**Consultative Committee for Time and Frequency**

Seventeenth Session

(Sèvres, 15 and 16 September 2006)

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

G. de Jong, chairman

## 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. All RMO's have a representative as member of this WGMRA.
Reports of the WGMRA have been presented at the 15th CCTF (June 2001) and at the 16th CCTF (1&2 April 2004).
From the discussions of these reports, the CCTF decided that the Key Comparison for time is the result of the computation of UTC –UTC(k), that its designation is CCTF-K2001.UTC and the Key Comparison Reference Value is UTC as computed by the BIPM Time Section. A list of service categories for Time and Frequency to be used for CMC entries was also adopted at the 16th CCTF Meeting.
The Working Group takes care of any MRA matters between meetings of the CCTF

### 1.1 Terms of Reference
The agreed Terms of Reference for the CCTF WGMRA were reconfirmed at the 16th CCTF. They were:
• Authorization on a provisional basis for any actions needed between meetings of the CCTF as indicated by the MRA. This should be done in consultation with the CCTF President.
• Perform coordination between RMO's
• Act as point of contact for BIPM on MRA matters
• Report of its actions to the next CCTF Meeting; the CCTF may then make final decisions as required

### 1.2 Action List
The list of remaining actions for the WGMRA after the previous CCTF meeting in April 2004 was:
• Coordinate and facilitate organization of Supplemental Comparisons for GPS, Glonass, TWSTFT
• Further realisation of the CIPM CCTF KC on UTC in collaboration of the BIPM

## 2. Activities since April 2004

### 2.1 WGMRA Membership
In the period April 2004 to September 2006, the WGMRA consisted 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 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) |

**2.2 Coordination of CCTF CMC service category list and CCTF Guidelines**
At the 15th CCTF the main TF quantities for the TF CMC's were determined: Time scale difference, Frequency and Time interval. The CMC service category list, which resulted from WGMRA coordination, was adopted at the 16th CCTF Meeting and published as WGMRA Guideline 1 (Rev. 20021209), see Annex 4.

The two more Guidelines, related to the first, were also adopted at the 16th CCTF Meeting after a few modifications. These are:
- WGMRA Guideline 2 (Rev. 20040402) see Annex 5, clarifies the estimation of the uncertainty to be taken for the measurement capability in the case of an ideal DUT.
- WGMRA Guideline 3 (Rev. 20040402) 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.

The CMC's were revised to bring them in line with the new Guidelines and discussed and approved in the RMO's. They were sent to the MRA secretariat and were adopted by other RMO's after some modifications to accommodate the remarks made. The number of fully accepted CMC's in the BIPM KCDB appendix C database is now 19.

**2.3 Organization of Supplemental Comparisons for TF**
A few Supplemental Comparisons (SC's) were organized, after the Key Comparison for TF was in place. These SC's were organized by the RMO's. The WGMRA could facilitate with coordination in cooperation with BIPM Time section. At the moment no SC is yet fully finalized and published in the BIPM KCDB data base.

**2.4 Progress of CIPM CCTF KC on UTC in collaboration with the BIPM**

The BIPM calculation of TAI and UTC was defined as the base for the CCTF-K2001.UTC Key Comparison. In the second half of 2004, BIPM has developed a model for the propagation of the uncertainties of clock comparison links into the calculations of TAI and UTC. A paper of this solution was presented at the PTTI in December 2004: Lewandowski W., Matsakis D., Panfilo G., Tavella P., First evaluation and experimental results on the determination of uncertainties in [UTC – UTC(k)], see Proc. 36th PTTI, 2004, 247-261. During a meeting organized just before this PTTI, WG MRA members have fruitfully discussed and accepted this solution and have agreed its implementation with the Dr Arias and Dr Lewandowski of the BIPM. An evaluation should be done after one year.

So from January 2005, the uncertainties of [*UTC* – *UTC*(*k*)] are also published in the *Circular T*, followed one month later by the first publication of the results of the key comparison for time, CCTF-K2001.UTC, in the KCDB!
The results of this ongoing key comparison are shown for the last standard MJD of the month and is published one month after the publication of *UTC – UTC(k)* in Circular T. This gives the laboratories k the opportunity, in the case of errors or disagreement, to prevent the publication of their *UTC – UTC(k)* in the KCDB. The degree of conformity of UTC(k) for about 40 institutes is now published, see annex 3. The majority of the UTC(k) are within the recommended +/- 100 ns now, the other labs are encouraged to bring their UTC(k) within these limits.

**3. MRA tasks remaining for the CCTF**

**3.1 Status and possible implementations of procedures**
To find tasks to be executed, we check with the requirements of a CIPM KC in 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: this is done at the 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: this is realized, at a one month interval new data is added to CCTF-K2001.UTC as calculated by the Time Section of BIPM as the pilot laboratory.

