CCTF Guidelines for Planning, Organizing, Conducting and Reporting Key, Supplementary and Pilot Comparisons

Version 1 (May 2018)

1. Introduction

The technical basis of the CIPM MRA is the set of results obtained in the course of time through Key Comparisons (KCs) carried out by the Consultative Committees of the CIPM, the BIPM and the Regional Metrology Organizations (RMOs), and Supplementary Comparisons (SCs) carried out by the RMOs. Results are published by the BIPM and reported in the BIPM key comparison database (KCDB). In addition, Pilot Comparisons (PCs) may be organized. These are meant to be a preparatory exercise to gain experience with new subject fields or measurands, to check the travelling behavior of transfer standards or to test the feasibility of a key or supplementary comparison. They will not be recorded in the KCDB.

The CCTF considered that a single key comparison conducted by the BIPM is sufficient in the field of time and frequency metrology and through it the participating laboratories can obtain traceability to SI for the various related quantities. The identifier of the comparison is CCTF-K001.UTC and the value of UTC is the reference value.

This document lays down guidelines to be followed by the CCTF and the Technical Committees of the RMOs (RMO TCs) in planning, organizing, conducting, and reporting new CCTF comparisons and any potential RMO comparisons. Since CCTF.K001-UTC is an existing, ongoing comparison, it is excluded from these requirements, but changes to CCTF-K001.UTC must be approved at a CCTF meeting.

The CCTF Working Groups on matters related to the MRA (WGMRA) consider these guidelines a strong recommendation which should be followed unless compelling reasons are against it.

The main document to refer to for general rules concerning comparisons is “Measurement comparisons in the CIPM MRA” [CIPM MRA-D-05].

2. Initiating a comparison

The CCTF is ultimately responsible for approving all aspects related to CCTF comparisons. At present, the CCTF runs one continuous key comparison of which UTC is the reference value. Refer to guidelines 6 and 8 regarding rules for participation in the calculation of UTC and to guideline 7 dealing with participation in the KC CCTF-K001.UTC for National Metrology Institute (NMI) or Designated Institute (DI) of a Member State of the BIPM or of an Associate of the CGPM.

The next section provides more details related to initiating specific type of comparisons, should the need arise for more comparisons.

2.1 Key Comparisons

Key comparisons (KCs) are carried out only for quantities identified by the CCTF as key quantities. For each key quantity, the CCTF allows only one KC at a time.

New CCTF key comparisons can be proposed by any CCTF Working Group or directly by CCTF members. Such a proposal must be forwarded to the CCTF WGMRA for discussion at the WGMRA meeting that precedes the full CCTF meeting or by correspondence. A written submission should accompany the proposal and should detail the need for such a comparison. Accepted proposals will be added to the CCTF meeting agenda for discussion and possible approval.

The discussion of a new proposed CCTF comparison during the CCTF meeting should include the proposed technical protocol, the list of participants and an approximate timetable (also see section 4).

Participation in CCTF comparisons will be open to institutes having the highest technical competence and experience, normally the member laboratories of the CCTF. A participating institute that is not a member of the CCTF must be a signatory of the CIPM MRA or a designated institute, listed in Appendix A of the MRA. The CCTF can invite other institutes where the CCTF feel it will add value to the comparison.

The CCTF must ensure that enough participants from each RMO take part so that any subsequent regional KCs are properly linked to the new CCTF KC. The number of participants to such a KC are at the discretion of the CCTF but should be limited to prevent undue delays in the comparison. Each RMO will be asked to nominate participants from their region.

Since the CCTF currently considers the single existing key comparison conducted by the BIPM as sufficient, and RMO key comparisons can only be carried out where there is an existing CCTF key comparison having the same scope, it is not foreseen that there is currently a need for RMO key comparisons. Since all RMO key comparisons must be approved by the CCTF, rules for submitting such RMO key comparisons will only be put in place once approval of a new CCTF key comparison (other than CCTF-K001.UTC) is granted in a CCTF meeting.

