# Global MRA and Traceability

## Time and Frequency area

# Contents

- MRA
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  - Traceability of Time & Frequency
    - Key comparisons
  - Quality system
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# CIPM MRA -Objectives

The CIPM MRA was drawn up by the International Committee of Weights and Measures (CIPM), under the authority given to it in the Meter Convention, for signature by directors of the NMIs of Member States of the BIPM and Associates of the CGPM.

- Objectives
  - to establish the degree of equivalence of national measurement standards maintained by NMIs;
  - to provide for the mutual recognition of calibration and measurement certificates issued by NMIs;
  - thereby to provide governments and other parties with a secure technical foundation for wider agreements related to international trade, commerce and regulatory affairs.

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# CIPM MRA-Process & Outcome

- Process
  - international comparisons of measurements, to be known as key comparisons;
  - supplementary international comparisons of measurements;
  - quality systems and demonstrations of competence by NMIs.
- Outcome
  - statements of the measurement capabilities of each NMI in a database maintained by the BIPM and publicly available on the Web.

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# CIPM MRA - Engagement

NMI directors sign the CIPM MRA with the approval of the appropriate authorities in their own country and thereby:

- accept the process specified in the MRA for establishing the database;
- recognize the results of key and supplementary comparisons as stated in the database;
- recognize the calibration and measurement capabilities of other participating NMIs as stated in the database.

# CIPM MRA - Exclusions

- signature of the MRA engages NMIs but not necessarily any other agency in their country;
- responsibility for the results of calibrations and measurements rests wholly with the NMI that makes them and is not, through the MRA, extended to any other participating NMI.

# CIPM MRA
# - Organizational structure

- overall coordination is by the BIPM under the authority of the CIPM, which is itself under the authority of the Member States of the BIPM;
- the Consultative Committees of the CIPM, the Regional Metrology Organizations and the BIPM are responsible for carrying out the key and supplementary comparisons;
- a Joint Committee of the Regional Metrology Organizations and the BIPM (the JCRB) is responsible for analyzing and transmitting entries into the database for the calibration and measurement capabilities declared by the NMIs.

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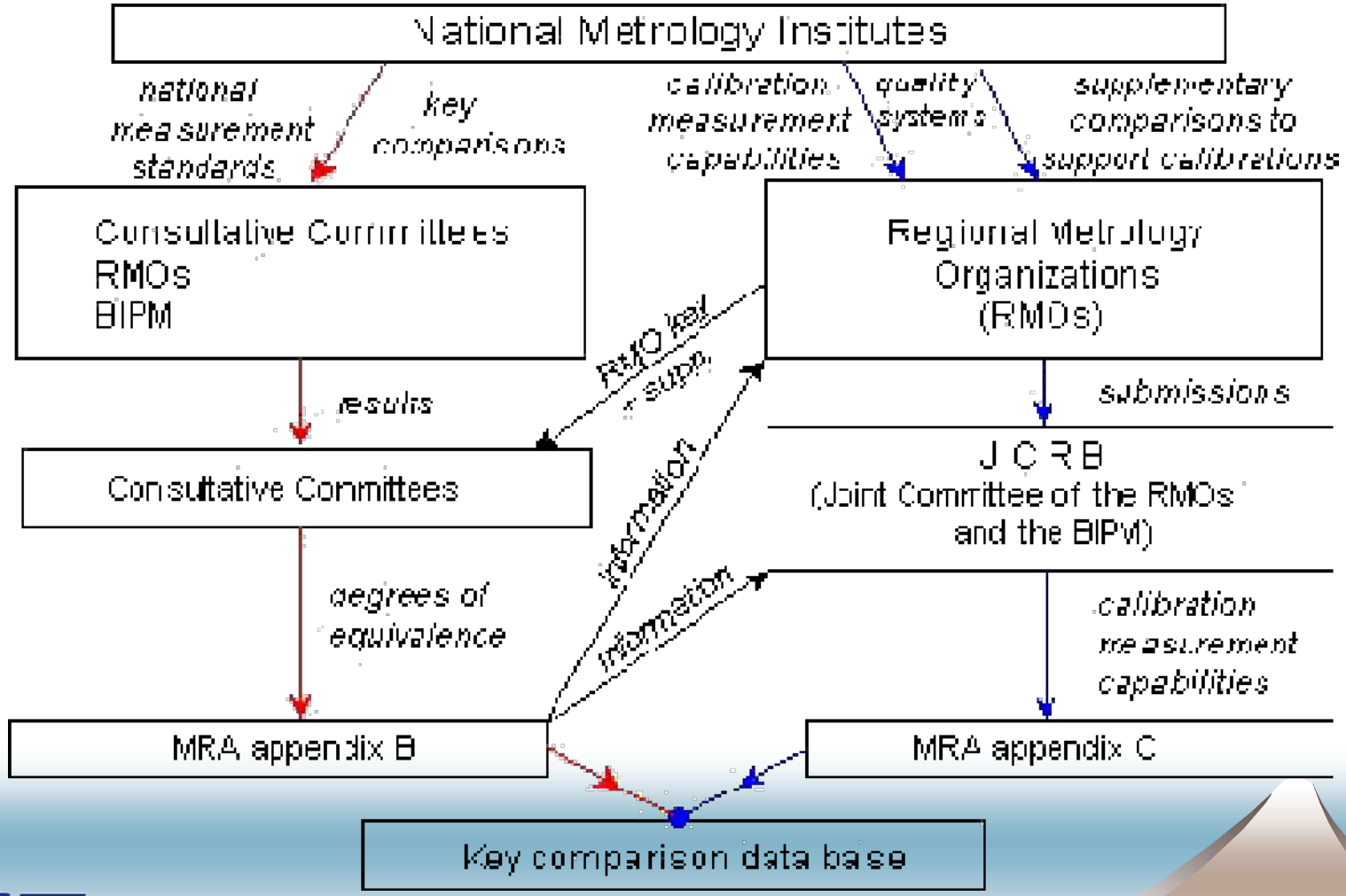
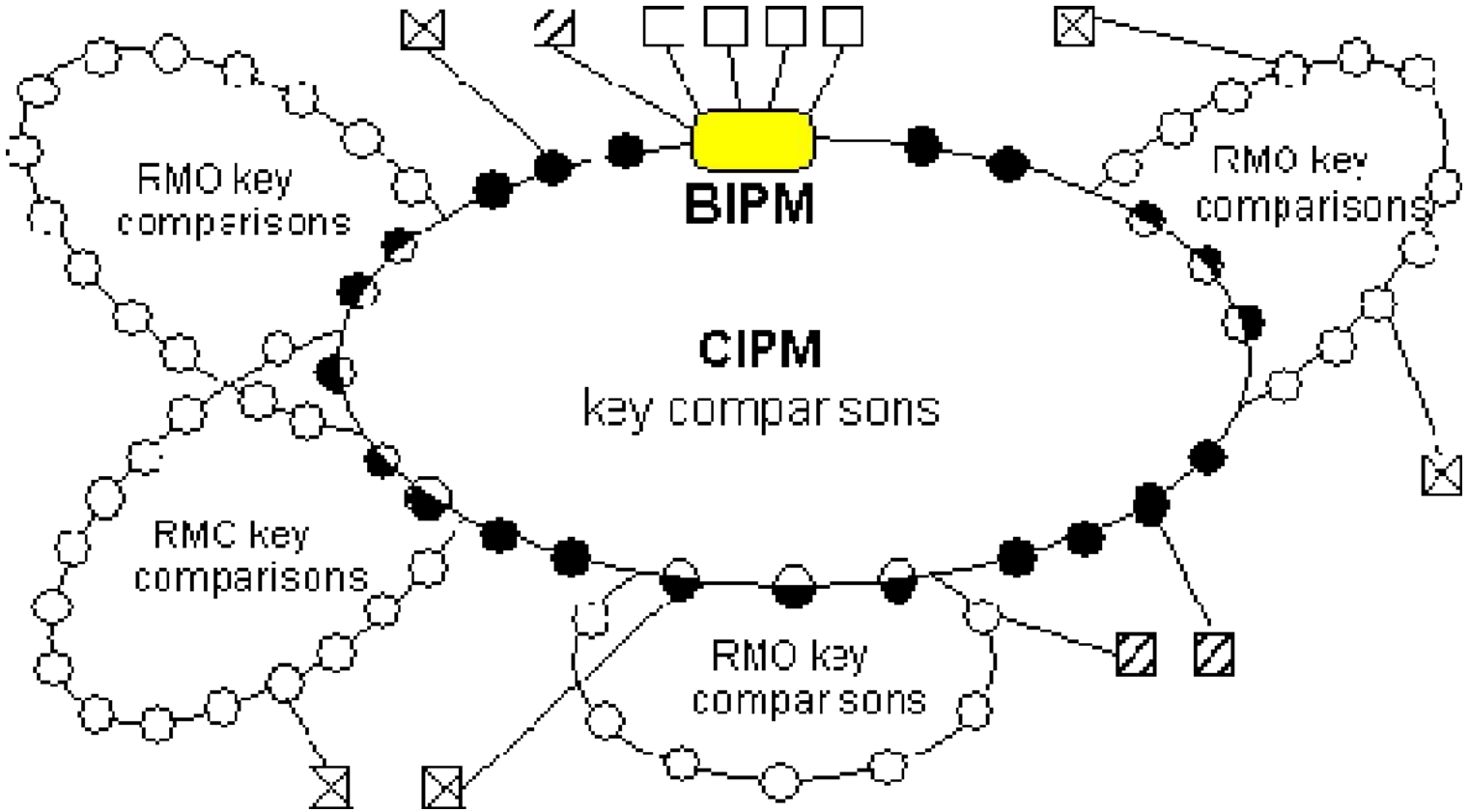
# Outline of the organization of the MRA



# Key comparisons for traceability




● National metrology institute (NMI) participating in CIPM key comparisons

◐ NMI participating in CIPM key comparisons and in regional metrology organization (RMO) key comparisons

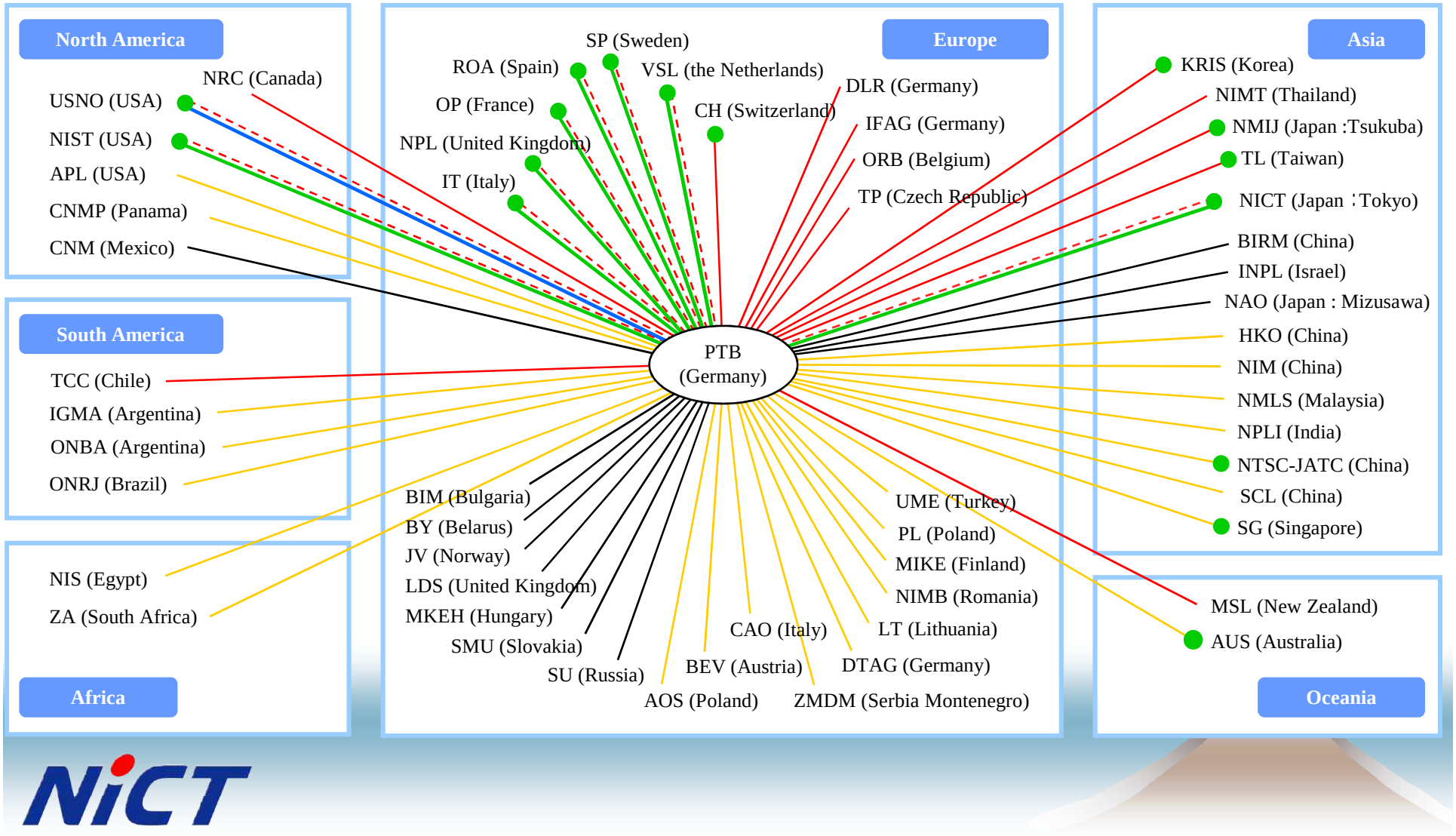
○ NMI participating in RMO key comparisons

☐ NMI participating in ongoing BIPM key comparisons

☒ NMI participating in a bilateral key comparison

▨ International organization signatory to the MRA

# Network for international Time comparison



# Supplement and Appendices of the MRA(1)

- Technical supplement:

  specifies conventions and responsibilities relating to the key comparisons.

