to establish the MeP for the definition of the metre was through the "recommended values of standard frequencies" in common with the CCTF. The MeP recognizes that there are different ways to realize the metre, for example time of flight and interferometry. It also includes the silicon crystal parameter as a secondary representation for nanodimensional measurements. Three guidance documents have been published to cover the use of the silicon crystal parameter in atomic force microscopy, x-ray spectrometry and transmission electron microscopy.

Dr Castelazo concluded by recalling that the CCL strategic plan and Summary document were published in 2018.

The President thanked Dr Castelazo and asked if there is any cooperation between the CCL and the CCQM Working Group on Surface Analysis (CCQM-SAWG) in the area of nanodimensional measurements, particularly for transmission electron microscopy. Dr Castelazo replied that they are working on different areas; the CCQM-SAWG looks at the broader scale of surface analysis, whereas the CCL focuses on a much narrower scale. However, the CCL has been asked for clarification on the use of m^2/kg for specific surface area (SSA) in the CCQM. The CCL-WG-MRA has been informed of the issue and the conclusion is that it is a separate quantity.

Consultative Committee for Time and Frequency (CCTF)

Dr Dimarcq, CCTF President, congratulated Dr Tavella and the BIPM Time Department on the quality of the work it has undertaken. He said that the last meeting of the CCTF had been held in June 2017 and the 22nd meeting is scheduled for 29-30 October 2020. The CCTF Working Group on Strategic Planning (CCTF-WGSP) had met on 26 June 2019, 11 October 2019 and its next meeting is scheduled for 20 April 2020. Meetings of the CCTF-WGSP receive progress reports from the CCTF Working Group Chairs and a core team has been established to reflect on important subjects that are identified and to prepare for the next meeting of the CCTF. The 22nd meeting of the CCTF will be preceded by meetings of its Working Groups from 22-28 October 2020 and a one-day workshop on optical time scales as proposed by Dr Donley, NIST (USA).

He recalled that a CCTF statement on relativity had been presented at the 24th meeting of the CCU in October 2019. The statement noted that general relativity is a correct framework for time and frequency metrology down to uncertainty levels of 1×10^{-18} in frequency (for clocks) and 1 ps in time (for time transfer). It is properly managed in scientific and industrial applications such as GNSS. The CCU meeting had been followed by the joint CCU-CCTF Workshop on Advanced Time and Frequency Transfer (ATFT): the ultimate frontier for remote comparison methods on 10 October 2019.

Dr Dimarcq said that one of the major areas of work in progress within the CCTF is the proposed redefinition of SI second, including scientific and practical aspects as well as the potential impact for stakeholders and end users. He commented that a roadmap is in place for the redefinition. He will propose a CCTF Task Group, consisting of members of the CCTF-WGSP with additional experts, to prepare a document that will outline the status and characteristics of optical frequency standards as well as providing a description and comparison of the options for choosing a new definition of the SI second and its realization. The document should also review the status and characteristics of time and frequency transfer techniques for standards comparisons and the dissemination of the unit for end users, as well as validating the criteria to decide if it is the right time to propose a new definition of the SI second. The Task Group will be asked to prepare a questionnaire to determine the needs of stakeholders to evaluate the possible impact of a redefinition of the second in their fields.

Dr Dimarcq commented that a major area of work for the CCTF is the increasing role of secondary frequency standards in the steering of TAI and the emergence of optical time scales. The latter will be the subject of the previously mentioned one-day workshop on optical time scales in October 2020. He added that this will be supported by a capacity building and knowledge transfer (CBKT) initiative in the construction of atomic time scales. The CCTF is also working on promotion of the important benefits of the unique reference time scale, UTC, to the international scientific and industrial communities.

A considerable amount of work is being undertaken in the CCTF on the subject of UTC-UT1 and leap seconds in preparation for the International Telecommunication Union (ITU) World Radiocommunication Conference 2023. Dr Dimarcq explained the background to the need for leap seconds by saying that when the rotation of the Earth (UT1 time scale) reaches a one second difference with respect to International Atomic Time (TAI), one second is added to maintain the agreement of the reference time scale Coordinated Universal Time (UTC) with the Earth's rotation. Users have addressed the issue of UTC and the second discontinuity in different ways. GNSS systems defined their own time scale, initially synchronized with UTC and then not adding a leap second (with the exception of GLONASS), to avoid discontinuities. Some users implement the leap second in various non-standard ways. For example Google smear, which adjusts the frequency of the clock to add a second over a longer period such as a day; and the Microsoft method, which slows the time advance by a factor of 2 during the last second of the leap second day, so that 23:59:59 advances monotonically at one-half of the normal rate; the extra second is added as the first second of the next day, so that the time 00:00:00 is repeated twice. These methods can agree with UTC in the long-term, but produce non-standard time scales that have offsets from each other in time or in frequency in the vicinity of a leap second. Since the methods are not standard, they generally disagree with each other, and it is not clear to a user what time value is actually being received. The CCTF would like to avoid the proliferation of such time scales otherwise there is a long-term problem that UTC will slowly become less relevant to a large segment of the time community.

Dr Dimarcq recalled that Resolution 2 of the 26th meeting of the CGPM (2018) "On the definition of time scales" addressed this issue and recommended that: all relevant unions and organizations consider these definitions and work together to develop a common understanding on reference time scales, their realization and dissemination with a view to consider the present limitation on the maximum magnitude of UT1-UTC so as to meet the needs of the current and future user communities. It further recommended that all relevant unions and organizations work together to improve further the accuracy of the prediction of UT1-UTC and the method for its dissemination to satisfy the future requirements of users.

