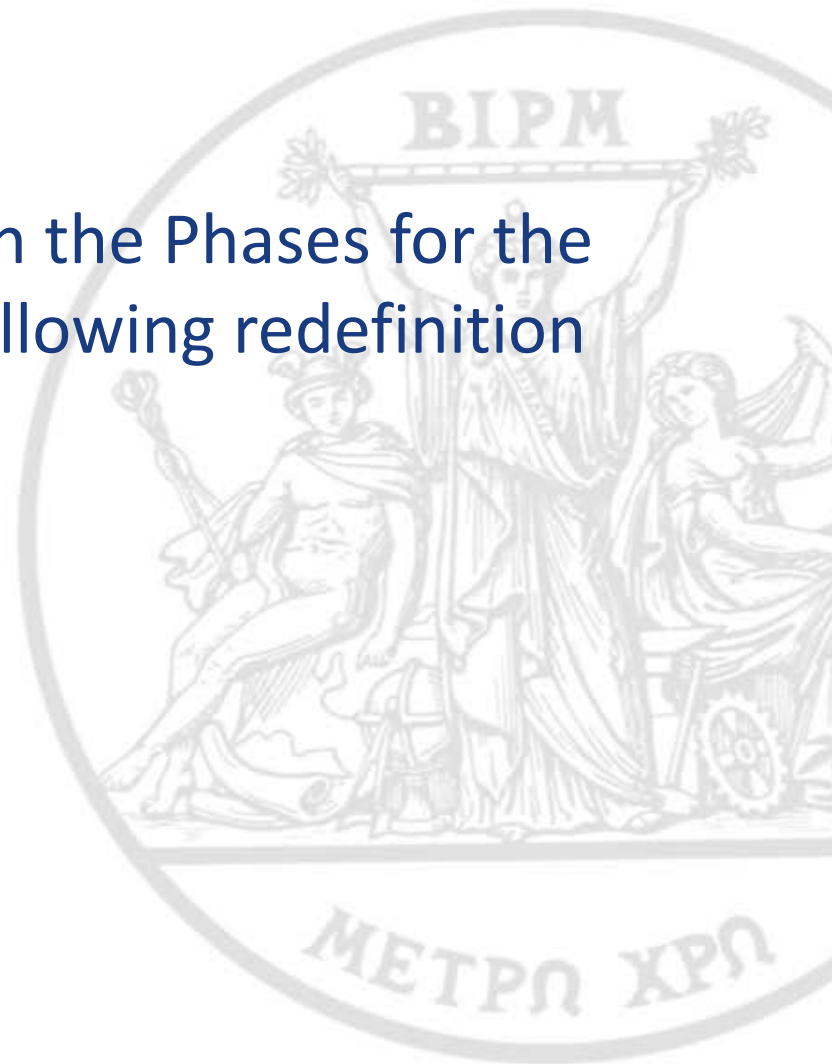


Report of the CCM Task Group on the Phases for the Dissemination of the kilogram following redefinition

Stuart Davidson

17th CCM meeting, 16 May 2019

Bureau
+ **I**nternational des
+ **P**oids et
+ **M**esures



Terms of Reference

The dissemination of the kilogram after 20 May 2019 will take place in three consecutive phases:

- Present traceability (taking into account the additional uncertainty coming from the new definition),
- Dissemination of the consensus value,
- Dissemination of individual realizations.

Terms of Reference (cont.)

Based on "the mise en pratique of the definition of the kilogram" and on "the CCM short note on the dissemination process after the proposed redefinition of the kilogram" the task group will:

- Ensure the correct implementation of the present traceability across the period of the redefinition of the kilogram,
- **Propose a detailed calculation of the consensus value and its uncertainty** and oversee the transition for the "present traceability" to the use of the consensus value,
- Propose methods to maintain the best possible stability of the consensus value over time (including comparison periodicity),
- **Propose clear criteria for moving from the consensus value dissemination phase to the individual realization dissemination phase,**
- Maintain a detailed document describing the three dissemination phases for the CCM and the mass community. This document includes the calculation of the consensus value, its uncertainty and time scale as well as any other relevant information related to the dissemination of the kilogram,
- Provide advice to the CCM-WGD-kg and CCM-WGR-kg in all questions regarding traceability of the kilogram during the first two phases above.

