

## **Consultative Committee for Mass and Related Quantities (CCM)**

President: Dr Philippe Richard

Executive Secretary: Dr Hao Fang

### **1. Executive summary**

The CCM has active working groups that span the following diverse areas of metrology: realization of the unit of mass, dissemination of the unit of 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 these activities.

Much of the present activity of the CCM is focused on preparing the transition to a new definition of the kilogram by following a roadmap developed to organize this work.

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

### **2. Scope of the CCM**

Present activities concern matters related to the comparisons of mass standards with the international prototype of the kilogram (IPK), considerations affecting the definition and realization of the unit of mass, 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.

### **3. Strategy**

A major revision of the CCM Strategy was made by the Working Group on Strategy and MRA coordination in 2017. The [CCM strategic plan for 2017-2027](#), as well as the [executive summary](#), are available on the CCM website.

The major themes, challenges and actions in the strategy document are to:

- Coordinate the transition to the new definition of the kilogram;
- Ensure consistent dissemination of the mass unit after the redefinition;
- Stay current with technical developments in CCM technical areas not directly affected by redefinition of the kilogram;
- Improve the operating efficiency of the CCM by defining clear action plans and structured reporting;
- Further improve the efficiency and effectiveness of the KC and CMC reviews by addressing the key recommendation of the CIPM MRA review;
- Encourage common views across the CCs and aim at an improved coordination of work across the CCs.

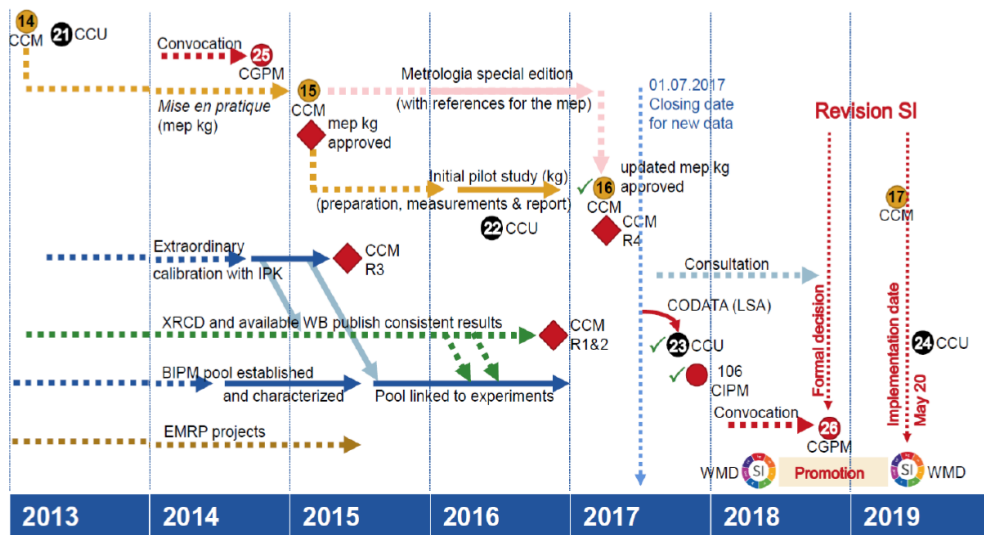
Many of these themes are reflected in the following sections.

#### 4. Activities and achievements since the last meeting of the CGPM

##### 4.1. Main activities / services / projects

Two CCM meetings were held during the period 2015-2018, one on 26-27 February 2015 and one on 18-19 May 2017. The meeting reports and the majority of the presentations/working documents are publicly available on the [CCM webpages](#). The progress of the tasks according to a joint CCM and CCU roadmap, based on the CCM roadmap established in 2013, was reviewed during these meetings. The meetings also saw progress within the CCM on the final drafting of the *mise en pratique* as well as the formulation of two CCM recommendations, in particular [CCM Recommendation G1 \(2017\)](#) for a new definition of the kilogram in 2018. The latter recommendation was formally submitted and approved by the CIPM.

A calibration campaign with respect to the IPK in anticipation of the redefinition of the kilogram was performed at the BIPM. A pilot study of 1 kg mass standards, calibrated with relation to future primary realization experiments for the mass unit was completed successfully. The results



◆ Conditions from CCM Recommendation G1 (2013)

of both the calibration campaign and the pilot study were published in *Metrologia* and made publicly available on the CCM webpage. The first key comparison of realizations of the redefined kilogram is being organized.

A *Metrologia* Focus Issue on [Realization, Maintenance and Dissemination of the kilogram](#) was coordinated by the Working Group on the Realization of the kilogram. The first contributions were published online in 2016. The issue contains technical papers in support of the *mise en pratique* of the new definition of the kilogram. A short note on the dissemination process after the proposed redefinition of the kilogram has been written. A more detailed guidance document is being developed for the CCM members and the NMIs. A joint CC statement on the proposed revision of the SI is now available as well as a CCM statement about the redefinition of the kilogram. A new tab giving links to the future redefinition of the kilogram was created on the CCM webpage. Therefore, all key documents mentioned above, as well as others related to this important change, are easily accessible.