- Appendix A:

  contains the growing list of national metrology institutes (NMI's) that have signed the MRA;

- Appendix B:

  contains the key comparisons of quantities that have been carried out and its results (reference values and deviations and associated uncertainties of the participating NMI's);

# Supplement and Appendices of the MRA(2)

- Appendix C:

  contains the detailed list of quantities and ranges for which calibration and measurement certificates is recognized by the participating institutes;

- Appendix D:

  is the list of (chosen quantities for) which CIPM and RMO key comparisons will be held;

# Supplement and Appendices of the MRA(3)

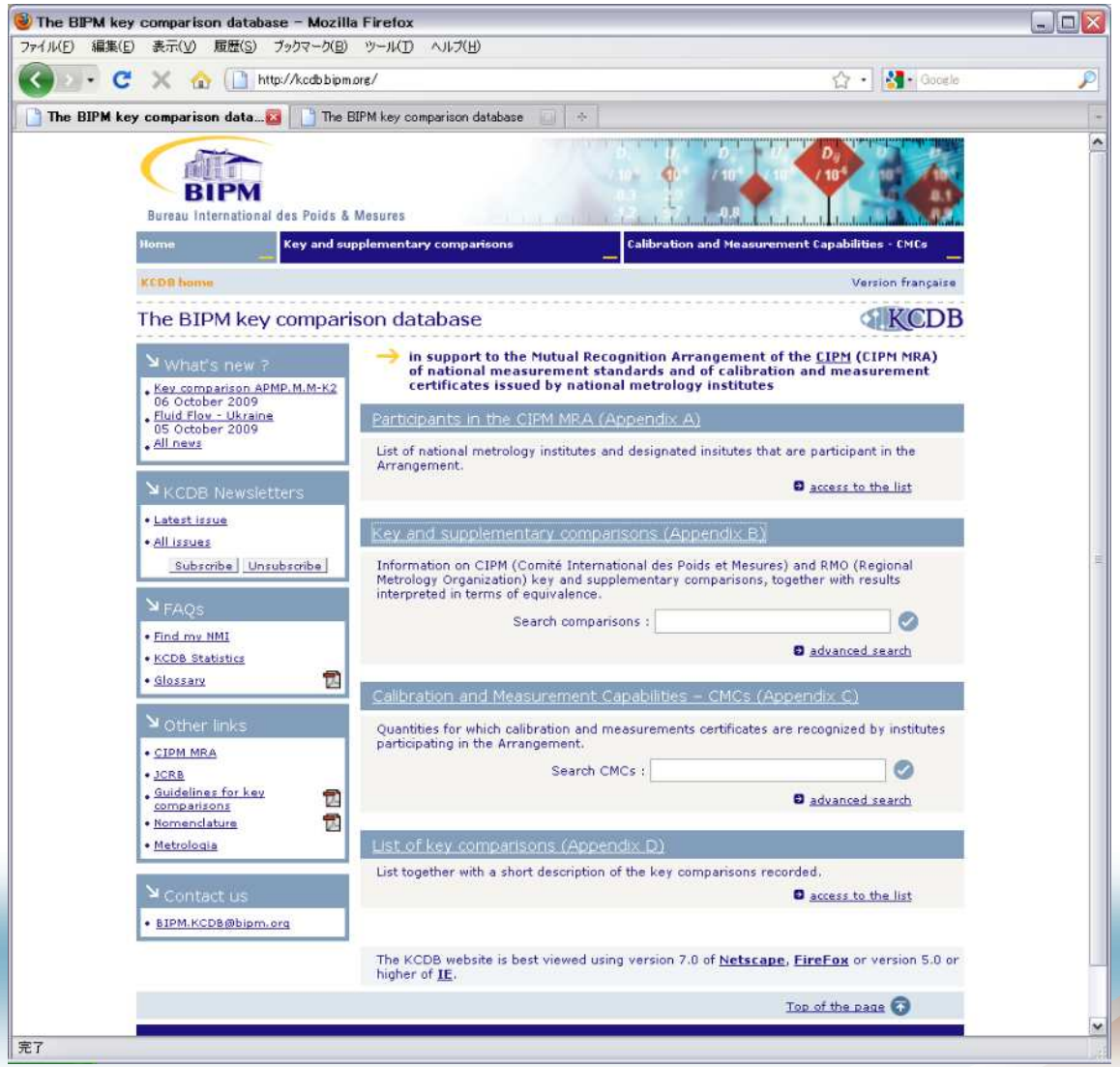
- Appendix E:

  contains the terms of reference of the Joint Committee of the Regional Metrology Organizations (RMO's) and the BIPM (JCRB);

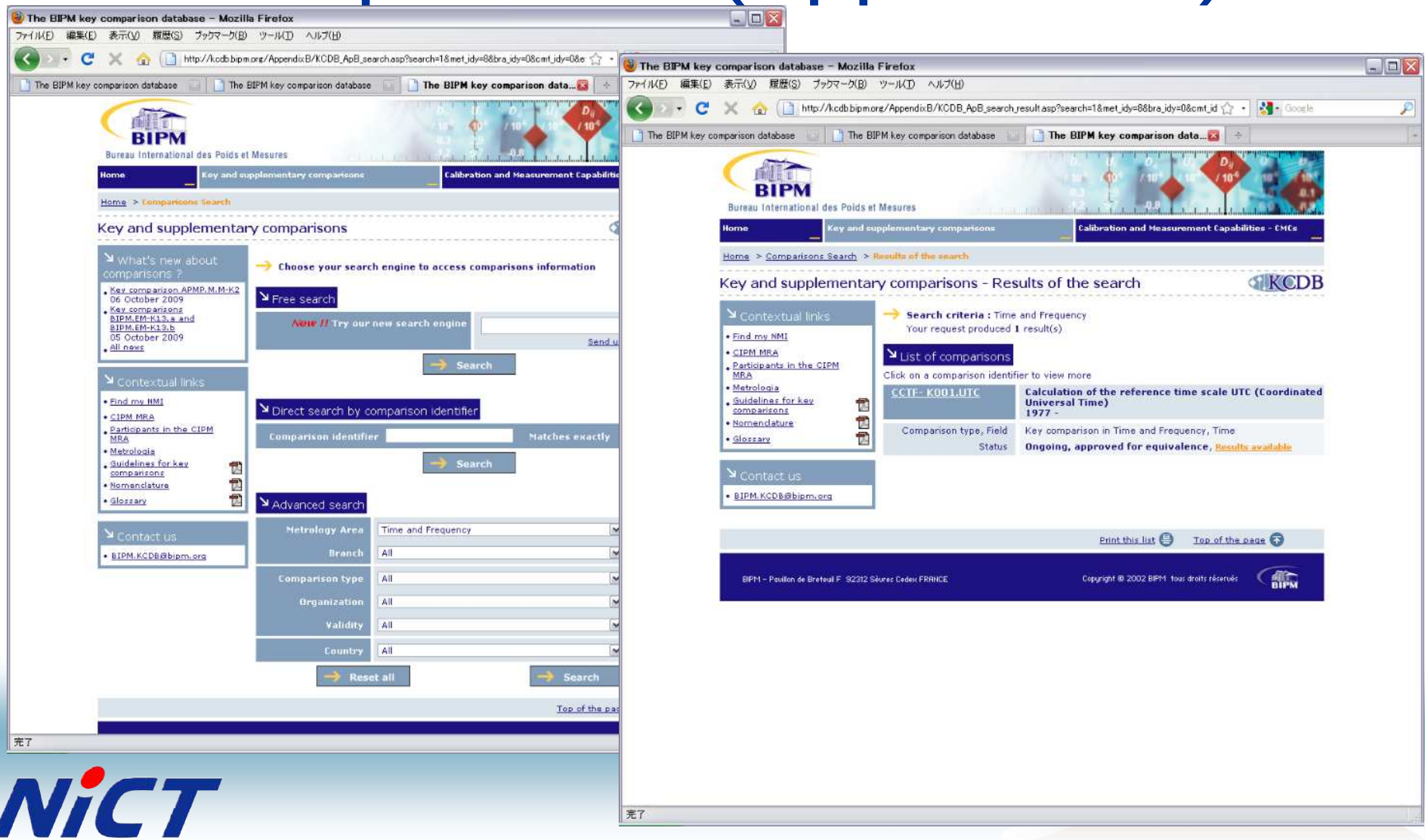
- Appendix F:

  contains the Guidelines for CIPM key comparisons dated 1 March 1999, see Technical Supplement T.6.

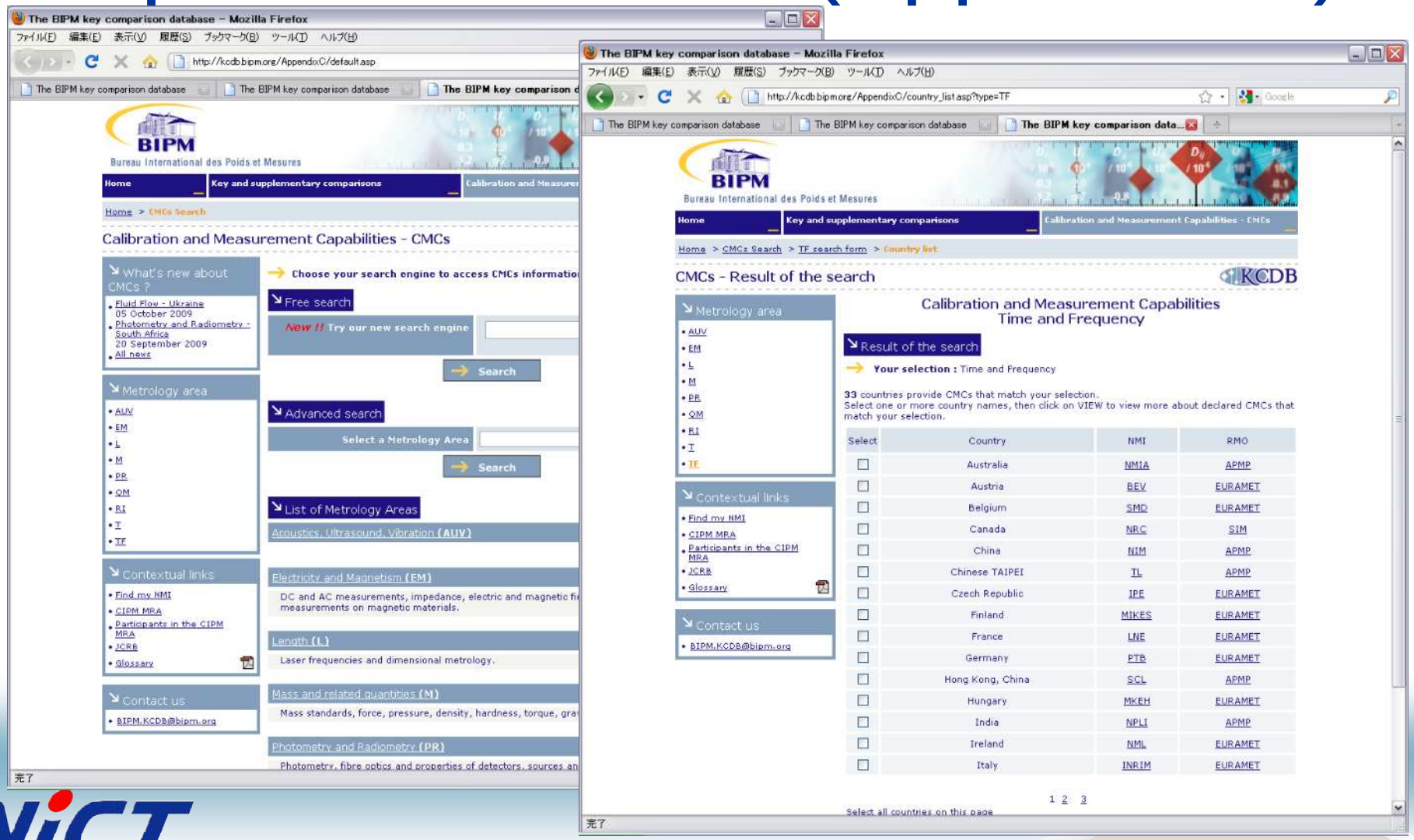
# The BIPM key comparison database



# Key and supplementary Comparisons (Appendix B)



# Calibration and Measurement Capabilities - CMC (Appendix C)



# Accepting a quality system Basic Requirement

- the implementation of a quality system satisfying ISO/IEC 17025 (or for reference material producers, ISO Guide 34 or ILAC Guide 12), and

- technical competence to provide a calibration and measurement service that can deliver the uncertainties claimed.

# Accepting a quality system Compliance

(a)Third party accreditation, or

(b)Certification to ISO 9001 and attestation by technical peers, or

(c)Attestation by a team consisting of quality system experts and technical peers. This may be organized by the NMI or another recognized body, such as an accreditation agency or APLAC.

# Accepting a quality system Evidence(1)

- NMIs following pathway (a)
  - Copies of accreditation certificate(s).
  - Scope of accreditation.
  - Names and affiliations of technical assessors.