Dr Dimarcq suggested that in order to prepare for the ITU World Radiocommunication Conference 2023 a CIPM Task Group could be created that could take actions at a “political level”, with communications and a pedagogical approach aimed at NMIs, International Unions and particularly ITU members who will be attending the 2023 ITU meeting. The Task Group could also gain a better understanding of the origins of the opposition to the suppression of leap seconds, for example to have $UTC-UT1 > 1$ s. He suggested that the composition, ToR and methodology for the Task Group could be developed and presented at the next CIPM meeting in 2020. It was noted that the ToR will need to be clear on the independence of CIPM members that participate in the Task Group. The CIPM agreed Decision CIPM/108-40.

Decision CIPM/108-40 The CIPM asked the CCTF President and the Director of the BIPM Time Department to establish a CIPM task group to support the preparation of the CIPM for the World Radiocommunication Conference in 2023.

The Director informed the CIPM that following discussions between the BIPM and the ITU, a draft memorandum of understanding agreement has been developed. The legal departments of both organizations have reviewed the draft.

Review of the ICG recommendation on GNSS time scales

Dr Dimarcq said that the UN International Committee on Global Navigation Satellite Systems (ICG) is discussing the interoperability of different GNSS systems. He commented that in order to use the systems together, it is necessary to know the time offsets between system time scales, for example GPS-Galileo, GPS-BeiDou, Galileo-BeiDou, GLONASS-BeiDou and GPS-GLONASS. If sufficient satellite observations are available, the preferred solution is for the receiver to estimate any additional “unknowns”. In some special cases, for example in urban canyons, it is useful to have additional broadcast information. It was proposed that only one type of information should be broadcast: the offset. This could take the form of a simple average of GNSS time scales or a high-precision time scale broadcast in real time. Alternatively, an existing reference such as UTC could be used. Each GNSS is already predicting and broadcasting “GNSST – UTC/UTC(*k*)” for time dissemination services. If an uncertainty of 5-7 ns is acceptable (as in urban canyons), the use of the current UTC common reference time scale is sufficient and there is no need to establish a new, real-time broadcast, time reference.

The International GNSS Services (IGS), with the support of many NMI time experts, is working on a recommendation that does not support the realization of a new time scale in order to avoid proliferation of international standards and the confusion that this could cause. The BIPM is keen to work together with GNSS and timing experts with the common aim of finding a solution to ensure interoperability and to reinforce the benefits of a unique common reference time scale (UTC). Dr Dimarcq recalled that Resolution 2 of the 26th meeting of the CGPM (2018) “On the definition of time scales” stated that UTC produced by the BIPM, based on TAI, is the only recommended time scale for international reference and the basis of civil time in most countries. Furthermore, the 15th meeting of the CGPM (1975) strongly endorsed this usage, and recommended working together with relevant organizations to develop a common understanding on reference time scales. He asked the CIPM to support the work of the IGS and ICG in this matter.

Proposal for a CIPM decision

Considering also the Resolution 2 of CGPM (2018) recommending to work together with relevant organizations to develop a common understanding on reference time scales, it seems appropriate that the CIPM is also involved in this debate and thus the following decision is proposed. The CIPM decision would be forwarded to the ICG-14 as a contribution to the ongoing discussion.

The CIPM considering

- the need of common space and time references for the interoperability of GNSS and the current

discussion going on at the ICG (International GNSS Committee) of the United Nations.

- the current work within the IGS (international GNSS services), with the support of many NMI time experts, on a recommendation not supporting the realization of a new time scale to avoid proliferation of international standards.
- the risk of having different international time scales broadcast world-wide that, at user level, could create confusion.
- Resolution 2 of the 26th meeting of the CGPM in 2018 that recommended working together with relevant organizations to develop a common understanding on reference time scales.

Decides

to strengthen the collaboration with the involved organizations, such as IGS and ICG, to work together to understand the needs of Multi GNSS interoperability and to explore the capacity of the current and future Coordinated Universal Time to serve to this purpose, with the final goal of avoiding the proliferation of international time standards

After a brief discussion, the following decision was agreed.

Decision CIPM/108-41 The CIPM decided to support the International GNSS services (IGS) and the International GNSS Committee (ICG) in exploring the capacity of GNSS providers to ensure multi-GNSS interoperability, based on Coordinated Universal Time (UTC), with the final goal of avoiding the proliferation of international reference time scales.

16. ELECTIONS (INCLUDING PRESIDENTS FOR THE CCAUV AND CCRI) AND APPLICATIONS FOR MEMBERSHIP AND OBSERVERSHIP OF THE CCs

Elections were held for the vacant positions of President of the CCAUV and the CCRI. The positions became vacant after Dr Usuda (CCAUV) and Dr Louw (CCRI) stepped down from the roles. The candidates for the vacant positions gave presentations in support of their applications. Following a vote, the CIPM appointed Dr Laiz as the President of the Consultative Committee for Acoustics, Ultrasound and Vibration (CCAUV) and Dr Sené as the President of the Consultative Committee for Ionizing Radiation (CCRI).

Decision CIPM/108-42 The CIPM appointed Dr Laiz as the President of the Consultative Committee for Acoustics, Ultrasound and Vibration (CCAUV).

Decision CIPM/108-43 The CIPM appointed Dr Sené as the President of the Consultative Committee for Ionizing Radiation (CCRI).

Applications for membership and observership of the CCs were discussed, with the following outcomes.