2.2 Supplementary Comparisons and Pilot Comparisons

To meet specific needs not covered by KCs, supplementary comparisons (SCs) can be carried out. Supplementary comparisons are intended as complementary to key comparisons, or for lower level comparisons in developing economies. CCTF supplementary comparisons are discouraged. It is expected that only RMOs will be required to focus on supplementary comparisons.

Any proposal for a CCTF supplementary comparison must follow the same process as for CCTF key comparisons (discussed above in section 2.1)

Proposals for RMO supplementary comparisons are discussed and agreed upon in the relevant RMO Technical Committees according to rules and/or guidelines decided by each RMO. RMOs are encouraged to draw up documents detailing the processes for RMO comparisons.

The RMO does not require permission from the CCTF WGMRA for a supplementary comparison, but the input of the CCTF WGMRA is strongly suggested for the Technical Protocol (see section 4).

2.3 Bilateral Comparisons

Bilateral comparisons are normally intended for scenarios where institutes want to proof a new or improved capability.

Institutes requiring linking to the key comparison CCTF-K001.UTC are encouraged to participate in the key comparison directly and not via a bilateral comparison.

Should an institute require linking to a supplementary comparison, the institute must contact the RMO responsible for the original supplementary comparison. Such a bilateral comparison should follow the same procedure as the original multilateral comparison. The RMO can decide if they will include the result of the bilateral in an updated report, or if they want to issue a new comparison identifier for this bilateral (also see section 2.5).

For any other planned bilateral comparison, it the recommended to contact the CCTF WGMRA for comment on the proposed procedure.

2.4 Pilot studies

Pilot comparisons or pilot studies are carried out to validate new devices and/or new measurement techniques. In some cases, they can be carried out by the CCTF. They will not be recorded in the KCDB and are normally not considered sufficient support for calibration and measurement capabilities (CMCs).

CCTF pilot comparisons/studies should follow the same approval processes for all other CCTF comparisons, while RMO pilot comparisons/studies should follow the approval process for RMO comparisons.

2.5 Comparison Identifier

It is strongly recommended to adopt the present CCTF key comparison identifier scheme for all types of comparisons. Using this scheme will minimize possible confusion, in particular for the customers of the KCDB. The KCDB office can provide help in defining the identifier.

The principle structure of a comparison identifier must be as follows:

1. As institution choose “CCTF” for CCTF comparisons or the correct RMO (“APMP”, ”COOMET”, “EURAMET”, “GULFMET”, “AFRIMETS”, “SIM”) for RMO comparisons. For pilot studies organized by BIPM, “BIPM” should be used as the identifier, unless the CCTF assigns “CCTF” to the study.
2. For RMO comparisons, the subject-field is “TF”. (For a CCTF comparison, the subject-field is omitted.)
3. No subfield is used in TF.
4. The type of a comparison is a capital letter “K” for a key comparison, “S” for a supplementary comparison and “P” for a pilot study.
5. The consecutive number will be given by the KCDB Coordinator and is normally incremented by 1 for each new comparison.
6. If required, a suffix may be used to identify the main parameter, e.g. UTC, or to indicate the results of a bilateral linked to the original comparison.

Examples:

- “CCTF-K001.UTC”: currently, the only CCTF key comparison;
- “GULFMET.TF-S1”: A supplementary GULFMET comparison in the TF field;

3. Organization of a comparison

Section 2 explained how to initiate a comparison and how to obtain approval for such a comparison. Once the proposal for a new comparison has been approved, a pilot laboratory must be appointed. The pilot assumes the main responsibility for running the comparison and producing the Draft A and Draft B versions of the report.

It is recommended that a support group, consisting of the pilot laboratory itself and experts from participating institutes, is formed. The pilot laboratory, with help from the support group, is responsible for the organization of the comparison. The first task is to finalize the detailed technical protocol (see section 4). This group will also help with the preparation of the Draft A and B reports, especially in the statistical treatment of the data and by checking the calculations. Such a support group would typically not be required for bilateral comparisons.

For comparisons that will take a long time to complete, it is recommended that the pilot laboratory plans for scenarios where key personnel may change during the execution of the comparison.

