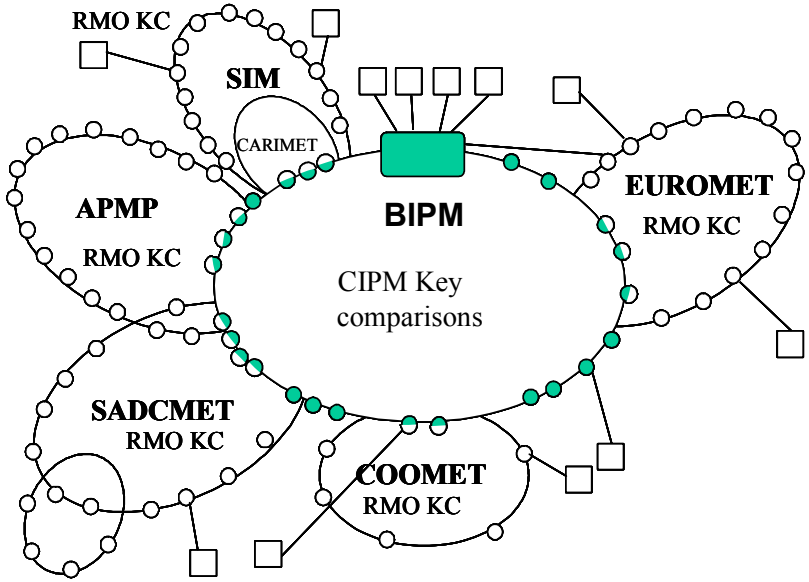
Guidelines for CIPM key comparisons

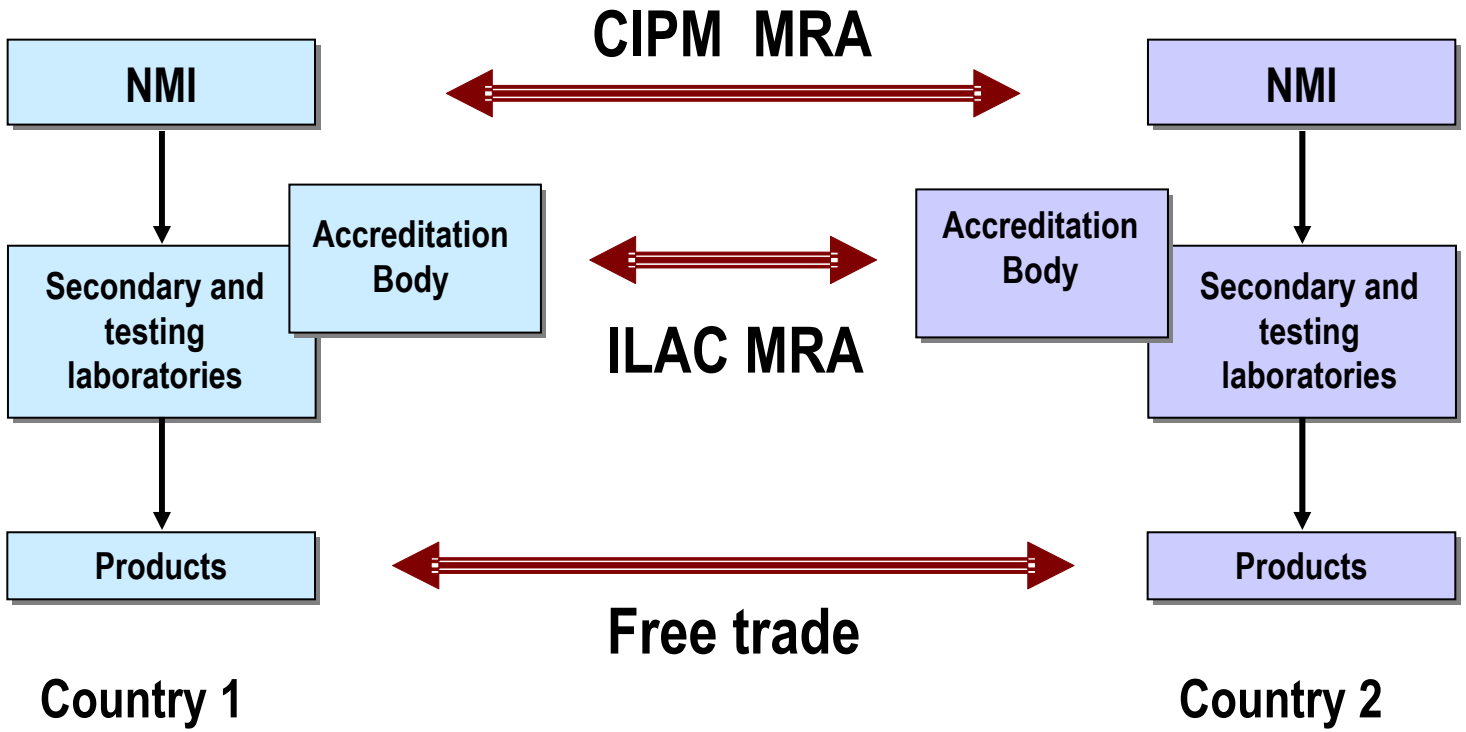


Luis Omar Becerra

CENAM
CENTRO NACIONAL DE METROLOGÍA