Decision CIPM/108-44 The CIPM accepted the following changes to the membership and observership of the Consultative Committees:

- CCEM
 - CMI (Czechia) as a member
- CCM
 - INMETRO (Brazil) as a member
 - IPQ (Portugal) as a member
- CCPR
 - SCL HK (Hong Kong (China)) as an observer
- CCQM
 - INTI (Argentina) as an observer
 - SE “Ukrmetrteststandard” (Ukraine) as an observer
- CCRI
 - BEV (Austria) as a member
 - CMI (Czechia) as a member
 - METAS (Switzerland) as a member
 - NMISA & iThemba LABS (South Africa) as a member
- CCU
 - INRIM (Italy) as a member
 - NSC “Institute of Metrology” (Ukraine) as an observer

An election was held to fill the vacant Chair of the CIPM Sub-Committee on Finance. Following a presentation the CIPM appointed Dr Richard as the Chair of the CIPM Sub-Committee on Finance. Dr Steele, the Chair of the Pension Fund Advisory Board, was confirmed as an *ex officio* member of the CIPM Sub-Committee on Finance.

Decision CIPM/108-45 The CIPM appointed Dr Richard as the Chair of the CIPM Sub-Committee on Finance and as an *ex officio* member of the Pension Fund Advisory Board (PFAB). Dr Steele, the Chair of the Pension Fund Advisory Board, was confirmed as an *ex officio* member of the CIPM Sub-Committee on Finance.

17. MISCELLANEOUS REPORTS

BIPM International Liaison and Communication (ILC) Department

Mr Henson, Director of the ILC Department, presented the different types of interaction carried out between the BIPM and other organizations and highlighted the ‘door opening’ topic-based *ad hoc* liaisons. These are early-stage liaisons that may be a one-off topic, such as the specific engagement with the European Aviation Safety Agency (EASA), or which may develop into a deeper liaison.

Mr Henson recalled that 2003 was a pivotal year for BIPM liaison activities. A number of resolutions at the 22nd meeting of the CGPM (2003) introduced a “generalized” concept for liaison activities, which had previously been handled as single-topic liaisons. This series of resolutions noted and welcomed the formal arrangements with ILAC, WHO and WMO, and invited international and intergovernmental organizations for which metrology impinges on their activities to cooperate with BIPM, to develop similar formal relationships and, if necessary, participate in Joint Committees. The resolutions also initiated the cooperation between the

BIPM and the WTO Committee on Technical Barriers to Trade (WTO-TBT) and participation in the work of the JCDCMAS (now INetQI); the collaboration with the JCDCMAS was used as a method of promoting wider membership of the BIPM. In addition, the resolutions promoted participation in the CIPM MRA, participation of DIs in the MRA and collaboration between the NMIs and national accreditation bodies.

Mr Henson presented an internal guidance document on liaison activities that is used internally by members of the ILC Department. It amalgamated a number of separate texts into one document. The 40 page document "*Introduction to the BIPM liaison work with International Organizations*" ensures a consistent message for the work of the ILC Department and provides a classification of the type of liaison and collates and maintains the knowledge the BIPM has for each organization. The document also provides useful information such as a chronology of key events in each liaison including the signing of Memoranda of Understanding and the exchange of letters, with the associated governance information.

The key outcomes of cooperation with liaisons from March to October 2019 included the receipt of the draft poster for World Metrology Day (WMD) 2020 from AFRIMETS on 4 October 2019. This has been produced as part of the long-standing and ongoing collaboration with the OIML. Mr Henson recalled the discussions in §7 on the revision of CIPM document OIML D 1 "Considerations for a Law on Metrology" (2012) and thanked the CIPM for their agreement to form a small task group to support this revision, which will be discussed at the bilateral meeting in March 2020. He remarked on the ongoing collaboration with the WTO-TBT noting that the BIPM had attended the Committee's meetings in March and June 2019 and will give a presentation in the Quality Infrastructure thematic session of the WTO-TBT Committee on 12 November 2019 and a joint presentation with the OIML at the WTO-TBT Advanced Short Course for least-developed countries (LDCs) on 13 November 2019.

Mr Henson commented that the BIPM has a long-standing liaison with the United Nations Educational, Scientific and Cultural Organization (UNESCO), although it had been dormant in recent years. A joint BIPM-OIML proposal was submitted to the UNESCO International Basic Sciences Programme (IBSP) during July 2019 to have WMD proclaimed by UNESCO as a World Day. The IBSP will have to endorse the proposal before it can be submitted to the UNESCO Executive Board. He asked the CIPM if they have any contacts in UNESCO, and if so to let him know so that advocacy can be discussed in case the process with the IBSP is unsuccessful.

Staff from the ILC Department have contributed actively to the second phase of the Organisation for Economic Co-operation and Development (OECD) International Organizations Partnership for effective international rule-making and, in addition, the OECD study "The Case of the BIPM" is expected to be launched in February 2020.

The text of a Memorandum of Understanding (MoU) between the BIPM and the International Union of Pure and Applied Chemistry (IUPAC) has been agreed by the CIPM (see Decision CIPM/108-23) and the signing is scheduled for 17 October 2019. A MoU with the International Telecommunication Union (ITU) has been drafted and the initial comments from the ITU are being reviewed by the BIPM.

Mr Henson informed the CIPM that he had participated in the annual meeting of INetQI in June 2019 and the NCSLI Board meeting in August 2019. In addition, he had taken part in the Pacific Quality Infrastructure Initiative – Regional Workshop in September 2019. He commented that there are 18 members of the intergovernmental body, the majority of which are small islands that wish to participate in the quality infrastructure. The Pacific Island Forum has suggested that it may wish to participate as an Associate Economy of the CGPM in the future, although this option had been called into question in Resolution 5 of the 24th CGPM (2011). This resolution did however include the proviso that the CIPM would consider further appropriate means by which intergovernmental organizations, in particular those from regions without well-developed metrology infrastructure, can be involved in the work of the BIPM and to bring forward proposals to the next meeting of the CGPM on how this can best be achieved. Mr Henson suggested that the CIPM should revisit this commitment.