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: this CCTF meeting may do this review of the results now, although after the fact; however, the WGMRA has preliminary accepted the practice as realized since January 2005 by the BIPM Time Section. Further proposals for improvement or modification can be done and discussed and decided at this CCTF meeting.

d) approve the final report of CIPM key comparisons for publication by the BIPM;
Status: this CCTF meeting should approve the continuing "final" report as published at the KCDB now, although after the fact; the WGMRA has, however, preliminary accepted the present practice as realized by the BIPM Time Section. Further evaluation and proposals can be done and discussed and decided at this CCTF meeting.

e) examine and confirm the results of RMO key and supplementary comparisons and incorporate them in Appendix B and the key comparison database;
Status: no (results from) RMO key or supplemental comparisons are yet known to the WGMRA, but some procedure for this should be developed.

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

g) coordinate the CIPM and the RMO KC's through consultations with the RMO's
Status: now only CCTF-K2001.UTC KC exists, any additional KC and procedures can be discussed further at this CCTF meeting or later by the WGMRA.;

h) discuss disputes from MRA + KC's
Status: As far as known, there are no disputes now, the actual CCTF-K2001.UTC KC can be evaluated and discussed further at the CCTF meeting.

**3.2 Remaining actions for the CCTF meeting and/or WGMRA:**

- In the next years any additional tasks should be taken care of when necessary and the WGMRA may take this duty between CCTF meetings.
- Other CC's now also have formed a WG on CMC with terms of reference as stated in Annex 7. The CCTF WG on MRA should take these also on board. But its terms of reference should include also its present terms.
- Procedures and Guidelines to transform (regional) Calibration trips into formal Supplemental Comparisons should be developed in cooperation with RMO's and the BIPM Time Section.
- It could be considered that it is preferable that the Members of the WGMRA be the chairmen of RMO TF Technical Committees; this would shorten the communication lines for the RMO representatives. However, if the TF TC Chairman's affilation is not a CCTF member, the combination would not be advisable.
- A successor for the resigning present chairman, Mr Gerrit de Jong, should be appointed, as well as for the EUROMET representative, Dr. Juan Palacio and the SADCMET representative, Dr. Louis Marais.

**3.3 Possible Resolutions for adoption by the CCTF**

The 3 guidelines from the WGMRA and the present implementation of CCTF-K2001.UTC could be formally adopted by the CCTF as Resolutions.

**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 (NMI’s) 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 NMI’s;
2. to provide for the mutual recognition of calibration and measurement certificates issued by NMI’s;
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.7 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 and its uncertainty,
- 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 30 d,
- 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 result 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. Click on Appendix B Search Form

4. Select in as Metrology Area: Time and Frequency, select the others: All

5. Click on Search at the bottom of the page

6. You now arrive at CCTF-K2001.UTC

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

8A. You may click on Pilot/Contact to find the reference to the dr F. Arias of the Time Section of BIPM

8B. You may click on Participants to find the KC participants list

8C. You may click on Results or Results available to find results under Year 2005 and Year 2006;

9. For 2006 results, click on Year 2006.

10A. After selecting Equivalent Statements you find that the Key Comparison Reference Value is defined as UTC

10B. After selecting Degrees of Equivalence you find the results $D_k = UTC - UTC(k)$ and its uncertainty $U_k$ in ns for the last standard MJD of the last month.

10C. After selecting Graphs of Equivalence you find a graphical presentation of $D_k$ and $U_k$ in ns of the selected month.

**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 Artefact" 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.

**This Guideline was modified at the 16th CCTF Meeting on April 02, 2004 into:**

**CCTF**
**WGMRA Guideline 2**
(Rev. 20040402)
**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 recommends that the CMCs claimed by each NMI or designated laboratory refers to the hypothetical case of an ideal Device Under Test (DUT). The calibration certificates issued by NMIs, however, have to indicate the uncertainty of the actual calibration results including the influence of the DUT. The WGMRA therefore recommends that the CMC entries into the KCDB contain the following statement "The uncertainty depends on the performance 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.*

**This Guideline was modified at the 16th CCTF Meeting on April 02, 2004 into:**

**CCTF**
**WGMRA Guideline 3**
(Rev. 20040402)
**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 CCTF has declared UTC-UTC(k) as published in BIPM Circular T as a KC in the T&F field. BIPM Circular T gives 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 for frequency and its corresponding uncertainty is therefore available for time intervals of 5 days.
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.

**Annex 7**

DOCUMENT JCRB-11/6(2) 2003-11-07 Previously: DOCUMENT JCRB-10/6(3)_rev

## Consultative Committee Working Groups on CMCs

Terms of Reference:

To facilitate the Inter-regional CMC Review Process, it is recommended that each Consultative Committee form a Working Group on CMCs. The objective of the WG will be:

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.