Workshop on Hydrometer Calibration
21 -23 November, 2006

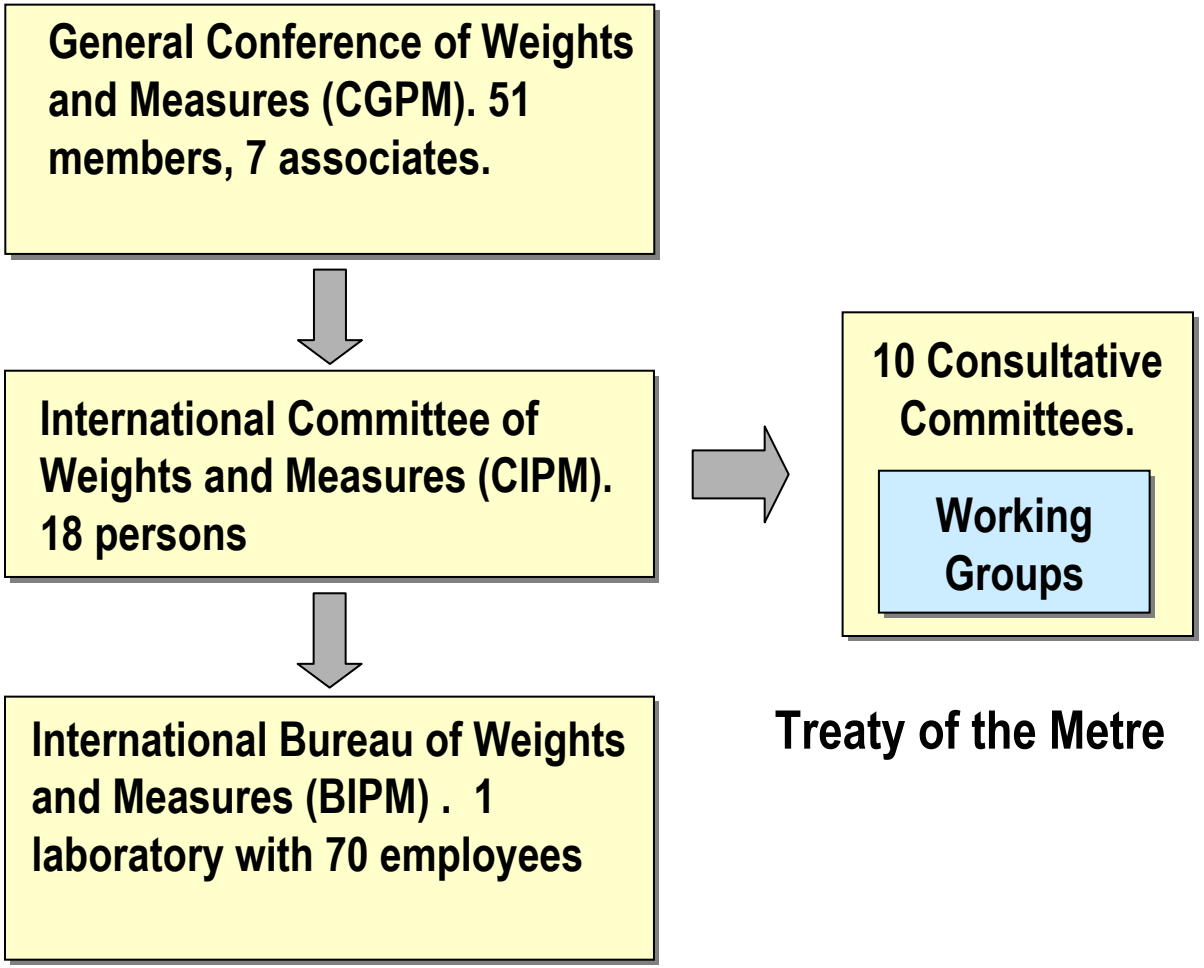
Importance of international uniformity of measurements