Mr Henson reminded the CIPM that if they were aware of any issues for discussion with ILAC, the BIPM should be informed ahead of the next bilateral meeting in March 2020 so that the topics can be added to the agenda. He referred to the request from two of the CC Presidents for CC brand identity and presented a few examples of the proposed new logos for the CCs (and Working Groups if needed), noting that they have a “family identity” across the BIPM. He added that the CC Presidents may wish to collaborate on the guidance for the use of the logos. He concluded by saying that the ILC Department includes many other activities that were not covered in the report, for example operation of the website and the CBKT programme.

CIPM Vice-President coordinating liaison activities

Dr Olthoff said that there were two actions from the 41st meeting of the Joint Committee of the Regional Metrology Organizations and the BIPM (JCRB), which was held in Dubai (United Arab Emirates) in September 2019. Action 41/1 endorsed the establishment of an *ad hoc* Task Group, led by Dr Macdonald from the NRC (Canada), to formulate a proposal for consideration at the 42nd meeting of the JCRB in March 2020 regarding the reporting requirements and associated process related to the JCRB actions to establish confidence in each RMO’s QS review process. The proposal may include recommendations related to the informal meeting of RMO QS review representatives and updates to CIPM MRA-G-02 ‘Guidelines for the monitoring and reporting of the operation of quality systems by RMOs’. The latest date for submitting the proposal to the JCRB is 11 February 2020. Action 41/2 called for APMP to send its revised guidelines for the operation of hybrid comparisons to the next meeting of the JCRB in March 2020. He noted that the 42nd meeting of the JCRB will take place at the BIPM on 11-12 March 2020 and the 43rd meeting will take place in week 37 of 2020 in Bogota (Colombia).

Dr Louw added that hybrid comparisons had been approved at the 40th meeting of the JCRB. Dr Olthoff said that the revised guidelines will give advice on when it is appropriate to use hybrid comparisons, particularly if a key comparison or regional comparison is not appropriate.

Progress with the KCDB 2.0

Mr Henson presented a series of screenshots from the KCDB 2.0 and reported that the launch is scheduled for 29 October 2019, with different sections being rolled out in stages. He thanked the NMIs for the beta testing that they have carried out. It was noted that any CMCs submitted into the existing KCDB will continue to be reviewed in that system.

Mr Henson said that a training session for the KCDB 2.0 will be held at the BIPM in November 2019, with sponsorship from NIST (USA). Training will also be carried out in the regions. A range of short video clips have been produced to explain specific tasks in the KCDB 2.0. Guidance documents are also available.

18. REPORTS FROM THE CIPM SUB-COMMITTEES

CIPM Sub-Committee on Finance

Dr Sené, outgoing Chair of the Sub-Committee, said that the 2018 BIPM accounts had been completed within the scheduled time by the Finance Office, with external support from In Extenso. The accounts were audited and signed off on 31 May 2019 without qualification, although there was a note on the pension fund as a reminder that there is a significant liability that rests with and is covered by the Member States. The BIPM Financial Report 2018 was published on time in June 2019.

The meeting of the Sub-Committee held on 20 June 2019 reviewed the 2018 financial statements and a minor restatement of the 2019 budget. In addition the Sub-Committee reviewed the agreed budget for 2020-2023 and received an update on the Pension and Provident Fund.

Dr Sené presented the main points of the 2018 financial statement. Income was in line with the forecast at 13 636 k€. Operating expenditure saw a reduction in staff costs of 350 k€ due to the changing profile of staff,

retirements and the policy on annual pay rises and progression. In absolute terms, staff costs were lower than in 2012. Pension contributions were reduced in line with plans. There were a number of one-off costs in 2018, including the 26th meeting of the CGPM, some offsite comparisons, disposal of radioactive sources, and increased use of subcontractors. It was noted that the healthcare indemnity provision in the financial statement for 2018 is an actuarial gain that did not involve any transactions. Capital expenditure increased to 1 537 k€ in 2018 due to the late arrival of a mass spectrometer that had been scheduled to arrive in 2017 and because of the cost of software and website renewal projects.

Earnings before interest, taxes, depreciation, and amortization (EBITDA), excluding healthcare provision and capitalization of staff cost, amounted to 1 990 k€ in 2018, which more than covered depreciation of 1 502 k€. Cash flow in 2018 was positive, with an operational cash flow of 2 419 k€ and net cash flow of 1 380 k€. The cash flow was positively impacted by improved processes to follow up on outstanding contributions. Total reserves for 2018 were 16 529 k€.

Dr Sené remarked that the CIPM Sub-Committee on Finance had commended Dr Milton and his team on its prudent financial control and performance. The Sub-Committee had unanimously agreed that the financial statements for 2018 should be recommended for approval by the CIPM and that the “director be granted quietus”. It had also agreed that the changes in format and content of the 2019 budget, proposed by the BIPM Director, should be recommend to CIPM for formal ratification. These changes in format made a clear distinction between the costs associated with laboratory activities and those for liaison and communication activities.

The Sub-Committee had had a brief discussion on the budget for 2020. It also agreed that lessons should be learned from the delay in the delivery of the mass spectrometer for the Chemistry Department, which had been due in 2017, to avoid similar CAPEX delays in the future.

The President thanked Dr Sené and invited questions. The Director added that three decisions related to financial issues had been agreed by correspondence.

Decision CIPM/108-46 The CIPM noted the decision taken by correspondence to approve the audited financial statements of the BIPM and of the BIPM Pension and Provident Fund, which were reviewed by the CIPM Sub-Committee on Finance in June 2019. The CIPM granted the BIPM Director quietus for the 2018 exercise.

Decision CIPM/108-47 Following the recommendation of the CIPM Sub-Committee on Finance, the CIPM approved the budget for the BIPM proposed by the Director for 2019.

Decision CIPM/108-48 Following the presentation to the 26th meeting of the CGPM (2018), the CIPM approved the budget for the BIPM for 2020.