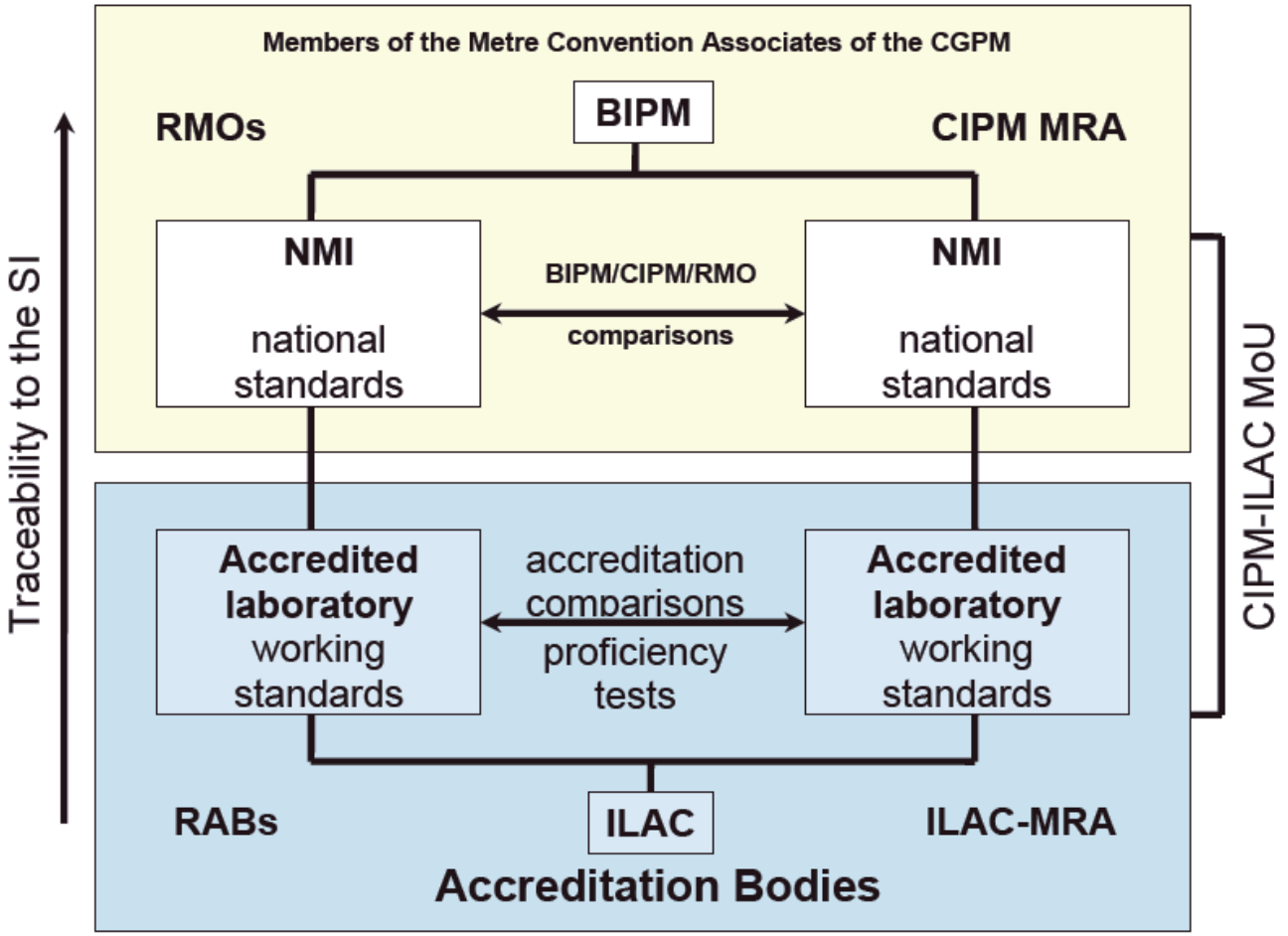
# Accepting a quality system Evidence(2)

- NMIs following pathway (b)
  - Quality (ISO 9001) certificate(s) with details of areas covered by the certification.
  - Summary report by the technical peers.
  - Final attestation by the reviewers, or at least the leader of the review team, stating that all the non-conformances have been satisfactorily addressed.

# Accepting a quality system Evidence(3)

- NMIs following pathway (c)
  - Summary report by the review team consisting of quality system experts and technical peers.
  - Final attestation by the reviewers, or at least the leader of the review team, stating that all the non-conformances have been satisfactorily addressed.
  - Names, affiliations, qualifications and experience of the quality experts.

# BIPM and ILAC



# Thank you for your attention


# Calibration and Measurement Capabilities in the context of the CIPM MRA

**CIPM MRA-D-04**

**Version 1**

## Contents

# 1. Background.

## 1.1. On the CIPM MRA

Paragraph 2 of the CIPM MRA, defines the scope of the arrangement as:

*2.1 Participating national metrology institutes, listed in Appendix A, recognize the degree of equivalence of national measurement standards, derived from the results of key comparisons, for the quantities and values specified in Appendix B. This constitutes part one of the arrangement.*

*2.2 Participating institutes recognize the validity of calibration and measurement certificates issued by other participating institutes for the quantities and ranges specified in Appendix C. This constitutes part two of the arrangement.*

The recognition of the calibration and measurement certificates, is done through the peer review and inter regional approval of the Calibration and Measurement Capabilities (CMCs) published in the Appendix C of the MRA. However, this term is not defined in the main part of the CIPM MRA, but in the Technical Supplement – T 7,

> *For calibration and measurement certificates, the quantities, ranges and calibration and measurement capabilities expressed as an uncertainty (normally at a 95 % level of confidence but in some cases it may be at a higher, specified, level), are listed for each participating institute in Appendix C. They must be consistent with the results given in Appendix B, derived from the key comparisons. If, as a result of a key comparison, a significant unresolved deviation from the key comparison reference value persists for the standard of a particular participating institute, the existence of this deviation is noted in Appendix C. The same applies for significant inconsistencies resulting from a supplementary comparison. In this case, the institute has the choice of either withdrawing from Appendix C one or more of the relevant calibration and measurement services or increasing the corresponding uncertainties given in Appendix C. The calibration and measurement capabilities listed in Appendix C are analyzed by the Joint Committee following the procedures given in 7.3 above.* ***The calibration and measurement capabilities referred to in this paragraph are those that are ordinarily available to the customers of an institute through its calibration and measurement services; they are sometimes referred to as best measurement capabilities****.*

This definition began to be discussed soon after the initial signature of the CIPM MRA in 1999. The main discussions were based on the meaning of the term “best” in the definition of “best measurement capabilities”. Also, there were some discrepancies on the interpretation of this definition among NMIs and accreditors.

### 1.2. On the CIPM and JCRB documents

As the coordinating body of the CIPM MRA, the CIPM and the JCRB have along the years produced a series of documents defining rules for the way that CMCs are presented, reviewed, and the criteria for acceptance in appendix C.

These documents resulted in many cases from particular problems that appeared in the implementation of the CIPM MRA. At present, it can be considered that system has reached maturity and all the documents related to CMCs can be compiled in a single document covering all aspects of CMCs.

In some cases, however, documents contradicted earlier ones – either because there was a need to improve the process or because the old versions or decisions were forgotten. There is a need, which this document addresses, to clarify the current policy and, if necessary, to describe the history so as to avoid confusion.

### 1.3. On the definition of CMC

The term Calibration and Measurement Capability (CMC), was first used in the CIPM MRA text as a synonym of the term Best Capability Measurement (BMC) used by the accreditation community. The word “Best” brought some conflicts in the definition and in the data for the Appendix C of the CIPM MRA. After several joint meetings of BIPM, ILAC, the RMOs and the RCABs (formerly RABs) a common terminology for Best Measurement Capability (BMC) and Calibration and Measurement Capability (CMC) was agreed.

The BIPM/ILAC working group finalized the text during the “St. Paul meeting” in August 2007, and was then presented to the ILAC General Assembly in October 2007, and to the CIPM in November 2007. The working group suggested that, after approval, BIPM and ILAC should draft a joint statement on the subject. It also recommended that ILAC should adapt its current draft policy on estimation of uncertainty in calibration so as to take account of the recommendations and the outcome of the working group.

Finally in 2008, the definition of the term CMC was agreed and accepted by both communities. The definition contains a series of explanatory notes that are of crucial importance, and aim to clarify issues of immediate relevance to the definition. They do not claim to cover every implication, or to address related issues. They may, however, be developed further, either in the current draft ILAC policy document on the estimation of

uncertainty in calibration, or in any guidance subsequently developed by the JCRB, for approval by the CIPM.

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## 2. Definition of Calibration and Measurement Capability (CMC)

In the context of the CIPM MRA and ILAC Arrangement, and in relation to the CIPM-ILAC Common Statement, the following shared definition was agreed upon:

> ***"A CMC is a calibration and measurement capability available to customers under normal conditions:***
>
> ***(a) as published in the BIPM key comparison database (KCDB) of the CIPM MRA; or***
>
> ***(b) as described in the laboratory's scope of accreditation granted by a signatory to the ILAC Arrangement. "***
>
> ***Where the term NMI is used it is intended to include Designated Institutes (DIs) within the framework of the CIPM MRA."***
>
> *NOTES*
>
> *N1. The meanings of the terms Calibration and Measurement Capability, CMC, (as used in the CIPM MRA), and Best Measurement Capability, BMC, (as used historically in connection with the uncertainties stated in the scope of an accredited laboratory) are identical. The terms BMC and CMC should be interpreted similarly and consistently in the current areas of application.*
>
> *N2. Under a CMC, the measurement or calibration should be:*
>
> *- performed according to a documented procedure and have an established uncertainty budget under the management system of the NMI or the accredited laboratory;*
> *- performed on a regular basis (including on demand or scheduled for convenience at specific times in the year); and*
> *- available to all clients.*

*N3. The ability of some NMIs to offer "special" calibrations, with exceptionally low uncertainties which are not "under normal conditions," and which are usually offered only to a small sub-set of the NMI's clients for research or for reasons of national policy, is acknowledged. These calibrations are, however, not within the CIPM MRA, cannot bear the equivalence statement drawn up by the JCRB, and cannot bear the logo of the CIPM MRA. They should not be offered to clients who then use them to provide a commercial, routinely available service. Those NMIs which can offer services with a smaller uncertainty than stated in the database of Calibration and Measurement Capabilities in the KCDB of the CIPM MRA, are, however, encouraged to submit them for CMC review in order to make them available on a routine basis where practical.*

*N4. Normally there are four ways in which a complete statement of uncertainty may be expressed (range, equation, fixed value and a matrix). Uncertainties should always comply with the Guide to the Expression of Uncertainty in Measurement (GUM) and should include the components listed in the relevant key comparison protocols of the CIPM Consultative Committees. These can be found in the reports of comparisons published in the CIPM MRA KCDB as a key or supplementary comparison.*

*N5. Contributions to the uncertainty stated on the calibration certificate and which are caused by the client's device before or after its calibration or measurement at a laboratory or NMI, and which would include transport uncertainties, should normally be excluded from the uncertainty statement. Contributions to the uncertainty stated on the calibration certificate include the measured performance of the device under test during its calibration at the NMI or accredited laboratory. CMC uncertainty statements anticipate this situation by incorporating agreed-upon values for the best existing devices. This includes the case in which one NMI provides traceability to the SI for another NMI, often using a device which is not commercially available.*

*N5a. Where NMIs disseminate their CMCs to customers through services such as calibrations or reference value provision, the uncertainty statement provided by the NMI should generally include factors related to the measurement procedure as it will be carried out on a sample, i.e., typical matrix effects, interferences etc. must be considered. Such uncertainty statements will not generally include contributions arising from the stability or inhomogeneity of the material. However, the NMI may be requested to evaluate these effects, in which case an appropriate uncertainty should be stated on the measurement certificate. As the uncertainty associated with the stated CMC cannot anticipate these effects, the CMC uncertainty should be based on an analysis of the inherent performance of the method for typical stable and homogeneous samples.*

*N5b. Where NMIs disseminate their CMCs to customers through the provision of certified reference materials (CRMs) the uncertainty statement accompanying the CRM, and as claimed in the CMC, must indicate the influence of the material (notably the effect of instability, inhomogeneity and sample size) on the measurement uncertainty for each certified property value. The CRM certificate should also give guidance on the intended application and limitations of use of the material.*

*N6. The NMI CMCs which are published in the KCDB provide a unique, peer reviewed traceability route to the SI or, where this is not possible, to agreed - upon stated references or appropriate higher order standards. Assessors of accredited laboratories are encouraged always to consult the KCDB (http://kcdb.bipm.org) when reviewing the uncertainty statement and budget of a laboratory in order to ensure that the claimed uncertainties are consistent with those of the NMI through which the laboratory claims traceability.*

*N7. National measurement standards supporting CMCs from an NMI or DI are either themselves primary realizations of the SI or are traceable to primary realizations of the SI (or, where not possible, to agreed - upon*

*stated references or appropriate higher order standards) at other NMIs through the framework of the CIPM MRA. Other laboratories that are covered by the ILAC Arrangement (i.e. accredited by an ILAC Full Member Accreditation Body) also provide a recognized route to traceability to the SI through its realizations at NMIs which are signatories to the CIPM MRA, reflecting the complementary roles of both the CIPM MRA and the ILAC Arrangement.*

*N8. Whereas the various parties agree that the use of the definitions and terms specified in this document should be encouraged, there can be no compulsion to do so.*

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# 3. Drawing up CMCs files

There are two different cases to be taken into consideration:

- CMCs files from a institute that has not previously submitted CMCs in a particular area (New CMCs)
- CMCs files than imply the modification or expansion of already approved CMCs.

Blank Excel files and particular instructions for the different areas can be found in the JCRB website, under "Instructions for drawing up CMC excel files":

- Basic excel template
- Excel template with uncertainty matrices and closely related CMCs
- Excel template for CMCs in chemistry
- Instructions for closely related CMCs
- Additional instructions for CMCs files in EM
- Instructions for uncertainty matrices in CMC files
- International rules for filling in the CMC tables for ionizing radiation

## 3.1. General instructions, format of the CMCs file.

The following rules should be followed to ensure the reliability of the information included in the part "Appendix C" of the BIPM key comparison database.

The submission of CMCs for the review process is done in EXCEL files, in the formats established in general by the JCRB and with particular cases for QM, EM and IR.

It is essential that the submissions are done following the prescribed formats, to allow the upload in the KCDB of the reviewed and approved data.

The information to be submitted in the EXCEL file is shown in the following figure:

| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CMC Table for (Name of the NMI or DI doing the submission) | | | | | | | | | | | | | | | | | | | | | |
| 2 | Calibration or Measurement Service | | | Measurement Level or Range | | | Measurements Conditions/ Independent Variables | | Expanded uncertainty | | | | | Reference Standard used in calibration | | List of Comparisons supporting this Measurement | Comments | APMP TCTF Service Administration | | | | |
| 3 | | | | | | | | | | | | | | | | | | | | | | |
| 4 | Quantity | Instrument or Artifact | Instrument Type or Method | Minimum Value | Maximum Value | Units | Parametrer | Specifications | Value | Units | Coverage Factor | Level of Confidence | Is the Expanded Uncertainty a relative One | Standard | Source of Traceability | | | NMI Service Identifier | Classifications of Services | NMI | Review status | Review Comments |
| 5 | Column 1 | Column 2 | Column 3 | Column 4 | Column 5 | Column 6 | Column 7 | Column 8 | Column 9 | Column 10 | Column 11 | Column 12 | Column 13 | Column 14 | Column 15 | Column 16 | Column 17 | Column 18 | Column 19 | Column 20 | Column 21 | Column 22 |
| 6 | | | | | | | | | | | | | | | | | | | | | | |

The BIPM Appendix C database provides information contained in the "white part" of the CMC Excel files, namely "Calibration and measurement service" (Columns 1-3), "Measurand level or range" (Columns 4-6), "Measurement conditions/independent variable" (Columns 7-8), "Expanded uncertainty" (Columns 9-13), and in the column of comments (Columns 17) on the CMC lines. Three additional columns are also needed: the yellow column including the NMI acronym (Columns 18), the yellow column including the NMI service identifier (Column 18, not mandatory to be filled) and the yellow column including the service number (Columns 19) drawn up from the Classifications of Services defined by the CC of each metrology area. The remaining columns, especially the "blue part" and any additional columns of information useful for the regional and inter-regional review are for review purposes only and are not part of the KCDB. It follows that these instructions concern only the "white part" of CMC Excel files and the three columns mentioned above.

