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),

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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.