Pension Fund Advisory Board (PFAB)

Dr Steele, Chair of the PFAB, remarked that the difficult decisions and practical changes related to the pension fund have been implemented. He presented the new structure of the PFAB, noting that there are now three elected staff representatives and one elected pensioner representative. The Board includes an external expert, Mr Grenon from the LNE (France) to provide context for the pension situation in France as well as financial expertise.

Dr Steele said that the two recent meetings, in June and October 2019, began the process of moving forward with the post-implementation phase of the reforms to the fund. He recalled that the CIPM bureau had met with the BIPM staff in June 2019 to discuss the reforms to the Pension and Provident Fund; this meeting had been welcomed by the staff and had proved successful. Dr Steele commented that he is conveying the message to staff that the PFAB is not a decision making body, it is an advisory board that provides an advisory opinion to the CIPM.

The penultimate draft of the Actuarial study for 2019 by Mercer will include adjustments made in response to the PFAB meeting in October 2019, will be delivered by mid-November 2019. The PFAB will use this as the basis for its recommendation to the CIPM. The principal message is that the stability of the Pension and Provident Fund has been greatly improved by the changes that are being implemented. The original scenario presented to the 25th meeting of the CGPM (2014) showed a declining balance. The draft study provided by Mercer seems to support the view that the financial decisions recommended for implementation by the CIPM have addressed these issues. He added that the final report from Mercer will be made available to the BIPM staff and the advisory opinion of the PFAB will be presented to the CIPM members for their consideration.

The next meeting of the PFAB will be in March or April 2020, depending on the date of the next CIPM meeting. In the meantime, the PFAB will continue to work by correspondence to discuss any matters arising from the discussion of the Mercer report in November 2019.

The President thanked Dr Steele and invited questions. The Director said that the decisions related to the Pension and Provident Fund that had been previously taken are being implemented.

CIPM *ad hoc* Working Group on Conditions of Employment (WG-CoE)

Dr Usuda, Chair of the *ad hoc* Working Group, presented its membership and commented that it had held its last meeting at the BIPM on 18 June 2019. It was agreed at the meeting of the WG-CoE that its terms of reference should be updated so that its remit is “to oversee a review of the BIPM remuneration package (basic salary, allowances and benefits), in comparison to those offered in various employment markets, namely: other international organizations based in France and other western European countries, such as the European Space Agency (ESA), World Meteorological Organization (WMO), World Health Organization (WHO), the European Organization for Nuclear Research (CERN) and the European Commission and some major national metrology institutes, including the LNE” and report to the CIPM.

Dr Usuda remarked that the WG-CoE had agreed to endorse the proposed terms of reference for a Salary Levels Study to be conducted by International Service for Remunerations and Pensions (ISRP) with the study to be delivered in principle by late July 2020. The WG-CoE had welcomed the participation of a BIPM staff representative and the proposal for a staff satisfaction survey to be carried out through the Commission for Conditions of Employment (CCE). Dr Usuda noted that the CIPM bureau shall maintain regular dialogue with delegates from the CCE as the WG-CoE is maintained under *ad hoc* status.

The President thanked Dr Usuda and following a brief discussion the CIPM approved the revised terms of reference for the CIPM *ad hoc* Working Group on Conditions of Employment.

19. ADJUSTMENT OF THE VALUE OF THE POINT FOR SALARIES AND THE PENSION POINT

The Director started by recalling that the value of the *point*, the unit of the BIPM salaries scale, is revised to correct for any increase in the cost of living on 1st January every year, in accordance with staff rules. In recent years, the CIPM, pursuant to its Decisions CIPM/101-27 and CIPM/104-29, has approved the adjustment of the *point* by a maximum of 1 % on an annual basis, for the years 2013 to 2019. However, with the exception of 2019, there was no need to apply this measure given that the annual cost of living increase was not higher than 1 %. In 2019, an adjustment of more than 1 % was applied in the interest of staff, given the extent of the adjustment over the previous three years and in accordance with BIPM financial obligations. Likewise, the value of the pension *point*, introduced as per Decisions CIPM/106-6 and CIPM/106-7, is adjusted using the same mechanism as for the calculation of the *point* used for salaries, as indicated by Article 17.4 of the Rules of the Pension and Provident Fund.

The Director indicated that he had been working towards streamlining the procedure with the aim to improve the yearly *point* revision exercise. He reminded the CIPM that there is a process used to carry out a

consultation with the CCE for any proposed change to the Regulations, Rules and Instructions (RRI) applicable to BIPM staff members and to seek their advisory opinion. As known by the CIPM, the CCE has been consulted several times during 2019 for their advisory opinion on proposals which would affect the conditions of employment of staff members.

One of these consultations concerned the proposal for the amendment of Rule 10.2.1 of the RRI concerning salary adjustments and the enlargement of what is called the “affordability clause”. The proposed amendment suggested an improvement of the actual text by mirroring the provisions of the staff rules of other international organizations like the OECD. However, taking into consideration the CCE’s advisory opinion to not modify this rule, it has been decided not to pursue the amendments at this stage.

The Director concluded by indicating that, the agreement of the BIPM dotation at the 26th meeting of the CGPM [Resolution 4 (2018)] and the Work Programme for the period 2020 to 2023 were costed on the assumption that the BIPM budget would correspond to a 1 % compound increase for each year during this period. Staff costs in the plans presented to the CGPM were based on an assumption of 2 % annual inflation applied to salaries and allowances.

The Director invited questions. Dr Sené, the outgoing Chair of the CIPM Sub-Committee on Finance, asked for clarification as to why there was an annual 1 % compound increase in the dotation, but in the calculations to arrive at the budget, the Director budgeted for a 2 % annual inflation increase in staff costs. It seems this is a prudent measure taken by the Director so as to set the cap at 2 %, which is consistent with the budgeting process, even though it is not expected that the cap will be reached unless inflation is affected by a significant change in the economic situation. The Director confirmed that indeed it is a prudent measure, and that the 2 % ceiling is not expected to be reached.