1. Following the 5th JCRB decision to present CMCs by countries rather than by NMIs, **use one Excel file per country, per metrology area and per category**. The Excel file may include several worksheets, but all CMCs should be listed in one single worksheet for all branches of the metrology area, the additional worksheets being used for information needed in the intra- or inter-regional review.

2. **THIS IS THE MOST IMPORTANT INSTRUCTION OF ALL.** Since the search engine of the database relies upon the Classification of Services, care should be taken to use **the most recent list of services** for choosing the service numbers. This list can be downloaded from the KCDB website.

   http://kcdb.bipm.org/appendixC/AUV/AUV_services.pdf

   http://kcdb.bipm.org/appendixC/EM/EM_services.pdf

   http://kcdb.bipm.org/appendixC/L/L_services.pdf

http://kcdb.bipm.org/appendixC/M/M_services.pdf

http://kcdb.bipm.org/appendixC/PR/PR_services.pdf

http://kcdb.bipm.org/appendixC/QM/QM_categories.pdf

http://kcdb.bipm.org/appendixC/RI/RI_services.pdf

http://kcdb.bipm.org/appendixC/T/T_services.pdf

http://kcdb.bipm.org/appendixC/TF/TF_services.pdf

3. Translate all words into **English**.

4. Use the **period** "." as the decimal separator rather than a **comma** ",".

5. Choose the setting **"text"** for all the cells of the useful part of the file. **Do not** choose "**percentage**" or "**scientific**". Formatting all cells in text ensures that information is safely imported into the database. In addition, as mentioned below, it does not prevent, and even often simplifies, the writing of statements such as "95%" or "4.25E-03".

6. Format all the cells of the useful part of the file in "**Center**" and "**Wrap text**".

7. Use by default the font "**Arial 10**" and not "Times new roman 10 or 12". The "**µ**" is obtained directly from your keyboard or by typing "**ALT+0181**" and the "±" by typing "**ALT+0177**". Greek letters cannot be written in "Arial 10": use instead "Symbol 10" for these special characters (for instance for "**Ω**", "**Ø**", etc.). Avoid using any other fonts than the two cited here.

8. **Italics** should be used for **quantities** (for instance "***L***" for a length), but never for units.

9. For cells including words (for instance the column describing the method), **avoid abbreviation** (for instance write "relative" instead of "rel.") and the wording should **always begin with a capital letter** but **no other capital letters** should be used in the same cell, except if an acronym is to be given (for instance "Relative AC/DC voltage difference", but not "Relative AC/DC Voltage Difference"). This applies to all cells except those giving the **specifications of parameters**, which **should never begin with a capital letter** (this case is very rare since the parameter specifications generally consist of value ranges).

10. Be careful with the insertion of blank characters into cells. **Blank characters should be used only to separate words** (for instance "AC/DC voltage difference"), **to separate a number from its unit** (for instance "20 °C"), **after a colon** ":" **and a comma** "," (such as “Length: central length, *L*") but never preceding a colon or comma. All **other blank characters should be deleted**, even if it slightly degrades the presentation (for example, do not write "1 mm, 10 mm, 100 mm" to make the "100 mm" appear well-centered in the cell.

11. **Do not use the semicolon ";"** inside a cell, which may be interpreted as a cell separator when importing the file into the database. You can, however, use the colon ":" and the comma ",".

12. **Do not imbed returns, spaces or tabs in a single cell** to force word wrapping, even if it appears to improve the presentation. In particular, **never use the function "Alt+Return"** (it inserts a "carriage return" inside an Excel cell).

13. Multiple entries in a single cell must be separated vertically into separate cells and cells **must not be merged** vertically. This holds specially when the description of one CMC is valid for different measurand ranges and/or includes several parameters with their specifications. In these cases:

    - use only **one measurand range per CMC** and repeat all other relevant information;
    - place each parameter and specification in its own cell.
    - See examples in appendix 1.

14. **Superscripts** and **subscripts** can be used, but **not for numbers** (especially not for powers of ten, see instruction 17). Superscripts must be used in the expression of units such as "m/s$^2$".

15. A blank character may be used in a complicated unit [for example "µW/(V A)"]. In such a case the blank character may be used but is not necessary. **Avoid using the "dot above the line"** (Alt+0149) which has the meaning of "multiplication" of units (this character is not accepted by the database; better to insert a blank character or nothing at all).

16. If a unit like "dB" needs **a reference value**, include it in column B "Instrument or Artifact" under the form: "Reference value for the unit: 1 µV".

17. **Use as often as possible the scientific notation "YE-XX" when writing numbers, especially powers of ten.** Note that since the cells are defined as "text" the characters "Y", "E" and "-XX" are sequentially typed without defining any other settings such as the number of decimals. The part "Y" may be a number including decimals; the point "." should be used as the decimal separator (for example "1.0E-09" does not convey the same meaning as "1E-09" since an additional decimal is given in the first case). **Do not separate the part "Y" from the part "E-XX"** by a blank or any other character. Always write the part "-XX" with three characters (and not two): a "-" or "+" sign and two integers (for instance, avoid writing expressions such as "1E-9" for "1E-09", or "4.23E04" for "4.23E+04"). The sign "-" is obtained in Arial as a short dash.

18. **Do not use "±" in the uncertainty column**; "±" is reserved for ranges in the specification of parameters.

19. The part "Expanded uncertainty" should at least be divided into five columns corresponding to the headings "Value", "Unit", "Coverage factor", "Level of confidence", and "**Is the expanded uncertainty a relative one?**". Answer this question in the CMC lines by inserting "**Yes**" or "**No**". A blank entry with no answer to the question cannot be accepted. Note that in Chemistry, the part "Value" is split into two columns "From" and "To".

20. **Do not use a blank character in the multiplication of a number by a quantity** (thus "0.24*L*" and not "0.24 *L*").

21. It may happen that the expanded uncertainty is a function of a quantity. In such a case, be sure to **define the quantity and its symbol** and specify the unit. This unit should be by default the unit given for the measurand range, but this has not always proved to be the case; it is obligatory that the unit be given explicitly (thus "Q[20, 0.24*L*]" should be written as "Q[20, 0.24*L*], *L* central length in mm".

22. Parameters are often specified as a range of values. Use the **ISO standard presentation for value ranges**: the unit should be given at both ends of the range. In

addition use "to" instead of "-" as the "-" may be interpreted as the "minus" sign (for example the specification of the parameter "Frequency", "10 - 20 Hz", should be written as "10 Hz to 20 Hz").

23. It was suggested that a typical range of values be given for the expanded uncertainty when this uncertainty is expressed as a function. This can be particularly informative, especially when the uncertainty value depends upon a number of parameters. Experience gained from the CMCs already published shows, however, that this is not often done and that some calculation errors were incurred in computing both ends of the values' range. This thus remains an option, but there is no obligation in this regard. **If a range of uncertainty values is given, it is important that it is computed correctly** (as no checks are made at the BIPM) and that the units of both limits of the range are given (see point 22 above). Thus "Q[20, 0.24*L*], *L* central length in mm, values range from 20 to 31" should be written as "Q[20, 0.24*L*], *L* in mm, values range from 20 nm to 31 nm".

24. The level of confidence should be written as a **percentage** (such as "95%") and **not as the number** "0.95". Since all cells should have been previously defined in "text", this result is obtained by typing "9" "5" "%" without inserting any blank character.

25. **Check that the NMI acronym is given for all the CMC lines included in the file**. The NMI acronym should be written with no blank character added before or after the acronym. Blank characters may be added inside the acronym if the acronym is composed of two or more words. A hyphen or a slash can be inserted in the acronym; adding blank characters before and after the hyphen is a choice that the laboratory should make. Once the acronym is chosen, **it should be unique and always written in the same way.**

26. Each laboratory can choose how to identify its internal service identifiers. The NMI internal service identifiers are often given by a simple number (for instance "23"), which is fine. It may also correspond to the identifiers of the catalogue of services provided by the laboratory (and often available via its website). An internal identifier that includes blank characters or a series of words.

27. **It is imperative that the service numbers refer to services which are actually listed in the Classification of Services of the relevant metrology area (see point**

**2)**. A service number is usually presented as "a.b.c", where "a", "b", and "c" are integers (for instance "2.1.3"). Sometimes it includes only two integers (as in Chemistry), or an additional identifier ("Co-60" for "Cobalt 60" as in the field of Ionizing Radiation); this depends on the agreed Classification of Services. In any case, only 1 service number should be written in the appropriate cell. If the CMC line corresponds to two services of the Classification, then either one single service number is actually adequate for the cited service, or the Classification is not precise enough; in the latter case the CMC line should be repeated twice with two different service numbers. **Do not add any blank character before, within or after the service number** (thus "2.1.  3" is forbidden).

28. **The cell of comments on the CMC line is published via the database. These comments, inserted in a white cell, should not be confused with review comments that are inserted in blue or yellow cells**. The comments to be published may include a complete sentence or a simple series of words. It should begin with a capital letter, should include no other capital letters (except acronyms), may include a period "." and a comma "," but the semicolon ";" should be avoided. It can also include the URL address of a website. In such a case, the link will be inserted by the BIPM. **Never use footnotes for information to be published via the database.**

29. All header/footnotes inserted in CMC Excel sheets are not used for the database. On the contrary, they are all suppressed for construction of the .pdf files and replaced by "Calibration and Measurement Capabilities", "The BIPM key comparison database", the date, and the page numbering. RMOs may thus decide upon their own header/foot notes for the identification of their Excel sheets (for example, the date of the internal RMO review and the arrangement of pages).

30. Information included in the blue and yellow cells relevant to a given CMC may include several items. **Write all items in the same cell or use other cells on the same line**. This would activate new columns of the CMC line and has no impact on the importation of the CMC into the database. **In general, do not add artificial lines to a CMC for notes, references, or special specifications; always add columns for this purpose**.

### 3.2. Specifying the scope of CMCs

1. CMC declarations should be self-consistent. A CMC specification should not depend on references to other services as the BIPM KCDB web page is capable of displaying a single CMC.

2. CMC declarations should have three unambiguous characteristics (see examples at the end):

   a) Measurand

   Only one measurand is allowed per CMC even if several closely-related variables can be reported. Examples of this are electric power and energy or mass and volume flow rate. In these cases each variable should be reported in a separate line with the correct units and uncertainty statement.

   b) Range

   The measurement range can be expressed explicitly or implicitly (i.e. through a range of parameters) but never with a reference to other services (see 1). Implicit specifications must provide enough information in the parameters section so as to indicate the range of validity of the uncertainty statement.

   c) Uncertainty

   There should be no ambiguity as to the uncertainty that can be expected from a CMC, in particular when the measurand covers a range of values. This is generally achieved employing one of the following methods:

   i. The uncertainty is declared as a single value, which is valid throughout the measurement range.

   ii. The uncertainty is declared as a range. In this case the assumption is that linear interpolation may be used to find the uncertainty at intermediate values.

   iii. The uncertainty is declared as an explicit function of the measurand or a parameter

   iv. The uncertainty is declared as a matrix where the values of uncertainty depend on the values of the measurand and one parameter or on two parameters.

Open intervals (e.g. "<X") are not allowed in the specification of uncertainties.

Examples of CMCs with common errors can be found in Appendix 2.

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## 4. Overview of the CMCs review process.

The process leading to the publication of CMCs in Appendix C of the CIPM MRA is summarized in the flowchart presented in Appendix 1. The present document covers the process followed for the review from the moment that the CMCs are submitted to the BIPM.

The way in which the intra regional review is done, is responsibility of each of the RMOs. However, the RMOs should establish the mechanisms to assure that the intra regional review follows the JCRB rules.

The process is conducted through an interactive website at www.bipm.org/JCRB. A manual for the website (CIPM–D–05) is available online.

Passwords to obtain access to the interactive website may be obtained from the JCRB Executive Secretary.

Every time that there is an intervention on the website, it sends automatic e-mails to the TC/WG chairs of the metrology area concerned, the RMO representatives to the JCRB and to the JCRB Executive Secretary. It is responsibility of the RMOs to maintain updated the names and addresses of the technical contacts for each metrology area. RMOs may opt for a partial notification option in which they only receive automatic e-mails when they update the status of a CMC submission or when somebody else updates the status of their CMCs (see the website manual).

Reviewing TC/WGs approve the submitted CMCs based on the criteria for acceptance of data for Appendix C and are the primary responsible for maintaining the JCRB website updated. However, RMO representatives to the JCRB also have access to the website and may update it for the TC/WG chairs if necessary.

The Executive Secretary has full control over the JCRB database and may perform any update or correction to the data should this be needed.

Controversies are resolved by the JCRB which may request arbitration by the CIPM.

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## 5. Submission of CMCs

1. TC/WG Chairs or RMO Representatives may submit a set of CMCs for inter-regional review at any time.
2. Submission of CMCs for inter-regional review is done through the JCRB website at www.bipm.org/JCRB, following instruction CIPM MRA-D-05, *"Use of the JCRB website for inter-regional review of CMCs."*
3. Only CMCs that are supported by a fully-implemented quality system, reviewed and approved by the respective RMO may be submitted for inter-regional review. All submissions must be accompanied by a declaration from the Chair of the RMO Quality Systems Working Group, indicating that this requirement has been met, employing the form provided in the Attachment.
4. Each submission may contain CMCs from several NMIs belonging to the same technical area. CMCs from different areas must be forwarded as separate submissions. Metrology areas have been classified according to the nomenclature of the Consultative Committees of the CIPM, as follows:
    - Acoustics Ultrasound and Vibrations (AUV)
    - Electricity and Magnetism (EM)
    - Length (L)
    - Mass and related quantities (M)
    - Photometry and Radiometry (PR)
    - Amount of Substance (QM)
    - Ionizing Radiation (RI)
    - Thermometry (T) and
    - Time and Frequency (TF)

The French acronyms shown in parenthesis are used in the CMC designations described in the next sub-section.