For CCTF comparisons, the invitation process and potential participation list will form part of the CCTF discussion. For RMO comparisons, the RMO itself decides the rules regarding the invitation to participate. For example, the RMO may decide that some (or all) correspondence must be channeled via the TC chair, or the pilot may be given permission to directly communicate with participants.

The pilot laboratory must draw up an itinerary and inform the participants when they can expect to receive the travelling standards (if any) or when they will be expected to make the measurements (for common-view or similar comparisons). The total circulation time for the standards must be fixed and should not exceed 18 months except under unusual circumstances. In addition, the pilot laboratory is responsible for organizing the circulation and transport of the travelling standards and requesting the participants to make proper arrangements for local customs clearance.

The main points decided by the pilot laboratory together with the support group are the following:

- Suitability of the travelling standards for use in the comparison (in some cases a study of the long-term stability and the transport behavior of the standards will be necessary)
- The pattern of the full scale comparison, e.g. single loop, multiple loop, or star configuration
- The list of participants, technical contact persons and mailing addresses, considering the requirements mentioned above
- The starting date, detailed timetable, means of transport and itinerary
- The procedures in the case of failure of a travelling standard or an unexpected delay on the part of a participant
- The customs documents to accompany the travelling standards.

4. The technical protocol for a comparison

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

For a CCTF comparison, the protocol would be in an advanced state, since it would have been discussed at the CCTF meeting.

For an RMO comparison, the protocol is approved in accordance to the RMO documentation. When the protocol is in an advanced state, the RMO TC chairperson submits the protocol to the CCTF WGMRA for comment. A four-week period should be allowed for the WGMRA members to comment on the protocol. Following the feedback by the CCTF WGMRA, the RMO TC chair sends the protocol to the KCDB coordinator for registration.

Review of the protocol is not required for pilot studies or comparisons that will not be registered with the KCDB.

The following points should be treated in the protocol:

- Detailed description of the travelling standard(s), their operating conditions, and the quantities to be measured (optional quantities included)
- Advice on handling the travelling standard(s), including customs information
- Actions to be taken upon receipt of the standard(s) by a participating institute
- Any tests to be carried out before measurement
- Actions to be taken if it is suspected that the travelling standard is faulty
- Actions to be taken upon completion of the measurements, e.g. return to pilot or forward to next participant
- A timetable for the communication of the results to the pilot laboratory.
- Instructions for reporting the results.
- A statement of how the comparison reference value will be computed
- For supplementary comparisons or RMO comparisons, a statement detailing how the comparison will be linked to a higher comparison
- A statement clarifying '*how far the light shines*' such that KCs and SCs are interpreted as widely as reasonably applicable to indicate coverage of CMCs.

5. Circulation of transfer standards and customs clearance

The pilot laboratory is responsible for organizing the itinerary, dispatching the standards, and requesting the participants to make proper arrangements for local customs clearance.

- If an ATA carnet is used, the pilot laboratory and the participants must be familiar with its proper use. It must be stamped by the customs authorities when leaving a country, and upon arrival in the country of destination. Note that for the European Union (EU) the ATA carnet is stamped before leaving and upon re-entering the EU. The pilot laboratory must be informed if a power of attorney (a letter from the owner of the travelling standards authorizing the participating laboratory to act on its behalf) is to accompany the carnet to simplify the customs formalities.
- The equipment must be handled with care, and in some cases, it is essential that the transfer instruments be hand-carried.
- A warning note should be attached to the package indicating that it should be opened only by laboratory personnel.

- Normally, the participating institutes are responsible (at their own cost) for any local customs duties and the transport to the next institute, according to the itinerary.
- Before dispatching the package, each participant must inform the next participant and the pilot laboratory, giving transportation details. (The contact procedure should be described in the technical protocol.)
- After arrival of the package, the participating institute shall inform the pilot laboratory and the sender of this receipt and shall check for any damage to the standards. (The contact procedure should be described in the technical protocol.)
- Having photographic evidence of the condition and contents of the transport box can assist in disputes with courier companies. The protocol should clearly state if the receiving laboratory is expected to photograph the transport box and contents upon receipt of the package as well as before dispatch.
- If a delay occurs the pilot laboratory shall inform the participants and revise the time schedule. (The contact procedure should be described in the technical protocol.)
- A participant who is unable to perform its measurements in time due to unforeseeable reasons (e.g. damaged measurement equipment, delays in customs) must still dispatch the instrument in time in order not to disrupt the remaining itinerary. The participant can ask the pilot laboratory to be rescheduled at the end of the itinerary. In most cases, this modification to the schedule should be allowed, but there may be scenarios where such a request would not be possible to grant.