Dr Steele suggested that the CIPM should consider that it is important to note that although a 1 % ceiling had been set for adjusting the *point* between 2013 and 2019, this ceiling had never been applied. In addition, although there is a concern that the salary burden out of the total BIPM budget is high compared to other organizations, the BIPM has been judicious in managing salary expenditure, which has gone down since 2012. He noted that the text of the CCE’s advisory opinion on the amendment to Regulation 10.2.1 of the RRI had been made available to the CIPM on its webpage. The President added that input from the BIPM staff is vital and stressed that the CIPM always considers the best interests of the staff at the same time as doing its duty to ensure that the BIPM stays within budget.

The Director submitted the following decision proposal to the CIPM for consideration:

The CIPM members,

RECALLING decisions CIPM/101-27 and CIPM/104-29 by which the CIPM approved the maximum adjustment of the value of the *point*, the unit of the BIPM salaries scale, by a maximum of 1 % on an annual basis;

RECALLING decisions CIPM/106-6 and CIPM/106-7 by which the CIPM decided to introduce the pension *point*, unit used to calculate pensions, and to suspend its adjustment for the period 2018-2019;

CONSIDERING that the agreement of the BIPM dotation at the 26th meeting of the CGPM [Resolution 4 (2018)] and the 2020-2023 Work Programme were costed on the assumption that the BIPM budget would correspond to a 1 % compound increase for each year during this 4-year period;

CONSIDERING that in order to meet the BIPM’s financial obligations for the period 2020 to 2023, staff costs were based on the assumption of a 2 % annual inflation applied to salaries and allowances;

DETERMINED to ensure the long-term financial stability of the BIPM Pension Fund;

DECIDES with respect to the value of the *point*, that:

- during the period 2020-2023, the value of the *point* for salaries be revised on 1st January every year,

in accordance with regulation 10.2 of the staff regulations applicable to staff members, up to a maximum adjustment of 2 % on an annual basis, in order to meet the BIPM's financial obligations and essential operating requirements;

- during the period 2020-2023, the value of the pension *point* be revised on 1st January every year, in accordance with article 17.4 of the common Rules of the Pension and Provident Fund, up to a maximum adjustment of 2 % on an annual basis, in order to meet the BIPM's financial obligations and long-term financial sustainability of the Pension Fund.

The following two decisions were adopted:

Decision CIPM/108-49 The CIPM decided that during the period 2020-2023, the value of the Point for salaries be revised on 1st January every year, in accordance with Staff Regulation 10.2 applicable to staff members, up to a maximum adjustment of 2 % on an annual basis, in order to meet the BIPM's financial obligations and essential operating requirements.

Decision CIPM/108-50 The CIPM decided that during the period 2020-2023, the value of the Pension Point be revised on 1st January every year, in accordance with Article 17.4 of the common Rules of the Pension and Provident Fund, up to a maximum adjustment of 2 % on an annual basis, in order to meet the BIPM's financial obligations and long term financial sustainability of the Pension Fund.

20. REPORT ON *METROLOGIA* AND RENEWAL OF THE BIPM WEBSITE

Dr Miles presented a brief report on *Metrologia* and highlighted that it had reached an impact factor of 3.447, in 2018, its highest ever.

She noted that *Metrologia* abides by the IOP ethical policy, and that IOP is a member of the Committee on Publication Ethics (COPE). *Metrologia*'s policy on data availability is to encourage authors to make their data freely available, although as yet there is little uptake in the metrology community. Pending her return to the editorial office, the editorial work is being undertaken by Dr Richard Davis (BIPM), Dr Giovanni Mana (INRIM), Dr Sten Bergstrand (BIPM, on secondment from RISE) and Dr D. Rod White (MSL), and she expressed her gratitude to the individuals as well as their institutes for their support.

Amongst the improvements that have been made in the last few years, "accelerated publishing" now means that a paper can be made available online on the same day it is accepted. Dr Miles demonstrated other new functionality available on the *Metrologia* website, for example real-time data on citations and statistics on the use of papers, and showed as an example "The CODATA 2017 values of h , e , k , and N_A for the revision of the SI⁷", which had already been downloaded over 20 000 times.

Dr Miles drew attention to recent Focus Issues, including "Advances in Metrology in Chemistry and Biology", "Metrology in Electricity and Magnetism", and "Quantum Metrology". These are often developed in association with the Consultative Committees, and she reminded the CIPM that *Metrologia* also includes a section on Guides, Standards and Conventions, which can be used to publish *Mise en Pratique* documents and other CC documents such as the joint CCPR-CIE document on Principles Governing Photometry.

Dr Miles concluded by reporting that the BIPM website is being redesigned and is scheduled for relaunch early in 2020. Participants at meetings will have an individual login that will provide access to all relevant documents.

Dr Liew expressed his thanks to Dr Miles for the advances made with *Metrologia* under her leadership.