5. Naming of a CMC submission

CMCs submissions are named according to the following nomenclature:

**RMO.Area.N.Year**

Where,

**RMO** is the organization submitting the CMC file

**Area** is the corresponding acronym of the metrology area, as specified in the previous numeral

**N** is a consecutive integer for each RMO and Area, started with the first submission (not restarted each year).

**Year** the year when the CMCs are submitted to the JCRB

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## 6. Steps followed in the inter regional review

1. After posting, the CMCs file is distributed by e-mail to:
   - RMO representatives
   - TC/WG Chairs in the area of the submitted CMCs
   - JCRB Executive Secretary
2. TC/WG chairs indicate their interest in participating in the review of the posted CMCs by acknowledging receipt in the website and indicating the date by which they plan to send their first comments.
3. In order to identify the TC/WGs that are interested in reviewing a particular submission, the chairs are requested to provide the date for sending comments no later than three weeks after the CMCs are posted in the website. After this time an automatic reminder is generated. After three more weeks, if the TC/WG chair has not provided a date for sending comments, the respective RMO relinquishes its right to continue with the review.

   **NOTE:** It is not sufficient to acknowledge receipt of a CMC submission to continue with the review. Only those TC/WGs that provide a date for sending comments are assumed to have expressed their interest.
4. TC/WG chairs post their first comments in the JCRB website by the date they set when they accepted to review them. If they have not sent them three weeks after this date an automatic reminder is generated. If they have not sent their comments after three more weeks (a total of six weeks after the promised date), in the absence of any other communication with the Executive Secretary, they relinquish their right to continue with the review.
5. If a TC/WG chair needs to change the date specified for sending their first comments he/she should contact the Executive Secretary. Deadlines are set to identify the RMOs that are not interested in pursuing the review. An RMO that requests an extension is expressing an interest and normally extensions are always granted.

However, repeated or unduly long requests may need to be justified and agreed on by the originating RMO.

6. After posting their first comments in the JCRB website the reviewing TC/WGs shall continue their communications directly with the originating TC/WG or even individual NMIs. There is no obligation on their part to copy the Executive Secretary or to post these comments in the JCRB website. However, should a TC/WG wish to take advantage of the distribution facilities of the website, they may post as many comments as they wish. Each one will be distributed to the reviewing TC/WGs, the RMO representatives and the Executive Secretary. Only the latest file will be available for download but all the posted comments will be saved at the BIPM for future reference.
7. The inter-regional review continues until all TC/WG chairs agree that the originating TC/WG has produced a submission that can be approved by all.
8. The originating RMO shall submit a revised Excel file through the website for final approval, which will be used for the publication in the KCDB.
9. The RMOs TC/WG chairs now have six weeks for considering the final vote. Three weeks after the final submission, a remainder e mail will be sent and after six weeks the RMO looses its right to vote and is considered an abstention. The final approval is done on a consensus basis. All the RMOs should approve or abstain to vote, but a single vote against is enough for not approving the CMCs.
10. After the final approval is obtained, the BIPM proceeds to publish the CMCs in the KCDB.

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## 7. BIPM interventions on CMCs.

The description of CMCs published in Appendix C of the CIPM MRA comes directly from the Excel files posted for approval in the JCRB web page. Therefore, it is the responsibility of the BIPM to assure that these files are not modified in any form that invalidates the inter-regional approval process.

However, the BIPM may make certain modifications to assure compliance with JCRB rules. The criteria normally reviewed by the BIPM are:

- Spelling and format
- CMC range and uncertainty specification
- NMI listing in Appendix A

Spelling and format modifications are done by the BIPM KCDB office on the final files posted for approval. The technical contacts of the issuing NMIs may be consulted to clarify certain points if the BIPM KCDB office deems it necessary.

Compliance with criteria for CMC range and uncertainty specifications as well as designation of laboratories is verified by the JCRB Executive Secretary and the BIPM KCDB office. The first one normally reviews files submitted for inter-regional review and the second final files posted for approval, in case non-conformities with the rules still remain.

If the JCRB Executive Secretary or the BIPM KCDB office finds a non-conformity with paragraph 3.2 they will notify each other and the JCRB Chairman. The JCRB Executive Secretary will then inform the RMO representative of the problem and will ask for a modification of the submitted CMCs.

CMCs from laboratories that have not been officially designated by their governments to participate in the CIPM MRA (i.e. listed in Appendix A) will not be published in Appendix C and are deleted from the approved file. RMO representatives and signatory NMIs will be promptly informed by the Executive Secretary whenever this situation arises. As soon as those laboratories are officially designated, their previously-approved CMCs are immediately published in the KCDB.

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# 8. Criteria for acceptance of CMCs

The JCRB requires that CMCs submitted for publication in Appendix C are accompanied by an RMO report indicating that the local Technical Committee/Working Group has approved the range and uncertainty of said CMCs and that each one of them is supported by a fully implemented Quality System reviewed and approved by the local RMO.

Furthermore, the JCRB requires that the range and uncertainty of the CMCs submitted be consistent with information from some or all of the following sources:

1. Results of key and supplementary comparisons
2. Documented results of past CC, RMO or other comparisons (including bilateral)
3. Knowledge of technical activities by other NMIs, including publications
4. On-site peer-assessment reports
5. Active participation in RMO projects
6. Other available knowledge and experience

While the results of key and supplementary comparisons are the ideal supporting evidence, all other five sources listed above may be considered to underpin CMCs not directly related to the available comparison results and those for which comparison results are not yet available.

The NMIs that issue the CMCs are primarily responsible for providing, through their local TC/WGs, the information that they believe is necessary to support their claims. TC/WGs from other RMOs may request additional information, if needed.

NMIs that do not hold primary standards or primary measurement capabilities are required to have traceability to the SI (or if not yet feasible to another internationally agreed reference) of their national standards or measurement capabilities established through the BIPM or through adequate calibration services of another NMI or other designated institute published in Appendix C of the CIPM MRA.

## 8.1. Special criteria for CRMs

The CIPM Mutual Recognition Arrangement (CIPM MRA) makes provision for the listing of certified reference materials (CRMs) in Appendix C. One or more CRMs can be listed in a field entitled “Mechanism(s) for Measurement Service Delivery”, in association

with amount of substance CMCs that are directly related to the ability of the designated NMIs and other designated institutes to characterize and assign traceable values to CRMs.

Appendix C of the CIPM MRA is not intended to be a catalogue of CRMs that can be delivered by the NMIs or other designated institutes. In order to have a CRM listed in Appendix C of the CIPM MRA as a mechanism of disseminating traceability, the NMI or designated institute must have demonstrated its measurement capabilities and competence in the field concerned, which are also explicitly or implicitly claimed by the institute in Appendix C. Furthermore, all CRMs listed in Appendix C must meet the requirements of the ISO Guide 34 (2000) and as far as applicable and useful of the ISO Guide 35, which pertain to the production of CRMs and to the assignment of certified values.

In order for a CRM to be listed in Appendix C, the review process should take into account the following criteria:

1. NMIs and other designated institutes listing CRMs in Appendix C of the CIPM MRA shall have a quality system in accordance with ISO/IEC 17025 and ISO Guide 34 (2000) or equivalent. The quality system must include a complete description of the whole CRM production and certification process, also defining the internal organization responsible for the certification process;
2. Values assigned to CRMs have to be traceable to the SI or if this is not (yet) feasible, to other internationally agreed references;
3. The institute may list a CRM as a service delivery mechanism in Appendix C only if the institute has an in-house competence and the measurement capabilities for assigning values to the measurand in question and the characterization (homogeneity and stability) of the CRM. The institute must take full responsibility and liability for the quality of the CRMs listed in Appendix C;
4. Value assignment and characterization should be carried out in conformity with relevant ISO guides, such as ISO Guide 35;
5. The value(s) assigned to the CRM can be a direct result from in-house measurement capabilities in the field concerned. Alternatively, the CRM value assignment capability can be the result of combining measurement results obtained internally with results obtained from other collaborating/subcontracted, competent institutes;

6. The claimed measurement uncertainties in the assigned value of a CRM must be representative of the capabilities and competence of the institute listing the CRM as a means of delivering traceability to its customers;
7. On request the complete certification report should be made available to the client;
8. The physical preparation of CRMs is not necessarily a task to be carried out solely by the institute, but the institute listing CRMs must carry out the value assignment and must include measurements that demonstrate adequate homogeneity and stability of the CRM;
9. In the case that an institute, in addition to its in-house capabilities and competences in the field concerned, collaborates for a part of the work with another (non-designated) expert laboratory the conditions mentioned before in this document and mentioned in the document CIPM/JCRB *"Subcontracting of measurements under the CIPM MRA"* have to be fulfilled;
10. If for special reasons it is desirable, or if it is considered desirable, CRMs listed in Appendix C may be subject to international comparisons by NMIs or designated institutes of other states or economies;
11. The institute listing CRMs in Appendix C must participate in relevant CCQM and/or RMO activities, which include CCQM and RMO studies and key comparisons and RMO supplementary comparisons;
12. Inasmuch as in many cases claimed CMCs and listed CRMs are not directly underpinned by the results of a key comparison or pilot study, it is highly recommended to have additional information available, justifying the claimed CMC and listed CRM, preferably by peer reviewed publications in an international journal or by an on-site peer review.

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## 9. Publication of CMCs

The publication of approved CMCs is performed by the BIPM through the KCDB office. Once the publication is done, the JCRB Executive Secretary sends an email to the RMOs and TC/WG chairs as a confirmation of the publication and availability of the CMCs in the KCDB website.

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## 10. CMC Review through the CC Working Groups on CMCs

To facilitate the Inter-regional CMC Review Process, the CIPM recommended that each Consultative Committee form a Working Group on CMCs. The objectives of the WGs are:

a) To establish and maintain lists of service categories, and where necessary rules for the preparation of CMC entries;
b) To agree on detailed technical review criteria;
c) To coordinate and where possible conduct inter-regional reviews of CMCs submitted by RMOs for posting in Appendix C of MRA;
d) To provide guidance on the range of CMCs supported by particular key and supplementary comparisons;
e) To identify areas where additional key and supplementary comparisons are needed;
f) To coordinate the review of existing CMCs in the context of new results of key and supplementary comparisons.

This WG should include representation from all RMOs that have NMIs active in the relevant technical area. WG membership is expected to come from the relevant RMO committees involved in CMC reviews; appropriate experts being chosen depending upon the particular field under review.

CC-WG on CMCs may establish their own rules and timelines for coordinating the inter-regional review of CMCs. Therefore, posting, distribution and submission of comments on CMC submissions may be done without the use of the JCRB website and without following the deadlines specified for this purpose.

However, in order to maintain a record of the formal approval of all CMCs, once the CC-WGs on CMCs have agreed on a set of submissions, these will be posted in the JCRB website only for final approval.

Reviewing TC/WG chairs will then be asked to confirm their acceptance of the final files posted in the website.

The CMCs will be published if the Executive Secretary has received a formal notification that they meet the MRA quality system requirements. Otherwise, the Executive Secretary will contact the RMO representative to request this information and the CMCs will not be published until this requirement is satisfied and formally communicated by the RMO.

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## 11. Fast track approval of CMCs

An NMI may request through its TC/WG Chair that a small group of already-published CMCs be reviewed by the other TC/WG in the same area without the formality of posting the file for review in the web page. This may occur, for example, when an upgrade of the laboratory facilities justifies an improvement of the declared scope of the published CMCs.

In this case, all communications will be done directly among the TC/WG Chairs. There is no need to inform the Executive Secretary or post any information in the JCRB website. After they reach a consensus on the new scope of the revised CMCs the CMCs will be posted only for final approval.

The reviewing TC/WG chairs shall approve the posted file in the JCRB website.

Once the reviewing TC/WG chairs have approved the CMCs under review the Executive Secretary verifies that the originating RMO has confirmed that the MRA quality system requirements have been met. In such a case, the KCDB office is notified that the approved CMCs must be published in Appendix C.

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## 12. Modification of existing CMCs

Modifications of a published CMC usually arise for reasons falling into one of three categories:

a. material or editorial errors and improvements to the explanatory text for a quantity, instrument, method etc.;
b. increase of the uncertainty or reduction in scope, decided by the NMI or following a comparison result;
c. change of the method of measurement or reduction of the uncertainty or increase in scope.

Modifications under category a) do not change the essence of the CMC (instrument, range of the quantity and of the parameters, method, uncertainty, traceability) but improve its content for the benefit of the user. For this category of modifications, the internal and the inter-RMO reviews are unnecessary. The NMI will send its proposal for change to the Technical Committee (TC) chairperson of its RMO, who will contact the coordinator of the BIPM database (BIPM.KCDB@bipm.org)

Modifications under category b) may be requested, for example, by an NMI wanting to reduce its engagement in the particular measurement activity or they may follow from a comparison result showing a significant unresolved deviation from the key comparison reference value (see Note 2). Also for this category internal and inter-RMO reviews are not needed. The proposal for change is received by the TC chairperson and transmitted to the coordinator of the BIPM database. However, in case that the change was originated by a comparison result, the TC chairperson should verify that the reduction in scope or the increase of the uncertainty is sufficient to assure the equivalence of the measurements. It is desirable in this case that the relevant RMO (or the BIPM) informs the other RMOs of the changes and their motivation.

Modifications under category c) should follow the full procedure of intra- and inter-RMO review as if they were new CMCs.

**NOTES**:

1. **Modifications must be made only on the Excel files available from the link "Get published CMCs"** located in the Summary box of the JCRB CMCs Website. These files have been produced by the BIPM KCDB office from the files posted for final approval and it has been verified that they do not contain any formatting errors.
2. To avoid overloading the BIPM, it is advisable not to submit individual modifications but to group a number of them together.
3. Modifications must be made clearly visible by the use of the following color code:
   a. bold red characters for corrections to be brought to a published CMC and for presenting a new CMC not yet published
   b. highlighting with a light pink background a CMC that should be deleted, the words "to be deleted from the KCDB" should also be placed in the "comments" column of the CMC.