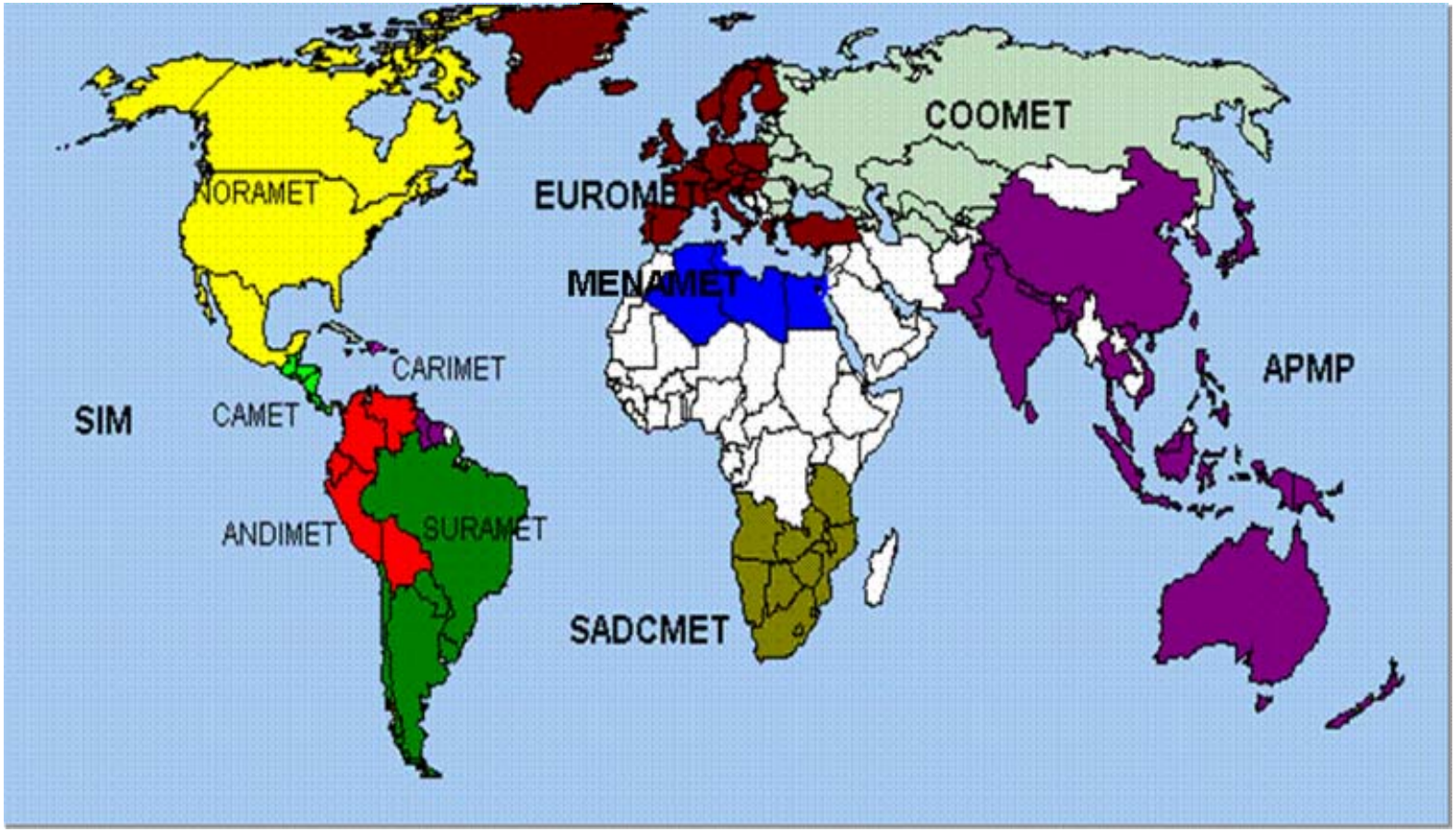
The Metre Convention

The Convention of the Metre (Convention du Mètre) is a diplomatic treaty which gives authority to the General Conference in Weights and Measures (CGPM), the International Committee for Weights and Measures (CIPM) and the International Bureau of Weights and Measures (BIPM) to act in matters of world metrology, particularly concerning the demand for measurement standards for even increasing accuracy, range and diversity, and the need to demonstrate equivalence between national measurement standards.

Organizations of the Metre Convention



Regional Metrology Organizations



SIM

SISTEMA INTERAMERICANO DE METROLOGÍA

Workshop on Hydrometer Calibration
21 -23 November, 2006

Consultative Committees of CIPM

CCEM: Consultative Committee for Electricity and Magnetism

CCAUV: Consultative Committee for Acoustics, Ultrasound and Vibration

CCL: Consultative Committee for Length

CCM: Consultative Committee for Mass and Related Quantities

CCPR: Consultative Committee for Photometry and Radiometry

CCQM: Consultative Committee for Amount of Substance - Metrology in Chemistry

CCRI: Consultative Committee for Ionizing Radiation

CCT: Consultative Committee for Thermometry

CCTF: Consultative Committee for Time and Frequency

CCU: Consultative Committee for Units

Technical Working Groups of SIM

MWG 1 - Electricity and Magnetism

MWG 2 - Photometry and Radiometry

MWG 3 - Thermometry

MWG 4 - Length

MWG 5 - Time and Frequency

MWG 6 - Ionizing Radiation and Radioactivity

MWG 7 - Mass & Related Quantities

MWG 8 - Chemistry (Amount of Substance)

