CGPM

CCM President's Report

27th CGPM (2022)

www.bipm.org

Report by the President of the CCM

Dr Philippe Richard, President of the Consultative Committee for Mass and Related Quantities (*Comité consultatif pour la masse et les grandeurs apparentées,* CCM) reported on the activities of the CCM since the 26th meeting of the CGPM (2018).

CCM Executive summary

The CCM has active technical working groups that span the following diverse areas of metrology: mass, density and viscosity, force and torque, pressure and vacuum, fluid flow, hardness and gravitational acceleration. The CCM Working Group on Strategy and MRA coordination seeks to provide guidance on coordinating and harmonizing the working group activities.

Much of the present activity of the CCM is focused on the realization and the dissemination of the new definition of the kilogram by following a detailed note[1] developed to manage this work.

However, not all the working groups are affected by this change and instead are concerned with the improvement of existing technical capabilities or the development of new capabilities.

Scope of the CCM

Present activities concern matters related to the realization and dissemination of the mass unit following the 2019 redefinition of the kilogram in terms of the Planck constant, establishment of international equivalence between national laboratories for mass and a number of related quantities (density, pressure, force, fluid flow, viscosity, hardness, gravitational acceleration) and advice to the CIPM on these matters.

Strategy

A completely revised CCM Strategy was prepared by the Working Group on Strategy and MRA coordination (WGS) in 2021. The strategy document 2022-2032 was approved by the CCM by correspondence in March 2022 and is available on the CCM website.

The strategy document presents an overview of major scientific, economic and social challenges which can be addressed by measurements of mass and related quantities for seven challenge areas identified by the CIPM in response to evolving needs in metrology. The revision of the SI in May 2019 enables the realization of the unit of mass and some related quantities directly from fundamental constants. Measurements directly traceable to the SI, dynamic measurements and measurements with a wider range and under wider conditions are the main topics for investigation over the next decade.

The CCM has set three strategic aims for the 2022-2032 period. The strategy foresees contributions to progressing measurement science across all technical areas covered by the CCM. To support global comparability of measurements, managing the transition from an internationally coordinated kilogram dissemination to the use of individual sovereign realizations remains the main focus. The CCM will continue to implement the CIPM MRA by efficiently organizing key comparisons and coordinating RMO key and supplementary comparisons. The CCM will support the introduction of the SI digital framework in mass related metrology. The CCM aims to facilitate stakeholder engagement and knowledge transfer by continuing the organization of workshops and initiating webinars and to seek extended collaborations with other Consultative Committees and involvement of external bodies.

The CCM oversees the work programme of the BIPM mass laboratories.

[1] Detailed note on the dissemination process after the redefinition of the kilogram CCM, available on the CCM web site: https://www.bipm.org/en/committees/cc/ccm.

Activities and achievements since the last meeting of the CGPM

Main activities and achievements

Two CCM meetings were held during the period 2019-2022, one on 16-17 May 2019 and one on 20-21 May 2021. The meeting reports and the majority of the presentations/working documents are publicly available on the CCM webpages. A workshop on new activities and developments in mass and related quantities was organized during the meeting in 2019. The meeting in 2021 was exceptionally held online due to travel restrictions. The detailed note on the phases for the dissemination of the kilogram prepared by the Task Group on the Phases for the Dissemination of the kilogram following redefinition (TGPfD-kg) was approved and the progress of the tasks following the detailed note was reviewed during these meetings. Other major decisions of these two meetings include:

- merging of the Working Group on Realization of the kilogram and of the Working Group on Dissemination of the kilogram into a single Working Group on Mass (WGM).
- appointment/re-appointment of the chairs and vice-chairs of the CCM Working groups.
- revision of the Terms of Reference of the Working Group on Gravimetry and of the TGPfD-kg to better reflect the activities undertaken and the issues addressed within the groups.
- formulation of a CCM request to the JCRB about the possibility of adding an explanatory note for clarifications on "Appendix A1 in CIPM-MRA-P11".

INMETRO (Brazil) and IPQ (Portugal) became CCM Members in 2019. CMS/ITRI (Chinese Taipei) and NSC IM (Ukraine) became CCM Observers in 2021.

Regarding the realization and dissemination of the new definition of the kilogram, the first key comparison of realization experiments CCM.M-K8 was completed in 2019. The BIPM compared realizations of the kilogram based on five Kibble balances and two applications of the X-ray crystal density (XRCD) method and the results of this, together with those of a previous Pilot Study, were used to calculate the first Consensus Value for the kilogram. Mass values based on the Consensus Value were 2 µg smaller than those based on the IPK, with a standard uncertainty of 20 µg. The dissemination of the kilogram entered Phase 2[2] on 1 February 2021, where the Consensus Value is used as an "international mean kilogram". Since the change between mass values based on the previous traceability and the new values is small compared to the uncertainty, no adjustment to the international mass scale was required. However, adjustments to the published Calibration and Measurement Capabilities (CMCs) of 31 NMIs were necessary to take into account the uncertainty in the Consensus Value. The BIPM prepared a note providing information on the impact of the redefinition of the kilogram on mass calibration uncertainties stated on BIPM calibration certificates that were issued before 20 May 2019. The note was sent to all previous customers. A paper "*Beginning of a new phase of the dissemination of the kilogram*" written by the chairs of the WGM and the TGPfD-kg and the BIPM was published in *Metrologia* in 2021.