CMCs should be modified if they are inconsistent with the results of a comparison.

The NMIs making the claims have the primary responsibility of assuring that they are consistent with comparison results.

Through its Technical Committees/Working Groups, the RMO should monitor the impact of key and supplementary comparison results on CMC claims for its member NMIs.

If, based on the results of a key or supplementary comparison, an RMO/NMI has concerns about the CMC claims of a particular NMI within another RMO, it should contact the NMI directly to seek resolution. If this is not successfully concluded, then the matter should be directed to the relevant RMO of the NMI making the CMC claims. In the event that further intervention is required, the JCRB Chairman should then be requested to help resolve the issue.

**NOTE**: Keep in mind that the Consultative Committee Working Groups on CMCs have among their responsibilities to:

- provide guidance on the range of CMCs supported by particular key and supplementary comparisons;
- identify areas where additional key and supplementary comparisons are needed; and
- coordinate the review of existing CMCs in the context of new results of key and supplementary comparisons.

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## 13. Related documents

1. CIPM MRA - Mutual recognition of national measurement standards and of calibration and measurement certificates issued by national metrology institutes
2. JCRB Minutes.
3. ISO/IEC 17025:2005 - General requirements for the competence of testing and calibration laboratories
4. The CIPM MRA: 2005 Interpretation Document
5. NMIs and other Designated Institutes
6. CIPM MRA-D-05, "*Use of the JCRB website for inter-regional review of CMCs.*"
7. Basic excel template
8. Excel template with uncertainty matrices and closely related CMCs
9. Excel template for CMCs in chemistry
10. Instructions for closely related CMCs
11. Additional instructions for CMC files in EM
12. Instructions for uncertainty matrices in CMC files
13. International rules for filling in the CMC tables for ionizing radiation
14. Services available to Associates States and Economies of the CGPM and their participation in the CIPM MRA
15. Calibration and measurement capabilities - A paper by the joint BIPM/ILAC working group
16. Subcontracting of measurements under the CIPM MRA
17. Recommendations for on-site visits by peers and selection criteria for on-site visit peer reviewers

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## 14. Revision History

| Version number | Date of Issue/Review | Summary of changes | |
|---|---|---|---|
| 1 | 2001-10-09 | Supersedes documents: | |
| | | JCRB 8/10 | Procedure for modifying CMCs already in Appendix C |
| | | JCRB 8/18 | Definitions of terms used in the CIPM MRA |
| | | JCRB 11/06(3) | Primer for TC/WG Chairpersons on the CMC Review Process |
| | | JCRB 11/06 (2) | Terms of Reference Consultative Committee Working Groups on CMCs |
| | | JCRB 12/06 (2) | JCRB Procedure for specifying the scope of CMCs |
| | | JCRB 12/06(3) | BIPM interventions on CMC files |
| | | JCRB 14/06(1) | JCRB Rules of Procedure for CMC entry into Appendix C |
| | | JCRB 14/06(2a) | Criteria for acceptance of data for Appendix C |
| | | CIPM-05/08 | Guidelines for the Acceptance of CRMs in Appendix C of the CIPM MRA |
| | | - | - |
| | 2008-10-12 | Approved by CIPM | |

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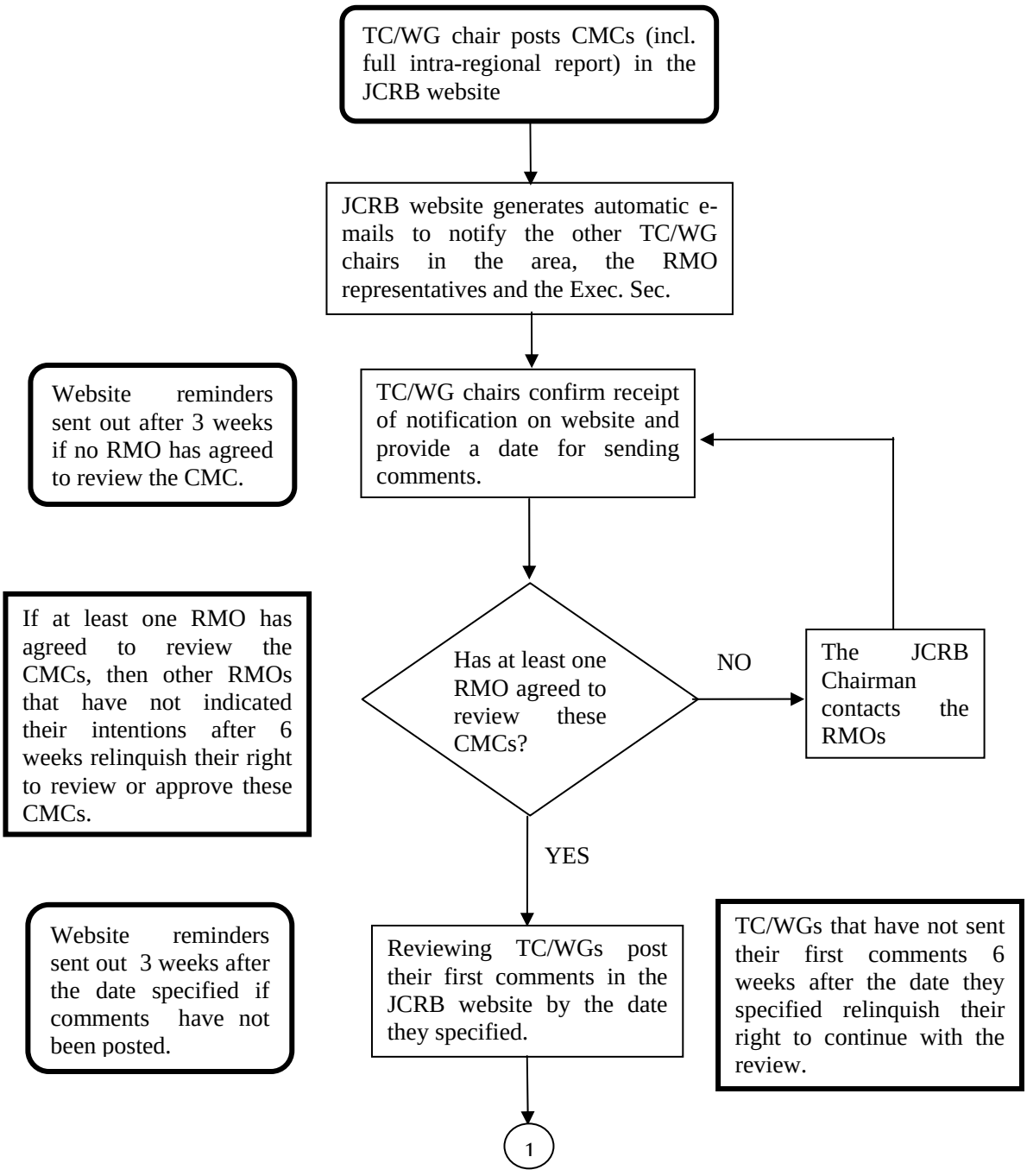
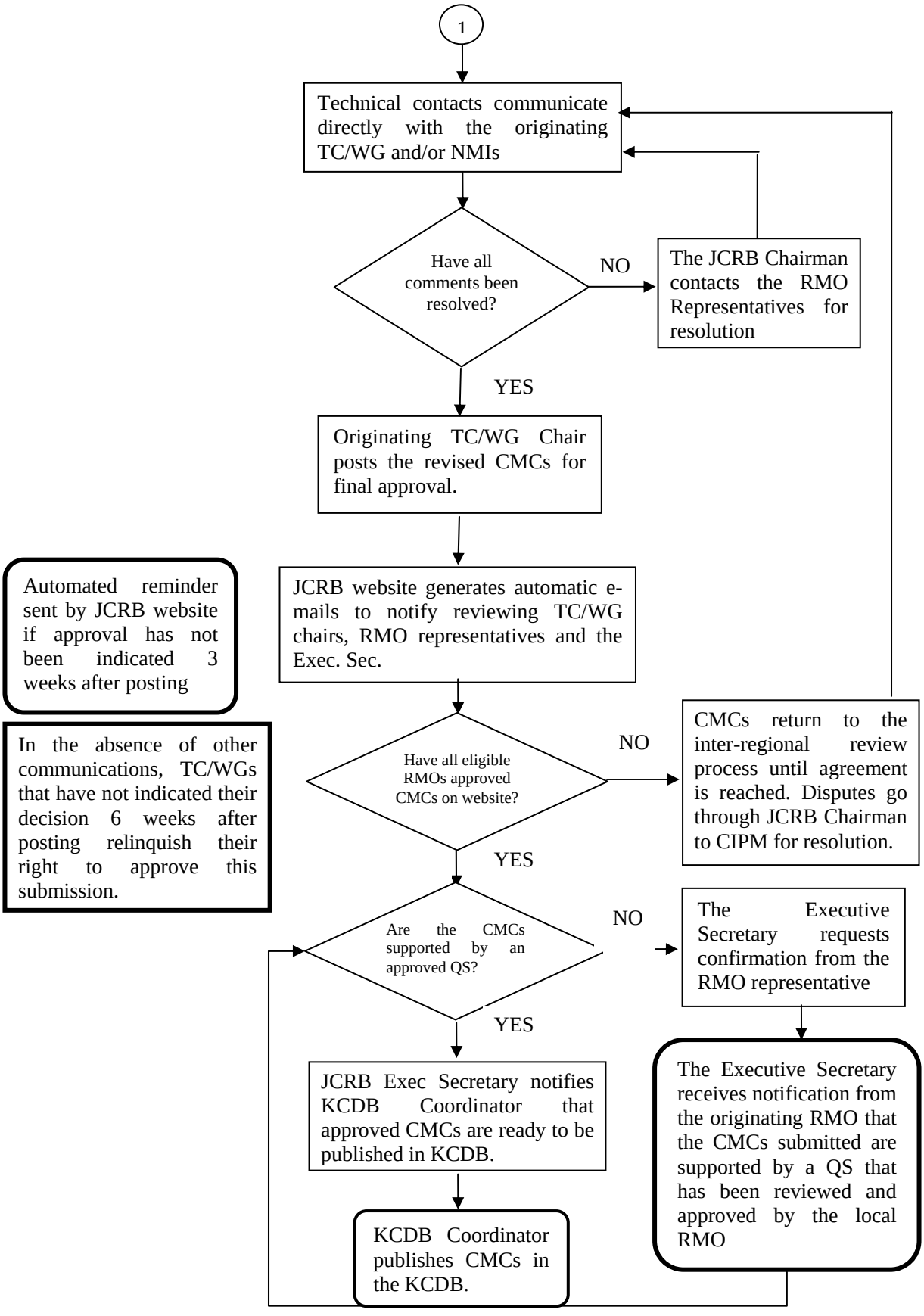
# Appendix 1 – Flowchart of the CMCs review process




1
Technical contacts communicate directly with the originating TC/WG and/or NMIs
Have all comments been resolved?
NO
The JCRB Chairman contacts the RMO Representatives for resolution
YES
Originating TC/WG Chair posts the revised CMCs for final approval.
Automated reminder sent by JCRB website if approval has not been indicated 3 weeks after posting
JCRB website generates automatic e-mails to notify reviewing TC/WG chairs, RMO representatives and the Exec. Sec.
In the absence of other communications, TC/WGs that have not indicated their decision 6 weeks after posting relinquish their right to approve this submission.
Have all eligible RMOs approved CMCs on website?
NO
CMCs return to the inter-regional review process until agreement is reached. Disputes go through JCRB Chairman to CIPM for resolution.
YES
Are the CMCs supported by an approved QS?
NO
The Executive Secretary requests confirmation from the RMO representative
YES
The Executive Secretary receives notification from the originating RMO that the CMCs submitted are supported by a QS that has been reviewed and approved by the local RMO
JCRB Exec Secretary notifies KCDB Coordinator that approved CMCs are ready to be published in KCDB.
KCDB Coordinator publishes CMCs in the KCDB.

# Appendix 2 – Examples of CMCs tables

General case

**Parameters and specifications**

| Calibration or Measurement Service | | | Measurand Level or Range | | | Measurement Conditions/Independent Variables | | Expanded Uncertainty | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quantity | Instrument or Artifact | Instrument Type or Method | Minimum value | Maximum value | Units | Parameter | Specifications | Value | Units | Coverage factor | Level of Confidence | Is the expanded uncertainty a relative one? |
| Encapsulated source strength | Radioactive source | Ionization chamber | 0 | 0.1 | GBq | Temperature<br>Pressure<br>Relative humidity | 22.0 °C<br>101.325 kPa<br>20% to 80% | 0.01 | | 2 | 95% | Yes |

| Calibration or Measurement Service | | | Measurand Level or Range | | | Measurement Condition/Independent Variable | | Expanded Uncertainty | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quantity | Instrument or Artifact | Instrument Type or Method | Minimum value | Maximum value | Units | Parameter | Specifications | Value | Units | Coverage factor | Level of Confidence | Is the expanded uncertainty a relative one? |
| Encapsulated source strength | Radioactive source | Ionization chamber | 0 | 0.1 | GBq | Temperature | 22.0 °C | 0.01 | | 2 | 95% | Yes |
| | | | | | | Pressure | 101.325 kPa | | | | | |
| | | | | | | Relative humidity | 20% to 80% | | | | | |

Each parameter and specification in its own cell.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Angle by circle-dividers | Optical polygon face angle | Index table & autocollimator, full closure | 360/n, n = 24 | 360/n, n = 3 | ° | n, number of faces | 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24 | 0.1" | " | 2 | 95% | No |

But this example is correct, since these are distinct values for a single parameter

**Different measurand ranges**

| Calibration or Measurement Service | | | Measurand Level or Range | | | Measurement Conditions/Independent Variable | | Expanded Uncertainty | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quantity | Instrument or Artifact | Instrument Type or Method | Minimum value | Maximum value | Units | Parameter | Specifications | Value | Units | Coverage factor | Level of Confidence | Is the expanded uncertainty a relative one? |
| Luminous Intensity | Tungsten lamp | Network of lamps & photometers, photometric bench | 0.001<br>1<br>1000<br>-- | 1<br>1000<br>100000<br>-- | cd | Distribution temperature | 2000 K to 3200 K | 1.5 to 0.4<br>0.4<br>0.4 to 1.5<br>with measurand | % | 2 | 95% | Yes |

| Calibration or Measurement Service | | | Measurand Level or Range | | | Measurement Conditions/Independent Variable | | Expanded Uncertainty | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quantity | Instrument or Artifact | Instrument Type or Method | Minimum value | Maximum value | Units | Parameter | Specifications | Value | Units | Coverage factor | Level of Confidence | Is the expanded uncertainty a relative one? |
| Luminous Intensity | Tungsten lamp | Network of lamps & photometers, photometric bench | 0.001 | 1 | cd | Distribution temperature | 2000 K to 3200 K | 1.5 to 0.4 | % | 2 | 95% | Yes |
| Luminous Intensity | Tungsten lamp | Network of lamps & photometers, photometric bench | 1 | 1000 | cd | Distribution temperature | 2000 K to 3200 K | 0.4 | % | 2 | 95% | Yes |
| Luminous Intensity | Tungsten lamp | Network of lamps & photometers, photometric bench | 1000 | 100000 | cd | Distribution temperature | 2000 K to 3200 K | 0.4 to 1.5 | % | 2 | 95% | Yes |

Individual measurand levels and uncertainties must have separate complete lines.