⁷ Newell D.B. *et al.*, The CODATA 2017 values of h , e , k , and N_A for the revision of the SI, *Metrologia*, 2018, **55**(1), L13

21. SCHEDULE OF MEETINGS FOR 2020-2022

2020

Week 12	(16 – 20 March)	CIPM bureau, liaison meetings, strategy workshop, CIPM Task Group on the Digital SI
Week 13	(23 – 25 March)	CCT
Week 17	(20 – 24 April)	CCQM
Week 25	(15 – 19 June)	CIPM and Working Groups
Week 42	(12 – 16 October)	CIPM and NMI Directors Meeting
Week 44	(26 – 30 October)	CCTF

2021

Week 12	(22 – 26 March)	CIPM bureau and liaison meetings
Week 15	(12 – 16 April)	CCEM
Week 16/17	(23 – 30 April)	CCQM
Week 20	(17 – 21 May)	CCM
Week 23	(7 – 11 June)	CCRI
Week 25	(21 – 25 June)	CIPM, Working Groups and workshop
Week 38	(20 – 24 September)	CCU
Week 40	(4 – 8 October)	CCAUV
Week 42	(18 – 22 October)	CIPM and NMI Directors Meeting
Week 43	(25 – 28 October)	CCL

2022

May	CCPR
June	CCTF

22. DEPOSITORY OF THE METRIC PROTOTYPES

The visit to the depository of the metric prototypes at the Pavillon de Breteuil took place at 17:35 on 15 October 2019 in the presence of the President of the CIPM and the Director. (see Appendix 2).

23. ANY OTHER BUSINESS

Dr Richard asked if any decisions were needed relating to the actions from the CIPM Sub-Committee on Strategy. It was recalled that decision CIPM/108-31 had been adopted, which included the terms of reference.

The President closed the meeting.

Appendix 1

REPORT OF THE SECRETARY AND ACTIVITIES OF THE BUREAU OF THE CIPM

(March 2019 – October 2019)

REPORT OF THE BUREAU MEETING HELD ON 22 MARCH 2019

Review of matters arising from Session I of the 108th meeting of the CIPM (2019)

The list of draft decisions were reviewed by the bureau and agreed for circulation to CIPM members.

Review of topics arising from the quadrilateral and bilateral meetings

The Director of the International Liaison and Communication (ILC) Department, Mr Henson, was invited to present the outcomes from the BIPM-ILAC, BIPM-OIML and the BIPM-ILAC-OIML-ISO meetings held immediately prior to the bureau meeting, as well as other international liaison issues. Dr Olthoff, a member of the CIPM bureau, will serve as a liaison with Mr Henson on issues related to interactions with ILAC. He will present progress at the meeting of NMI Directors.

CIPM-ILAC joint statement

The communication and circulation process for the revision of the CIPM-ILAC joint statement was discussed with recognition of the importance of the document. Consideration was given to each bureau member making contact with national/regional accreditation authorities with regard to the statement. A bureau member will be invited to attend the ILAC General Assembly.

BIPM-OIML joint action

Communications between the Director of the BIPM and the OIML found common areas of interest, such as sharing resources, including meeting spaces and e-learning materials.

BIPM-ILAC-OIML-ISO meeting

The Quadrilateral meeting will continue as an annual information exchange forum every March.

Communication with UNESCO

Contacts by the Director of the BIPM and Ms Guliyeva (ILC Department) with UNESCO have indicated that there is interest in making World Metrology Day an official UNESCO ‘international day’. The possibilities, benefits and application procedures will be examined for further discussion at the next CIPM meeting.

BIPM-IUPAC MoU

A draft memorandum of understanding (MoU) between the BIPM and IUPAC has been produced, which is intended to formalize existing arrangements. It will be sent to IUPAC for review and comments.

Actions on implementation of CGPM Resolution 5 (2018)

The bureau confirmed that the exclusion process for Venezuela has been concluded.

The bureau decided to charge the CIPM Sub-Committee on Finance with assessing in detail the consequences of Resolution 5 of the 26th meeting of the CGPM (2018) and to report back to the bureau, including recommendations on the various alternatives for further action. (The Director of the BIPM and Director of the ILC Department have drafted document CIPM/19-II-06 concerning arrears.)

BIPM Staff issues

Update on legal issues

Mr Rojas Ceballos, BIPM Legal Adviser, reported on the legal aspects with respect to the Administrative Tribunal of the International Labour Organization (ILOAT).

Actuarial review and salary review

The bureau discussed the actions to be undertaken.

BIPM Operation and Finance

The bureau confirmed the recent budget balance, and noted that there are no contributions outstanding from Member States for more than one year. The bureau welcomed the BIPM's sound financial situation.

The bureau also welcomed the successfully completed safety audit by the *Agence de securite nucleaire* (ASN).

Meeting schedule

The bureau drafted the schedule for its forthcoming meetings. Detailed plans will be presented to the BIPM.

Any other business

The bureau commented that the agenda, working documents and related materials for CIPM meetings should be prepared as far in advance of the meeting as possible.

REPORT OF THE BUREAU MEETING HELD ON 17-18 JUNE 2019

Progress with the CIPM Task Group established following Decision CIPM/108-19 - (To propose terms of reference for a Working Group of Member State representatives)

The convener of the Task Group, Dr Louw, reported on the current status of the communication to the Member States. A draft document is waiting for comment from Dr Richard and Dr Steele; it will then be circulated to the Task Group and the final document will be sent to the Member States.

BIPM operations and finance

Head of Finance, Ms Spelzini, was invited to report on the financial status of the BIPM. This included the audited financial statements for 2018, which were noted and, as of 31 May 2019, the current financial situation (1Q 2019).

Update on institutional issues

The Director of the International Liaison and Communication Department, Mr Henson, was invited to report on international liaison issues including new member applications, bank transfer issues, the World Metrology Day discussions with UNESCO, and the reference document on metrology to be published by the OECD. The issue of Member State advances made in respect of accumulated arrears was discussed. A proposal on the advances will be reported at the CIPM and the State Representatives meetings.

Other liaison activities and progress between IUPAC, IUPAP, ITU, CODATA, IAU, ICRU and CTBTO were reported by relevant members. Updates will be given at the next CIPM meeting. The BIPM Legal Adviser, Mr Rojas Ceballos, reported on the status of the Administrative Tribunal of the International Labour Organization (ILOAT). The issue of Kosovo and an ethics survey request from the USA were also reported and discussed.