TG Membership

Chairperson:

Dr Stuart Davidson (chair CCM WGD-kg, NPL)

Members:

Dr Horst Bettin (chair CCM WGR-kg, PTB)

Dr Nieves Medina (CEM)

Dr Lars Nielsen (DFM)

Dr Alan Steele (JCRB, NRC)

Dr Estefania de Mirandes (BIPM)

Dr Michael Stock (BIPM)

Dr Hao Fang (CCM Executive Secretary, BIPM)

Dr Philippe Richard (CIPM, CCM President, METAS)

TG Meetings held since last CCM

- ◆ 2 meetings held in July 2018 and January 2019

Phases for the dissemination of the kilogram

Phase	Time scale	Description	Source of traceability	Uncertainty of BIPM mass calibrations	Role of realization experiments	Dissemination of mass from NMIs with realization experiments
0	Until 20 May 19 ¹	Traceability to the IPK	$m_{\text{IPK}} \equiv 1 \text{ kg}$ $u_{m_{\text{IPK}}} \equiv 0$	$u_{\text{stab}}(t)$	Measurement of h	Dissemination from national prototype traceable to IPK
1	20 May 19 - date 1 ²	Traceability to the IPK, taking into account the additional uncertainty coming from the (new) definition	$m_{\text{IPK}} = 1 \text{ kg}$ $u_{m_{\text{IPK}}} = 10 \mu\text{g}$	$\approx \sqrt{u_{m_{\text{IPK}}}^2 + u_{\text{stab}}^2(t)}$	Contribute to Key Comparison (KC), improve to resolve discrepancies	Dissemination from national prototype traceable to IPK, with 10 μg added uncertainty
2	date 1 – date 2 ³	Dissemination via a consensus value ⁴ (CV)	Consensus value (CV)	$\approx \sqrt{u_{\text{CV}}^2 + u_{\text{stab}}^2(t)}$	contribute to CV (via KC), improve experiments to resolve discrepancies	Dissemination from consensus value with uncertainty $\approx \sqrt{u_{\text{CV}}^2 + u_{\text{stab.NMI}}^2(t)}$
3	from date 2	Dissemination by individual realizations	Fixed value of h $u(h) \equiv 0$	(Uncertainty of BIPM realization experiment)	Realization of the unit of mass, Participation in KCs to demonstrate equivalence	Dissemination from validated realization experiments with the uncertainty of the experiment. The terms of the CIPM MRA are applicable.

Progress

- ◆ Method for the calculation of the consensus value has been agreed
- ◆ Uncertainty in the consensus value is agreed
- ◆ Conditions necessary for moving from Phase 2 (use of the consensus value) to Phase 3 (Individual realisations) agreed
- ◆ Draft extended note on the Phases for the Dissemination of the kilogram following redefinition produced
- ◆ First KC of realisation experiments agreed

How will a Consensus Value for the kilogram work?

Requirements

- Consistency with IPK, linked to all available realisation experiments, temporal stability, easy access for dissemination

Determination

- KCs for the realisation experiment will take place every 2 years
- CV will be based on an average of the last 3 KCRVs (to ensure temporal stability)
- Initial value will be based on; IPK, Pilot study results, Ref. Value of first KC

Dissemination

- KCs will be piloted by the BIPM
- CV will be maintained and disseminated by the BIPM using their P_{tr} standards
- BIPM will continue to provide calibrations for NMIs but traceability will switch from the IPK to the CV following the completion of the first KC of realisation experiments

Uncertainty

- It is proposed that the uncertainty in the consensus value be $\pm 20 \mu\text{g}$

The uncertainty in the Consensus Value

Use of a consensus value during the process of transition from the IPK to individual realizations was driven by the need to address the inconsistency in the results of the realization experiments and not a desire to (statistically) reduce the uncertainty in the realization.

- Typical uncertainty of “mature” realization experiments such as those at NIST, NMIJ, NRC and PTB
- The target uncertainty of newer realization experiments which are predicted to be completed in the next 10 years
- Setting the expectations on future uncertainties from individual realization experiments (Phase 3) at the beginning of Phase 2.
- 20 μg was the target uncertainty that the CCM established to proceed with the redefinition of the kilogram

Transition to the use of individual realisation experiments (Phase 3)

- a) A minimum of five consistent realization experiments which:
 - I. Achieve Key Comparison results with a relative standard uncertainty of 40 parts in 10^9 or better
 - II. Demonstrate consistency with the KCRV
 - III. Demonstrate stability by producing consistent (equivalent) results for two consecutive Key Comparisons
- b) At least two of the realization experiments meeting the above criteria should have uncertainties less than 20 parts in 10^9 .
- c) The consistent set of experiments must include two independent methods of realizing the SI unit of mass (e.g. Kibble balance and X-ray crystal density experiments)
- d) The difference between the Consensus Value for the kilogram (determined from three last 3 Key Comparison results) and the KCRV for the final Key Comparison is less than 5 parts in 10^9 .

Stuart.Davidson@npl.co.uk



Bureau
International des
Poids et
Mesures

www.bipm.org