**No vertical cells merging**

| Calibration or Measurement Service | | | Measurand Level or Range | | | Measurement Conditions/Independent Variable | | Expanded Uncertainty | | | | | Reference Standard used in calibration | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quantity | Instrument or Artifact | Instrument Type or Method | Minimum value | Maximum value | Units | Parameter | Specification | Value | Units | Coverage factor | Level of Confidence | Is the expanded uncertainty a relative one? | Standard | Source of traceability |
| Gas flow | Gas flow meters | Sonic nozzles, turbine, laminar, P.D, rotameters, etc | 0.05 | 50 | L/min | Fluid Temperature Pressure | dry air 18 °C to 21 °C up to 0.8 MPa | 0.2 | % | 2 | 95% | Yes | Piston-Prover | CENAM |
| | | | 50 | 710 | | | | 0.3 | % | | | | Bell-Prover | |
| | | | 710 | 2800 | | | | 0.3 | % | | | | Bell-Prover | |

| Quantity | Instrument or Artifact | Instrument Type or Method | Minimum value | Maximum value | Units | Parameter | Specification | Value | Units | Coverage Factor | Level of Confidence | Is the expanded uncertainty a relative one? | Standard | Source of traceability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gas flow | Gas flow meters | Sonic nozzles, turbine, laminar, P.D, rotameters, etc | 0.05 | 50 | L/min | Fluid | dry air | 0.2 | % | 2 | 95% | Yes | Piston-Prover | CENAM |
| | | | | | | Temperature Pressure | 18 °C to 21 °C up to 0.8 MPa | | | | | | | |
| Gas flow | Gas flow meters | Sonic nozzles, turbine, laminar, P.D, rotameters, etc | 50 | 710 | L/min | Fluid | dry air | 0.3 | % | 2 | 95% | Yes | Bell-Prover | CENAM |
| | | | | | | Temperature Pressure | 18 °C to 21 °C up to 0.8 MPa | | | | | | | |
| Gas flow | Gas flow meters | Sonic nozzles, turbine, laminar, P.D, rotameters, etc | 710 | 2800 | L/min | Fluid | dry air | 0.3 | % | 2 | 95% | Yes | Bell-Prover | CENAM |
| | | | | | | Temperature Pressure | 18 °C to 21 °C up to 0.8 MPa | | | | | | | |

No vertical cell merging. Repeat all relevant information for each CMC

# Appendix 3 – Examples of CMCs tables with frequent mistakes.

## EXAMPLES OF MEASURAND SPECIFICATION

| Calibration or Measurement Service | | | Measurand Level or Range | | | Measurement Conditions/Independent Variable | | Expanded Uncertainty | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Class** | **Instrument or Artifact** | **Instrument Type or Method** | **Minimum value** | **Maximum value** | **Units** | **Parameter** | **Specifications** | **Value** | **Units** | **Coverage Factor** | **Level of Confidence** | **Is the expanded uncertainty a relative one?** |
| **CORRECT** | | | | | | | | | | | | |
| Mass water flowrate | Water meter | Coriolis | 14 | 833 | kg/s | Fluid | water | 0.06 | % | 2 | 95% | Yes |
| | | | | | | Pressure | 100 kPa to 400 kPa | | | | | |
| | | | | | | Temperature | ambient | | | | | |
| Volume water flowrate | Water meter | Positive displacement, turbine, differential pressure, ultrasonic, vortex meter, electromagnetic | 13.9 | 833 | $dm^3/s$ | Fluid | water | 0.06 | % | 2 | 95% | Yes |
| | | | | | | Pressure | 100 kPa to 400 kPa | | | | | |
| | | | | | | Temperature | ambient | | | | | |

| Calibration or Measurement Service | | | Measurand Level or Range | | | Measurement Conditions/Independent Variable | | Expanded Uncertainty | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Class** | **Instrument or Artifact** | **Instrument Type or Method** | **Minimum value** | **Maximum value** | **Units** | **Parameter** | **Specifications** | **Value** | **Units** | **Coverage Factor** | **Level of Confidence** | **Is the expanded uncertainty a relative one?** |
| **INCORRECT** | | | | | | | | | | | | |
| Mass or Volume Water Flowrate | Water meter | Coriolis | 14 | 833 | kg/s | Fluid | water | 0.06 | % | 2 | 0.95 | Yes |
| | | | | | | Pressure | 100 kPa to 400 kPa | | | | | |
| | | | | | | Temperature | ambient | | | | | |

## EXAMPLES OF IMPLICIT RANGE SPECIFICATION

| Calibration or Measurement Service | | | Measurand Level or Range | | | Measurement Conditions/Independent Variable | | Expanded Uncertainty | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Class** | **Instrument or Artifact** | **Instrument Type or Method** | **Minimum value** | **Maximum value** | **Units** | **Parameter** | **Specifications** | **Value** | **Units** | **Coverage Factor** | **Level of Confidence** | **Is the expanded uncertainty a relative one?** |
| **CORRECT** | | | | | | | | | | | | |
| **Pressure sensitivity level** | Measurement microphone type: IEC 61094-1 LS1P, LS2aP and LS2F | IEC 61094-2 | | | dB (reference: 1 V/Pa) | Frequency | 63 Hz to 6.3 kHz | 0.06 | dB | 2 | 95% | No |
| **INCORRECT** | | | | | | | | | | | | |
| **Volume of heat conveying flowing liquid (for thermal energy measurements)** | Any flow measurement instrument or flow device | Pulsed, electrical, digital and optical outputs, various methods | | | | Water | See lines 7 and 9 | As above | % | 2 | 95% | Yes |

## EXAMPLES OF UNCERTAINTY SPECIFICATION

| Calibration or Measurement Service | | | Measurand Level or Range | | | Measurement Conditions/Independent Variable | | Expanded Uncertainty | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Class** | **Instrument or Artifact** | **Instrument Type or Method** | **Minimum value** | **Maximum value** | **Units** | **Parameter** | **Specifications** | **Value** | **Units** | **Coverage Factor** | **Level of Confidence** | **Is the expanded uncertainty a relative one?** |
| **CORRECT** | | | | | | | | | | | | |
| End standards | Gauge block: central length L | Interferometry, exact fractions | 0.5 | 100 | mm | | | Q[26, 0.4*L*], *L* in mm, values range from 26 nm to 48 | nm | 2 | 95% | No |
| Mass | Mass standard | Weighing in air | 1 | 100 | mg | | | 0.4 to 0.8 | µg | 2 | 95% | No |

**In the last case it is assumed that the uncertainty, for example, at 50 mg, is 0.6 µg**

**INCORRECT**

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mass | Mass standard | weighing in air | 1 | 100 | mg | | | < 0.8 | µg | 2 | 95% | No |

## EXAMPLES OF UNCERTAINTY SPECIFICATION: Correct Uncertainty Matrix (Page 1)

| | A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Calibration or Measurement Service | | | Measurand Level or Range | | | Measurement Conditions/Independent Variable | | Expanded Uncertainty | | | | |
| 2 | Quantity | Instrument or Artifact | Method of Measurement | Minimum value | Maximum value | Units | Parameter | Specifications | Value | Units | Coverage Factor | Level of Confidence | Is the expanded uncertainty a reltive one? |
| 3 | AC voltage: AC-DC transfer difference at low voltages | AC-DC transfer standard | Comparison with reference standard | 0.002 | 0.5 | V | Frequency | 10 Hz to 1 MHz | 6 to 800 | µV/V | 2 | 95% | Yes |

| N | O | P | Q | R | S | T | U | V |
|---|---|---|---|---|---|---|---|---|
| Reference Standard used in calibration | | List of Comparisons supporting this measurement/ calibration service | Euromet Electricity Services Administration | | | | | |
| Standard | Source of traceability | | NMI Service Identification | Service category | NMI | Internal Comment | Comments to be published via the database | Uncertainty Matrix |
| a: MJTC, b: resistive divider | a: BEV, b: SP | | 22a | 5.1.1 | BEV | | | Matrix 1 |

CMC_spreadsheet | Matrix 1

## EXAMPLES OF UNCERTAINTY SPECIFICATION: Correct Uncertainty Matrix (Page 2)

The uncertainty matrix is stored in an Excel spreadsheet in the same Workbook, with the name indicated in column V (in this case, Matrix 1):

| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 10 Hz | 20 Hz | 30 Hz | 40 Hz | 55 Hz | 100 Hz | 500 Hz | 1 kHz | 5 kHz |
| 2 | 2 mV | 400 | 360 | 360 | 360 | 360 | 360 | 360 | 340 | 340 |
| 3 | 10 mV | 230 | 200 | 180 | 180 | 180 | 180 | 170 | 150 | 150 |
| 4 | 100 mV | 100 | 80 | 80 | 80 | 80 | 80 | 60 | 60 | 60 |
| 5 | 200 mV | 20 | 10 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| 6 | 500 mV | 16 | 8 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |

CMC_spreadsheet | Matrix 1

**Consultative Committee for Time and Frequency**

Sixteenth Session

(Sèvres, 1 and 2 April 2004)

# Report
from the
# CCTF Working Group on the consequences of the global MRA (WGMRA),

G. de Jong, chairman

P.O. Box 654, 2600 AR Delft, the Netherlands

## 1.0 Introduction

At the 14th CCTF meeting (April 1999) the Working Group (WG) on the consequences of the global Mutual Recognition Arrangement (MRA) was created to examine and report on the consequences of the global MRA for the CCTF. A report of this WGMRA has been presented at the 15th CCTF (June 2001). This report and the proposals were discussed at the CCTF meeting as reported under section 11 of the Report of the 15th Meeting of CCTF. It was decided that the Key Comparison for time is the outcome of the computation of UTC –UTC(k) , its designation is CCTF-K2001.UTC (for the year 2001) and the Key Comparison Reference Value is UTC as computed presently by the BIPM Time Section.

The director of the BIPM, dr. Quinn, intimated that BIPM would try to include the uncertainties for UTC-UTC(k) in Circular T by 1 March 2002.

### 1.1 Membership

At the 15-th CCTF it was also decided that a Working Group was needed to take care of MRA matters until the next meeting of the CCTF. It was decided that the new WGMRA should consist of 1 representative assigned by each Regional Metrology Organization (RMO) and a chairperson. The WGMRA members were:

| | |
|---|---|
| APMP TCTF: | Dr S.I.Ohshima (NRLM, Japan), |
| EUROMET TF: | Dr J.Palacio (ROA, Spain), |
| SIM TF: | Dr D.Sullivan (NIST, USA), in Dec. 2002 replaced by Dr J.-S.Boulanger (NRC, Can) |
| SADCMET WGTF: | Mr E.L.Marais (CSIR, SAF) |
| COOMET TF: | Dr N.Koshelyaevski (VIINIFTRI, RU) |
| Chairman: | Mr G. de Jong (NMi VSL, NL) |

### 1.2 Terms of Reference

The agreed Terms of Reference for the new CCTF WGMRA are:
- authorization on a provisional basis for all actions needed between 2 meetings of the CCTF as indicated by the MRA. This in consultation with the CCTF President.
- Perform coordination between RMO's
- act as point of contact for BIPM on MRA matters
- report of all actions to the next CCTF Meeting; the CCTF may then make final decisions as required

### 1.3 Action List

The Action List for the WGMRA (Oct. 2001) was:
- obtain membership of a representative of all RMO's
- Coordination of CMC items list

• practical organization of Supplemental Comparisons for GPS, Glonass, TWSTFT
• execution of CIPM CCTF KC on UTC in collaboration of the BIPM

## 2. Activities July 2001 to January 2004

### 2.1 Membership
The membership of the WGMRA is already given in section 1.1

### 2.2 Coordination of CMC items list
At the 15th CCTF the main TF quantities for the TF CMC's were determined: Time scale difference, Frequency and Time interval. The coordination of the CMC service category list to further refinement of the three main quantities started in 2001. Several proposals came from different RMO's and were discussed through e-mail. However, it was not possible to reach agreement. So, following the suggestion of dr Koshelyaevski, the WG met during the PTTI in December 2002. Here the final list was discussed and adopted in December 2002 and published as WGMRA Guideline 1 (Rev. 20021209), see Annex 4.

The two more Guidelines, related to the first, were also adopted then. These are:

- WGMRA Guideline 2 (Rev. 20021205) see Annex 5, clarifies the estimation of the uncertainty to be taken for the Best Measurement Capability (BMC);

- WGMRA Guideline 3 (Rev. 20021210) see Annex 6, clarifies how to extrapolate the uncertainty from the KC results for shorter averaging times than the 5 days interval of the BIPM circular T.

In the mean time CMC's were written and discussed in the RMO's. APMP and EUROMET TF participants discussed these at their meetings. However, later these CMC's had to be revised and brought in line with the three new Guidelines adopted at the WGMRA.