MWG 9 - Acoustics and Vibration

MWG 10 - Flow and Volume

MWG 11 - Legal Metrology Working Groups

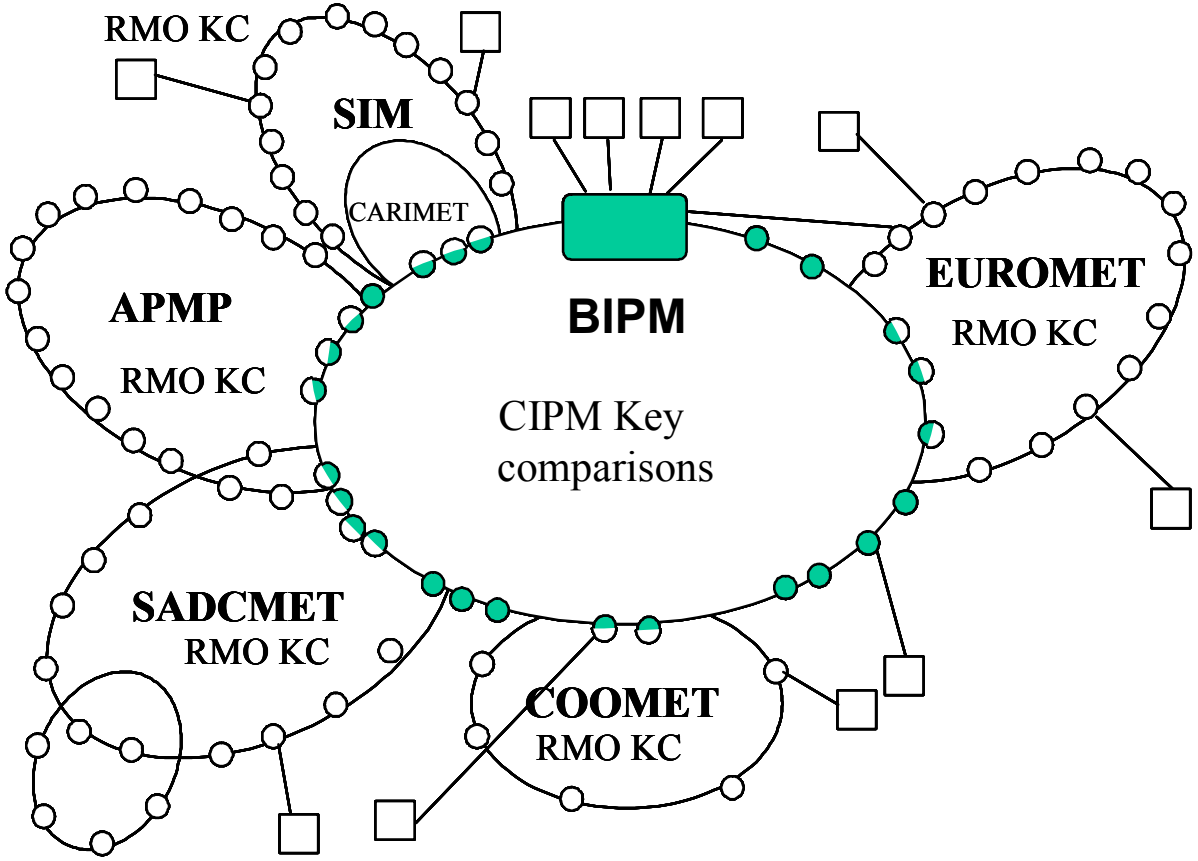
Documentation working groups of SIM

DWG 1 - Documents

DWG 2 - Quality System

DWG 3 - Database

Comparisons among
National Metrology Institutes



Guidelines for CIPM key comparisons

http://www.bipm.org/utils/en/pdf/guidelines.pdf

The procedures used by Consultative Committees for selecting, conducting and evaluating key comparisons, including the detailed technical protocols and periodicity of the comparisons, are designed to ensure that:

- **the comparisons test all the principal techniques in the field;**
- **the results are clear and unequivocal;**
- **the results are robust;**
- **the results are easy to compare with those of corresponding comparisons carried out by regional metrology organizations;**
- **overall, the comparisons are sufficient in range and frequency to demonstrate and maintain equivalence between the participating laboratories.**

2. Types of key comparison

There are two broad types of key comparison: in the first are those comparisons for which the standard or realization of a unit to be compared is assumed to have long-term stability,

in the second category are those for which long-term stability cannot be assumed. The procedures for conducting the comparisons and, in some cases, for evaluating the results may differ in the two cases.

3. Responsibilities for choosing key comparisons

The Consultative Committees are responsible for choosing the key comparisons. In each field a set of key comparisons is identified which covers a range of standards so as to test the principal techniques in the field.

On the basis of the results of the key comparisons, statements of equivalence can be made covering a wide range of measurements using these techniques, not just the measurements directly tested by a key comparison. The periodicity of the comparisons is set to ensure continuity of the equivalence without overloading the participating laboratories.

4. Initiating a key comparison

Key comparisons are initiated at a meeting of the Consultative Committee.