In 2015 and 2016 the CCM President held various seminars and made oral presentations to raise global awareness of the redefinition of the kilogram in Germany, China and Japan as well as at

the 2015 NCSL International Workshop and Symposium in the USA and at the XXI IMEKO World Congress in the Czech Republic.

A [Task Group on the Phases for the dissemination of the kilogram following redefinition](#) was created by the CCM President in early 2018. The Task Group held its first meeting in July during the 2018 Conference on Precision Electromagnetic Measurements. The Terms of Reference (ToRs) and membership of the CCM Working Groups (WGs) have been revised. The WGs now include common ToRs covering KCs and CMCs and, as *ex officio* members, the chairs of Regional Committees or their representatives. In addition, two WGs have changed their names to better reflect the activities undertaken and the issues addressed within the WGs.

NIS (Egypt) became a CCM Observer in 2015 and DFM (Denmark) became a CCM Member in 2017.

An important activity of the CCM since the last CGPM in 2014 has been to provide advice during a full review of the CIPM MRA. Additionally, the CCM has identified the needs for additional guidelines and templates to improve the efficiency of the KCs and the CMC review within the CCM. The [CCM Guidelines for approval and publication of the final reports of key and supplementary comparisons](#) was revised. The revisions mainly clarify the reporting of comparisons and their impact on CMC claims. A [template for key comparisons reports](#) containing detailed explanations and examples was produced. The [CCM Guidelines for Submission and Review of CMCs](#) was completed. The document outlines the general principles for an “efficient and effective” approach to CMC review within the CCM. Specific guidance documents, which apply to the measurands, are being developed in the CCM WGs. All these guidance documents are publicly available on the CCM webpages. In addition, a review of all CCM comparisons has been conducted; 33 CCM KCs were surveyed. Guidance is needed on: appropriate methods to calculate Key Comparison Reference Values (KCRVs), useful flow charts or software templates for KCRV calculations, and treating the consequences of unstable transfer standards. The NIST consensus builder is at present being tested in WGs for the KCRV calculation.

#### 4.2. Challenges and difficulties

The mass community faces major challenges in implementing the redefinition of the kilogram after its adoption in November 2018. Briefly, the various communities with legitimate concerns that must be addressed are: NMIs that have developed a suitable realization of the new definition; NMIs that are working on such a realization; all other NMIs; the legal metrology community; balance and weight manufacturers; the regulatory community; science educators; and the interested public.

The most crucial issue is to manage the different phases for the dissemination of the redefined kilogram in particular 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.

Within the CCM, there is a wide community of interest as reflected by the diversity of its technical working groups. Only a fraction of these groups are deeply concerned with the redefinition of the kilogram, and it is important to pay close attention to other important

concerns such as the metrology of dynamic measurements in force and pressure metrology or new instrumentation in other technical fields.

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

## **5. Outlook in the short and long term**

By the end of 2019 the CCM will have held its 17th meeting (16-27 May 2019), 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:

- Approval of the detailed guidance document on the dissemination process after the proposed redefinition of the kilogram;
- Approval of the protocol for the first key comparison on primary realizations of the new definition of the kilogram;
- Appointment/re-appointment of all WG chairs.

As for the 15th and 16th meetings, each CCM member will be asked to prepare a short written report of relevant scientific activities, to be received by the Executive Secretary prior to the meeting. In a change to previous practice, a half-day meeting will be dedicated to new activities and developments in the areas of metrology that are of interest to the CCM.

By the end of 2020 we expect to complete the first key comparison of primary realizations of the mass unit, the kilogram, and to compute the first consensus value for the dissemination of the mass unit.

In the long term, from 2022 and beyond, we expect to have a strengthened infrastructure that will support the new definition of the kilogram by facilitating the achievement of the following goals:

- Managing the dissemination phase from the consensus value and the transition to the dissemination from individual realizations of the mass unit;
- Reducing the dispersions in realizations of the mass unit;
- Ensuring that a sufficient number of primary realizations of the unit of mass are always available;
- Ensuring that an ensemble of artefact mass standards is maintained at the BIPM to aid in the dissemination of the unit of mass;
- 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.

**Annex: CC Data**

**CCM** set up in 1980

President: P. Richard

**Membership:**

List of CCM members and observers:

Executive Secretary: H. Fang

23 members and 6 observers

[http://www.bipm.org/en/committees/cc/ccm/members\\_cc.html](http://www.bipm.org/en/committees/cc/ccm/members_cc.html)

Meetings since the 24th CGPM meeting:

26-27 February 2015, 18-19 May 2017

Full reports of the CCM meetings:

<http://www.bipm.org/en/committees/cc/ccm/publications-cc.html>

Nine Working Groups:

[http://www.bipm.org/en/committees/cc/ccm/working\\_groups.html](http://www.bipm.org/en/committees/cc/ccm/working_groups.html)

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)

<b>CCM Comparison activity</b>	Completed	In progress	Planned
CCM key comparisons (and supplementary comparisons)	91	8	4
BIPM comparisons	0	0	0
CC pilot studies	2	4	1
CMCs	2802 CMCs in 36 service categories registered in the KCDB		