### 2.3 Organization of Supplemental Comparison for TF
No Supplemental Comparison (SC) was organized yet, because of the Key Comparison for TF should be in place first. On the other hand, it could be more practical that SC's could be organized by the RMO's. The WGMRA might facilitate with coordination in cooperation with BIPM Time section.

### 2.4 Execution of CIPM CCTF KC on UTC in collaboration of the BIPM

The BIPM calculation of TAI and UTC was defined as the base for the CCTF-K2001.UTC Key Comparison. See also Annex 2.
At the end of 2003 a few WGMRA members have met again at the PTTI meeting together with a representative of the Time Section of the BIPM and have discussed further steps. The RMO's were eager to know how the BIPM Time Section would state the uncertainties for the UTC-UTC(k) in circular T as promised by the Director of the BIPM for April 2002. This is because the result UTC-UTC(k) was decided to show the degree of conformity to the KCRV, UTC. It constitutes the outcome of the CIPM Key Comparison for Time and Frequency. The WG MRA has encouraged the Time section of the BIPM in this matter. A first approach to the publication of uncertainties for circular T now has been done by the BIPM Time section.

At the KCDB database at BIPM web site is the situation now that you find, since 15 February 2004, a reference to CCTF.K2001.UTC Key Comparison. There is the link to the BIPM Time Section publications of the UTC-UTC(k), other important data and circular T. So there is now a start. (see annex 3 for access of the KCDB). Uncertainties are expected to be added here also soon.

To obtain the status of the KC result similar to that in other fields, we should now consider what items need to be added to the present KC procedure. This is addressed in the next section 3.0

## 3. MRA tasks for the CCTF

### 3.1 Status and possible implementations of procedures

To find missing items we should check with the requirements of a CIPM KC. (MRA appendix F).

The CCTF should (see annex 1, section 1.3):
a) identify the key comparisons in the field of Time and maintain a current list (Appendix D);
Status March 2004: this is done at the last CCTF meeting in June 2001: CCTF-K2001.UTC.

b) initiate and organize, with the collaboration of the BIPM, the execution of key comparisons at intervals to be decided individually for each comparison;
Status March 2004: This is done, organized by the Time Section of BIPM, but should be addressed at CCTF in more detail.

c) review the results of CIPM key comparisons and determine the reference values and degrees of equivalence on the basis of the proposals of the appropriate working groups;
Status March 2004: this has still to be done, proposals should be done and discussed and decided at the CCTF.

d) approve the final report of CIPM key comparisons for publication by the BIPM;
Status March 2004: this has still to be done, proposals should be done and discussed and decided at the CCTF.

e) examine and confirm the results of RMO key and supplementary comparisons and incorporate them in Appendix B and the key comparison database;
Status March 2004: no (results from) RMO key or supplemental comparisons are known;

f) examine and confirm the results of bilateral key comparisons for entry into Appendix B and the key comparison database;
Status March 2004: no (results from) bilateral key comparisons are known;

g) coordinate the CIPM and the RMO KC's through consultations with the RMO's
Status March 2004: a coordinated classification guideline has resulted from consultations with the RMO representatives in the WGMRA; only CCTF-K2001.UTC KC exists, which will be discussed further at the CCTF meeting;

h) discuss disputes from MRA + KC's
Status March 2004: As far as I know, we have no disputes and the only CCTF-K2001.UTC KC will be discussed further at the CCTF meeting.

### 3.2 Actions left for the CCTF meeting and/or WGMRA:

For c) and d) we still have to find a workable solution. This can be addressed at the CCTF meeting based on proposals separate from this report.

In the next 3 years also the tasks in e), f), g), h) should be taken care of, the WGMRA may again take this duty between two CCTF meetings.

### 3.3 Possible Resolutions for adoption by the CCTF

The 3 guidelines from the WGMRA should be adopted by the CCTF as resolutions.
The outcome of further discussions under section 3.2 about working procedures for the CCTF KC , WGMRA and BIPM should also be subject of one or more resolutions of the CCTF.

**Annex 1**

**1.0 Summary of the MRA**

The MRA document is titled as “Mutual recognition of national measurements standards and of measurement certificates issued by national metrology institutes”. The International Committee of Weights and Measures (CIPM) has drawn up the MRA, under the authority given to it in the Meter Convention, for signature by directors of the national metrology institutes (NMIs) of Member States of the Convention.
It is well documented at the web-site of the BIPM (www.bipm.org). It consists of the main MRA dated 14 October 1999 signed for a 4 year period, a Technical supplement and the Appendices A to F.

The **objectives** of the MRA are:
1. to establish the degree of equivalence of national measurement standards maintained by NMIs;
2. to provide for the mutual recognition of calibration and measurement certificates issued by NMIs;
3. thereby to provide governments and other parties with a secure technical foundation for wider agreements related to international trade, commerce and regulatory affairs.
4. statements of the measurement capabilities of each NMI in a database maintained by the BIPM and publicly available on the Web.

The **process** is:
1. international comparisons of measurements, to be known as key comparisons (KC’s);
2.supplementary international comparisons of measurements (SC’s);
3. quality systems and demonstrations of competence by NMIs.

the **outcome** is:
statements of the measurement capabilities of each NMI in a database maintained by the BIPM and publicly available on the Web.

**1.1 Supplement and Appendices of the MRA**
Technical supplement: specifies conventions and responsibilities relating to the key comparisons.
Appendix A: contains the growing list of national metrology institutes (NMI’s) that have signed the MRA;
Appendix B: contains the key comparisons of quantities that have been carried out and its results (reference values and deviations and associated uncertainties of the participating NMI’s);
Appendix C: contains the detailed list of quantities and ranges for which calibration and measurement certificates is recognized by the participating institutes;
Appendix D: is the list of (chosen quantities for) which CIPM and RMO key comparisons will be held;
Appendix E: contains the terms of reference of the Joint Committee of the Regional Metrology Organizations (RMO’s) and the BIPM (JCRB);
Appendix F: contains the Guidelines for CIPM key comparisons dated 1 March 1999, see Technical Supplement T.6.

**1.2 Some Definitions**
Reference value: result from a key comparison, a close approximation to the SI value, but not necessary the best.
Degree of equivalence of a national standard: its deviation from the reference value + the uncertainty at 95% confidence level of this deviation.
CIPM key comparisons (KC’s by CC’s and BIPM)
RMO key comparisons (KC’s by RMO’s)

**1.3 Responsibilities of the Consultative Committees**
Cited from Technical Supplement T.8:
The Consultative Committees have a prime role in choosing and implementing key comparisons and in affirming the validity of the results. Their particular responsibilities are:

a) identify the key comparisons in each field and maintain a current list (Appendix D);

b) initiate and organize, with the collaboration of the BIPM, the execution of key comparisons at intervals to be decided individually for each comparison;

c) review the results of CIPM key comparisons and determine the reference values and degrees of equivalence on the basis of the proposals of the appropriate working groups;

d) approve the final report of CIPM key comparisons for publication by the BIPM;

e) examine and confirm the results of RMO key and supplementary comparisons and incorporate them in Appendix B and the key comparison database;

f) examine and confirm the results of bilateral key comparisons for entry into Appendix B and the key comparison database.

And also:
g) coordinate the CIPM and the RMO KC's through consultations with the RMO's

h) discuss disputes from MRA + KC's

**1.4 Task of RMO's**
a) Make proposals to the CC's on the choice of key comparisons;
b) Responsible for carrying out the RMO key comparisons corresponding to CIPM KC's, see Technical Supplement;
c) Participate in JCRB:
d) Responsible for carrying out the RMO supplementary comparisons and other related actions.

**1.5 Task of BIPM**
Responsible for carrying out the key and supplementary comparisons (see MRA p.29);
Participate in JCRB;
Maintain the database for data of MRA appendix A, B, C, and D as well as publicise the data.

**1.6 Participation in KC's**
CIPM KC's: NMIis that are labs with highest technical competence and experience (normally the CC members), and other labs nominated by their NMI and designated responsible for national measurements standards.
RMO KC's and Supplemental Comparisons (SC's): all RMO members having technical competence to the comparison subject

**1.7 Calibration Measurement Capability (CMC)** see T.7, declarations on calibration measurement capabilities of NMIs accredited according ISO 17025, to be sent to RMO, then to JCRB for review, and finally entered into Appendix C at the BIPM data base.

**Annex 2**

**2.0 Summary of present process for the calculation of TAI, UTC and UTC-UTC(k)**

Each participating institute sends to the BIPM:
- files containing UTC(k) - clock(i) per 5 days,
- UTC(k)- T(GPS) for each satellite as indicated on the schedules issued by the BIPM, or/and
- TWSTFT(k)-TWSTFT(l) following an agreed schedule (i.e.3 days per week).
- Institutes that have primary time standards, like a caesium fountain, periodically send data, which contains additional information from accuracy evaluations of their primary time standards (PTS).

Output products of the monthly BIPM calculations include:
- the time scale differences UTC - UTC(k) per 5 d,
- the scale interval of TAI (some times referred to as the rate of TAI or the TAI frequency), expressed in the SI unit of time and its uncertainty,
- the rates of the individual clocks with respect to the rate of UTC, all from the average over the recent 30d.
- the weights of the individual clocks used for the calculations
- the relative frequency (rate) difference correction between TAI and EAL that will be used in a period of 1 or more months.

The BIPM time scale calculations use fixed delay corrections (for cables, instruments, receivers, antennas) per institute k for GPS and TWSTFT data, based on (differential) delay calibration trips in the past. BIPM publishes the results of these calibrations and its uncertainty in technical reports. For the SI unit of time calculations these delays are assumed to be stable, thus any possible changes are attributed to the clock.

**ANNEX 3**

**3.0 Access to KCDB for Time and Frequency Key Comparison**

You can find the Time and Frequency Key Comparison at the KCDB website as follows.

1. Browse to the KCDB home page: http://kcdb.bipm.org

2. Click on Appendix B

3. Select in seach form Appendix B as metrology area: time and frequency

4. Clock on Search at the bottom of the page

5. You now find CCTF-K2001.UTC

6. Click on CCTF-K2001.UTC to get more information

7.A. You may click on Pilot/Contact to find the reference to the dr F. Arias of the Time Section of BIPM

7.B. You may click on Participants to find the KC participants list

7.C. You may click on Results to find that the Key Comparison Reference Value is defined as UTC and that the results UTC –UTC(k) for MJD's ending at 4 and 9 are not in the KCRB data base but at the FTP server of the Time section of the BIPM. Links to this site and the latest Circular T are provided.

8. At the webpage of the FTP server of the Time section of BIPM (http://www.bipm.org/en/scientific/tai/time_ftp.html) you may select several results, including the most recent UTC – UTC(k) and also for MJD's in the past starting about January 1998 (MJD 50814)

9. The uncertainties of UTC-UTC(k) are expected to become available soon.

**ANNEX 4**

CCTF

**WGMRA Guideline 1**

(Rev. 20021209)

The Service Category classification scheme for T&F CMC entries

The following Service Category classification for T&F CMC entries should be followed:

1 Time scale difference
1.1 Local clock
1.1.1 Local clock vs. UTC(NMI)
1.1.2 Local clock vs. UTC
1.2 Remote clocks
1.2.1 Remote clock vs. UTC(NMI)
1.2.2 Remote clock vs. UTC
2 Frequency
2.1 Standard frequency source
2.1.1 Local frequency standard
2.1.2 Remote frequency standard
2.2. General frequency source
2.2.1 General frequency source
2.3 Frequency meter
2.3.1 Frequency counter
2.3.2 Frequency meter
3 Time Interval
3.1 Period source
3.1.1 Period source
3.2 Time Interval source
3.2.1 Rise/fall time source
3.2.2 Pulse width source
3.2.3 Time difference source
3.2.4 Delay source
3.3 Period meter
3.3.1 Period meter
3.4 Time Interval meter
3.4.1 Rise/fall time meter
3.4.2 Pulse width meter
3.4.3 Time difference meter
3.4.4 Delay meter

Only the second sub-level items (underlined) should be selected for the column "Service category" and "Instrument or Artifact" of the CMC table.

**ANNEX 5**

CCTF

**WGMRA Guideline 2**

(Rev. 20021205)

**The estimation of uncertainties for T&F CMC entries**

In the field of time and frequency metrology, the performance of the measurement system of an NMI is estimated by daily time keeping procedures such as international time comparisons using GPS CV, TWSTFT, comparisons of individual atomic clocks and so on. The CCTF WGMRA has decided to accept the definition of Best Measurement Capability (BMC) on the CMC table entries as the uncertainty level of NMI's measurement system. Therefore each NMI can claim the uncertainty of its calibration system in the hypothetical case of an ideal Device Under Test (DUT). The calibration certificates issued by NMIs, however, have to indicate the uncertainty of the calibration results including the influence of the DUT.

**Annex 6**

**CCTF**
**WGMRA Guideline 3**
(Rev. 20021210)
**The uncertainty extrapolation for T&F CMC entries**

The results of a Key Comparison (KC) will provide the deviation and its uncertainty for each participating laboratory. This uncertainty will be reflected in the corresponding CMC entry and should be considered as its lowest uncertainty limit, the Best Measurement Capability (BMC).
The CCTF has declared UTC-UTC(k) as published in BIPM Circular T as the sole KC in the T&F field. BIPM Circular T is giving the deviation for each contributing laboratory in the form of UTC -UTC(k) with a given combined uncertainty for intervals of 5 days.
From this, the corresponding deviation and its uncertainty for frequency and time interval at 5 days can be derived.

Real calibrations at NMIs may be done and specified at intervals and averaging times tau shorter than 5 days. In that case there is a need to extrapolate the 5-day results of the KC to express the uncertainty in each CMC entry for shorter averaging times. Extrapolation should take into account the properties (TDEV, ADEV, MDEV, drift, ageing) of the Reference Standard used for calibration, obtained from generally accepted and published studies or from specifications of the manufacturer, and according to a fully documented procedure. Only in the case of an uncertainty claim better than this extrapolation result, a special review in the RMO is necessary.

*Example for frequency measurement*
*As the type A uncertainty (ADEV) depends on the averaging time tau as the inverse of the square root of tau, extrapolation back from type A uncertainty at the 5-day KC result for averaging times tau shorter than 5 days may be done to calculate the type A uncertainty at those averaging times. The total combined uncertainty is then the square root of the sum of the squared uncertainty at 5 days and that at the required averaging time.*