- **The Consultative Committee at each of its meetings examines the needs for comparisons and decides which ones from the list of key comparisons should be initiated at this meeting. In deciding this the committee takes into account, among other things, the views of regional metrology organizations. For each comparison, a pilot institute is identified to take the main responsibility for running the CIPM key comparison.**

- **In drawing up the provisional list of participants and an approximate timetable, the Consultative Committee ensures that an adequate number of participants from each of the main RMOs take part so that corresponding regional comparisons are properly linked to the CIPM comparison.**

- **In some CIPM key comparisons the number of participants is limited for technical reasons.**

- **Two or three institutes from the provisional list are nominated by the Consultative Committee to help the pilot institute in drawing up the technical protocol and timetable for the comparison.**

- **The timetable of this and any other comparisons decided by the Consultative Committee is discussed to ensure that the work load of the whole set is not too great for the participating and pilot institutes, and that the results will be available for the next meeting, normally in three (or occasionally two) years time. For this the total circulation time of the standards must be fixed and should exceed 18 months only in exceptional circumstances.**

5. Organization of a key comparison

The organization of a key comparison is the responsibility of the pilot institute helped by the two or three nominated participants.

The first task of this small group is to draw up the detailed technical protocol for the comparison.

The main points decided by the small group headed by the pilot institute are the following:

- the list of participants with full details of mailing and electronic addresses;

- the travelling standard or standards to be used in the comparison;

- whether or not a pilot comparison or any other preliminary work needs to be carried out among a restricted number of participants to verify the performance of the travelling standard;

- the pattern of the full scale comparison; this ranges from the simple circulation of a single travelling standard around all the participants to the sending of an individual travelling standard directly to each participant from the pilot institute, or from each participant to the pilot institute or some combination of these;

- the starting date, detailed timetable, means of transport and itinerary to be followed by each travelling standard; this starting date is subsequently referred to as the starting date for the comparison;

- **the procedure in the case of failure of a travelling standard;**

- **the procedure in the case of an unexpected delay at a participant institute;**

- **the customs documents to accompany the travelling standards, either ATA Carnet or some other for those participants not qualifying for the ATA scheme.**

6. The technical protocol for a key comparison

The pilot institute together with two or three nominated participants draws up the detailed technical protocol.

The technical protocol is an important part of the comparison and specifies in detail the procedure to be followed for the comparison.

It is important to remember, however, that the purpose of a key comparison is to compare the standards as realized in the participating institutes, not to require each participant to adopt precisely the same conditions of realization.

The protocol should, therefore, specify the procedures necessary for the comparison, but not the procedures used for the realization of the standards being compared.

Among the points treated in the protocol are the following:

- **Detailed description of the devices: make, type, serial number, size, weight, packaging etc. and technical data needed for their operation.**
- **Advice on handling the travelling standard, including unpacking and subsequent packing and shipping to the next participant; this should include a complete list of the content of the package including handbooks etc. and the weight and size of the whole package.**
- **Actions to be taken on receipt of the standards in a participating institute.**
- **Any tests to be carried out before measurement.**
- **The conditions of use of the travelling standard during measurement.**
- **Instructions for reporting the results.**

- **A list of the principal components of the uncertainty budget to be evaluated by each participant, and any necessary advice on how uncertainties are estimated (this is based on the principles laid out in the Guide to the Expression of Uncertainty in Measurement, published by ISO). In addition to the principal components of the uncertainty, common to all of the participants, individual institutes may add any others they consider appropriate. Uncertainties are evaluated at a level of one standard uncertainty and information must be given on the number of effective degrees of freedom, required for a proper estimate of the level of confidence.**

- **The traceability to the SI of each standard participating in the comparison.**

- **A timetable for the communication of the results to the pilot institute. Early communication helps to reveal problems with the travelling standard during the comparison.**

- **Financial aspects of the comparison, noting that in general each participating institute is responsible for its own costs for the measurements, transportation and any customs charges as well as any damage that may occur within its country. Overall costs of the organization of the comparison including the supply of the transfer devices are normally born by the pilot institute.**

- **Insurance of transfer devices is decided by agreement among the participants taking account of the responsibility of each participant for any damage within its country.**

7. Circulation of the transfer standards and customs formalities

The pilot institute is responsible for organizing the circulation and transport of the standards and ensuring that the participants make proper arrangements for local customs formalities.