The second key comparison of kilogram realizations was launched in late 2021. The number of participants increased by two compared to the first comparison. The mass comparisons of the transfer standards with respect to the BIPM working standards are complete. The draft A report is being circulated. The result of the comparison will contribute to the calculation of a new Consensus Value.

A completely revised CCM Strategy 2022-2032 was produced by the CCM-WGS. The WGS also establishes annual CCM action plans and monitors their progress. Regarding the CIPM MRA, the CCM provided comments to the updated CIPM MRA Guideline documents. Additionally, the CCM has identified its specific needs and contributed to the implementation of the KCDB 2.0 platform and the new BIPM website. The approval process for comparison reports has been simplified to accelerate

[2] Transition period where mass dissemination is based on a Consensus value calculated from the results of three comparisons of realization experiments.

the publication of comparisons results. Two CCM Guidance documents, the *CCM Guidelines for approval and publication of the final reports of key and supplementary comparisons* and the *CCM Key Comparison Report Template* have been revised to take into account these changes. For the Comparison Report Template, the chapter dealing with transfer standards was improved. The format of the core text and examples were also refined for better readability. Specific guidance documents for an "efficient and effective" approach to CMC review exercises have been established in some WGs and are being developed in others. The CCM is working with RMOs and NMIs on reducing the number of CMCs following the recommendations of the CIPM MRA review.

Challenges and difficulties

The revision of the SI and the associated redefinition of the kilogram in May 2019 represented a step change in the way the SI unit of mass is defined, maintained and disseminated at the NMI level. While the development of the realization experiments reached a level of uncertainty and equivalence which was acceptable to allow the redefinition of the unit of mass in 2019, work is needed to improve the number and reliability of the experiments and the degree of equivalence. The most critical issue for the CCM is to manage the dissemination phase from the Consensus Value as requested by CCM Recommendation G1 (2017), and its transition to the dissemination from individual realizations. There are a number of technical issues that must be addressed such as the computation of the Consensus Value and reducing the dispersion in realization experiments.

The CCM covers a very diverse range of measurements. The technologies applied to the measurements in these areas vary greatly, as do the scientific and industrial areas which rely on these measurements. Adding the diversity of the mass related measurement area to the fact that the measurement of dynamic quantities is becoming increasingly important in a number of these areas means that the scope for end-user benefit can potentially be very wide and a strategy to maximize the impact will need to focus on areas where the benefits can be most effectively exploited.

Other more routine difficulties must also be addressed continually. These include improving the efficiency of the CMC review process and minimizing delays in carrying out key comparisons and reporting their results.

Outlook in the short and long term

By the end of 2023 the CCM will have held its 19th meeting (25-26 May 2023), preceded by meetings earlier that week of most of its Working Groups, including the Working Group on Strategy and MRA coordination. The major goals of the CCM meeting are:

- review of the dissemination process of the kilogram including the results of the second key comparison of realizations of the kilogram CCM.M-K8, and the calculation and use of the second Consensus Value.
- review and approval of the protocol for the third key comparison of realizations of the kilogram.
- appointment/re-appointment of all WG chairs and vice-chairs.

As with previous meetings, each CCM member will be asked to prepare a written report of relevant scientific activities. A workshop dedicated to new activities and developments in the areas of metrology that are of interest to the CCM will be organized.

By the end of 2024 we expect to complete the third key comparison of realizations of the kilogram, and to compute the third Consensus Value for the dissemination of the mass unit.

In the long term, from 2024 and beyond, we expect to have a better view of the status of realization experiments and a strengthened infrastructure to facilitate the achievement of the following goals:

- Reducing the dispersions in realizations of the kilogram.

- Managing the dissemination phase from the Consensus Value and the transition to dissemination from individual realizations of the kilogram.
- Ensuring that a sufficient number of primary realizations of the unit of mass are always available and if possible, in each region.
- Development of less expensive and more easily operated apparatus (also those based on new ideas, alternative to Kibble balance and XRCD routes) to realize the kilogram in terms of the Planck constant for use by the NMIs.
- Development of commercial instruments for the realization of the kilogram and its submultiples for use at NMIs in the short term, and by a widening range of end users in the longer term.
- Continuing the development of technical and scientific activities in the CCM Working Groups according to the CCM Strategy and the Working Group action plans.

CCM Data

CCM set up in 1980

President: P. Richard — Executive Secretary: H. Fang

Membership: 25 members and six observers

List of CCM members and observers: https://www.bipm.org/en/committees/cc/ccm/members

Meetings since the 26th CGPM meeting: 16-17 May 2019, 20-21 May 2021

Full reports of the CCM meetings: https://www.bipm.org/en/committees/cc/ccm/publications

Nine Working Groups: https://www.bipm.org/en/committees/cc/ccm

- Strategy and MRA coordination (WGS)
- Realization of the kilogram (WGR-kg)
- Dissemination of the kilogram (WGD-kg)
- Density and Viscosity (WGDV)
- Force and Torque (WGFT)
- Pressure and Vacuum (WGPV)
- Fluid Flow (WGFF)
- Hardness (WGH)
- Gravimetry (WGG)

CCM Comparison activity	Completed	In progress	Planned
CCM key comparisons (and supplementary comparisons)	98	13	4
BIPM comparisons	0	0	0
CC pilot studies	4	2	0
CMCs	2 965 CMCs in 29 service categories registered in the KCDB		