CIPM Activities and Representation

It was noted that the Proceedings of Session I of the 108th meeting of the CIPM were being circulated for approval by the CIPM with minor modifications. The decisions and actions from Session I were reviewed.

Some minor revisions were pointed out in the decisions; these will be reported to the next CIPM meeting for discussion.

Criteria for honorary membership of the CIPM were discussed and a proposal was drafted for presentation at the next CIPM meeting. CIPM members will be asked to nominate candidates.

It was confirmed that the Report of the 26th meeting of the CGPM (2018) will be sent to participants by the end of 2019.

Review of topics to be addressed at CIPM Sub-Committees

It was noted that all CIPM Sub-Committee chairs should submit their reports to the CIPM Secretary after each meeting. These reports will be published as working documents for the next CIPM meeting. The chairs are also expected to provide an oral report including any updates at the CIPM meeting.

Plans and agendas for future meetings

The two-day CIPM meeting will be organized to include all technical coordination activities on day one and issues concerning governance of the BIPM on day two.

The agenda of the next CIPM meeting will cover:

Day 1:

- CIPM Sub-Committee reports
- CC President's reports (15 minutes for the seven CCs which held meeting since the last CIPM meeting, otherwise 5 minutes)
- Elections for CC Presidents.
- Review of criteria for honorary membership of the CIPM
- Discussion on Strategy and Governance
- Review of the NMI Directors/Member State representatives meeting agenda
- Reports from CIPM TGs and WGs (data, units).

Day 2:

- (Short) reports from BIPM Director and Department Directors
- Reports from SCs, *ad hoc* WGs and TGs concerned with governance (e.g. Pension Fund Advisory Board, CIPM Sub-Committee on Finance)
- Finances (Audited financial statements, budget 2019)
- Other CIPM governance topics (e.g. whistleblowing, neutrality, travel policy etc.)
- Proposal to address the advances in respect of Member State arrears
- Reconsideration of the OIML "Task Group".

Date of next meeting

The next bureau meeting will be held on 14 October 2019. Webcast meeting(s) and satellite meeting(s) will be planned before and after the face-to-face meeting.

Any other business

Dr Louw and Dr Usuda confirmed that they will step down from their CC President positions. The CIPM Secretary will call for candidates for the positions before the CIPM meeting in October.

REPORT OF THE BUREAU MEETING HELD ON 14 OCTOBER 2019

Minutes and actions from the previous meeting of the CIPM bureau

It was confirmed that all actions have been dealt with or are underway.

ToR for a Working Group of Member State representatives have been issued to Member States.

The draft report of the 26th meeting of the CGPM (2018) has been published for comments. Comments are to be submitted by the end of October 2019.

CIPM Sub-Committee chairs were reminded to submit their reports for upcoming CIPM meetings in advance. It was noted that not all Sub-Committee chairs had done so for Session II of the 108th meeting of the CIPM.

Candidates for vacant CC Presidents positions and the Chair of the CIPM Sub-Committee on Finance have been received.

Update on operational issues from the BIPM Director/CIPM Secretary/CIPM President that relate to the duties assigned to them by the Metre Convention

The Director of the BIPM commented that a few Member States have experienced difficulties in payment of their subscriptions/contributions due to problems with bank sanctions.

Update on liaison activities (Dr Olthoff)

A brief history and summary of past liaison agreements was presented. A full report will be presented at the CIPM meeting.

Review of agenda for the CIPM and the NMI Directors/Member State Representative's meetings

The agendas and timelines were reviewed and confirmed. The bureau reflected on issues of importance at the upcoming meeting of Member State representatives. It limited its discussions to defining a high-level strategy for how the bureau will participate and to guide the CIPM President; the detailed discussion/preparation will need to be carried out in the CIPM meeting.

Drafting of resolutions for the CIPM meeting

The following draft resolutions were prepared for the CIPM: to avoid exclusion of Member States that have experienced problems with bank sanctions; and to endorse the change of the Chair of CIPM Sub-Committee on Strategy from Dr Milton to Dr Louw.

Plans for future meetings of CIPM WGs, TGs and other meetings in 2020

A detailed list of upcoming meetings was presented.

Any other business

The CIPM bureau met four members from the BIPM staff commission (CCE) pursuant with Rule 21.2.1. *“The CCE may request the Director to inform the bureau of the CIPM that the CCE wishes to make an oral communication to the bureau of the CIPM on any matter related to conditions of employment”*.

The CIPM bureau expressed their appreciation of the CCE's activities, especially the staff survey carried out by the CCE. The CIPM President stressed the importance of this kind of communication.

Appendix 2

Visite du dépôt des prototypes métriques

PROCES-VERBAL

Le 15 octobre 2019 à 17 heures 35 en présence du Président du Comité international des poids et mesures, du représentant du conservateur des Archives nationales et du directeur du Bureau international des poids et mesures, il a été procédé à la visite du dépôt des prototypes métriques internationaux du Pavillon de Breteuil.

On avait réuni les trois clefs qui ouvrent le dépôt : celle confiée au directeur du Bureau international des poids et mesures, celle déposée aux Archives nationales et celle enfin dont le Président du Comité international des poids et mesures a la garde.

Les deux portes de fer du caveau ayant été ouvertes ainsi que le coffre-fort, on a constaté dans ce dernier la présence des prototypes et de leurs témoins.

On a relevé les indications suivantes sur les instruments de mesure placés dans le caveau :

température actuelle	:	21,8 °C
température maximale	:	21,9 °C
température minimale	:	21,7 °C
état hygrométrique	:	55 %

On a alors refermé le coffre-fort ainsi que les portes du caveau.

Le Directeur
du BIPM

Pour le Conservateur
des Archives Nationales

Le Président
du CIPM



M.J.T. MILTON



C. BÉCHU



W. LOUW