The equipment must be handled with care, i.e., only by qualified metrology personnel. It is desirable and in some cases essential that the transfer instruments be hand-carried.

The participating institutes are responsible for the transport to the next institute according to the circulation scheme.

8. Reporting the results of a comparison

The participating institutes must report the results of a comparison to the pilot institute as soon as possible and at the latest six weeks after the measurements are completed. The measurement results together with the uncertainties and any additional information required should be reported in the format given in the instructions as part of the protocol, usually by completing the standard forms annexed to the instructions.

9. Preparation of the report on a key comparison

The pilot institute is responsible for the preparation of a report on the comparison. The report passes through a number of stages before publication, and these are referred to here as drafts A and B.

The first draft, draft A, is prepared as soon as all the results have been received from the participants. It includes the results transmitted by the participants, identified by name. It is confidential to the participants.

The second draft, draft B, is subsequently prepared for the Consultative Committee and includes an Appendix containing proposals for a reference value and degrees of equivalence.

- **During the comparison, as the results are received by the pilot institute, they are kept confidential by the pilot institute until all the participants have completed their measurements and all the results have been received, or until the date limit for receipt of results has passed.**

- **A result from a participant is not considered complete without an associated uncertainty, and is not included in the draft report unless it is accompanied by an uncertainty supported by a complete uncertainty budget. Uncertainties are drawn up following the guidance given in the technical protocol.**

- **If, on examination of the complete set of results, the pilot institute finds results that appear to be anomalous, the corresponding institutes are invited to check their results for numerical errors but without being informed as to the magnitude or sign of the apparent anomaly. If no numerical error is found the result stands and the complete set of results is sent to all participants. Note that once all participants have been informed of the results, individual values and uncertainties may be changed or removed, or the complete comparison abandoned, only with the agreement of all participants and on the basis of a clear failure of the travelling standard or some other phenomenon that renders the comparison or part of it invalid.**

- **An institute that considers its result unrepresentative of its standards may request a subsequent separate bilateral comparison with the pilot institute or one of the participants. This should take place as soon as possible after the completion of the comparison in progress. The subsequent bilateral comparison is considered as a new and distinct comparison**

- **Draft A is considered as confidential to the participants. Copies are not given to non-participants, and graphs or other parts of the draft are not used in oral presentations at an outside Conference without the specific agreement of all the participants.**

- **Draft B, which supersedes draft A, is not considered confidential, and may be the subject of a publication with the exception of the Appendix containing proposals for the reference value and degrees of equivalence.**

- **The key comparison reference value and its uncertainty, normally that proposed by the pilot institute, is approved by the Consultative Committee on the recommendation of its working group on key comparisons.**

- **After deciding the key comparison reference value and its uncertainty, the deviation from the reference value and the uncertainty of the deviation are deduced for each of the individual results.**

10. Bilateral key comparisons

A bilateral key comparison may be carried out by two institutes meeting the following conditions:

(a) one of them must have already participated in the relevant CIPM or RMO key comparison; this institute acts as pilot for the bilateral comparison which must use the same or similar protocol as for the key comparison;

(b) the other must be an NMI that meets the requirements for participation in a key comparison.

11. Publication of the results of a key comparison and entry into Appendix B of the MRA and the BIPM key comparison database.

There are different forms in which the results of a key comparison may be published,

- **publication of an extended paper in Metrologia or some other journal**
- **publication in a shortened form in Metrologia or some other journal**
- **publication in a Conference Proceedings following presentation at a Conference;**
- **publication of the Final Report *in extenso* as a BIPM Report.**

A combination of more than one of these channels is possible.

12. Supplementary comparisons

Supplementary comparisons should be carried out following protocols inspired by these Guidelines for CIPM key comparisons.