6. Reporting the results of a comparison

The technical protocol will discuss the reporting timeframe and format (as mentioned in section 4). The participating institutes must report the results of a comparison to the pilot laboratory as soon as possible and in every case not later than four weeks after the measurements are completed. For comparisons similar to CCTF-K001.UTC, the timeframe will be much shorter.

If a report is delayed for more than three months, the pilot laboratory, acting through the chairperson of the WGMRA or the RMO TC, may inform the director of the participating institute. In the worst case, the participating institute can be excluded from the comparison. This will be mentioned in the comparison report.

The measurement results together with the uncertainties, supported by a complete detailed uncertainty budget and any additional information required, should be reported in a format given in the instructions as part of the protocol usually by completing the standard forms annexed to the instructions or submitting data files in a prescribed format. Any additional significant detail should also be reported to the pilot laboratory.

7. Preparation of the report of a comparison

(Similar to previous comments, this section is not applicable to CCTF-K001.UTC. The format for reporting of CCTF-K001.UTC results is discussed separately at CCTF meetings.)

The pilot laboratory is responsible for the preparation of the comparison report. Before publication, the report passes through the Draft A and Draft B stage.

The first version, Draft A, is prepared as soon as all results have been received from the participants. It includes the results transmitted by the participants, identified by name, and a first calculation of the comparison reference value, and the unilateral degrees of

equivalence. The support group helps the pilot laboratory to prepare the Draft A report, and especially in the statistical treatment of the data, and checks the conformity of the report with the requirements of the MRA or the RMO requirements.

The report is confidential to the participants. Until all the participants have agreed on the report, it should be considered to be in Draft A stage. The report is considered as Draft B only once the final version of Draft A is approved by the participants. The Draft B report is subsequently submitted to the CCTF WGMRA or the RMO TC.

Once the Draft B report is available, the pilot laboratory shall ask all participants to submit a declaration that they have checked their results against their CMC claims and a statement whether these claims are supported by their results. The pilot shall collect these statements in the Executive Report and send it to the CCTF WGMRA or the RMO TC.

In more detail the procedure is as follows:

- During the comparison the results received by the pilot laboratory are kept confidential until all participants have completed their measurements.
- A result from a participant is not considered complete and is not included in the draft A report without an associated uncertainty drawn up according to the instructions given in the technical protocol.
- If, on examination of the complete set of results, the pilot laboratory finds that the results of some participants appear to be anomalous, these participants are invited to check their results for numerical errors. No information can be given as to the magnitude or sign of the apparent anomaly. If no numerical error is found, the result stands.
- The pilot laboratory prepares the Draft A report, which includes the results of all participants, the calculation of the comparison reference value and the degrees of equivalence with respect to the reference value. The support group shall review the first version of the Draft A report.
- Draft A of the report is sent as soon as possible to all the participants for comment, with a reasonable deadline for replies. Draft A is considered confidential to the participants; copies are not given to non-participants.
- Note that once all participants have been informed of the results, the complete comparison may be abandoned with the agreement of all participants and on the basis of a clear failure of the travelling standard or some other phenomenon that renders the comparison or part of it invalid.
- An institute that considers its result non-representative of its standards may provide an explanatory note related to their measurement but may not alter their measurement result. (They may request a separate subsequent bilateral comparison with the pilot laboratory or one of the participants. It must follow the same rules as the original comparison and the results will be entered into the KCDB as a bilateral comparison.)
- If any controversial or contradictory comments are received by the pilot laboratory, they are circulated to all participants and the support group, and the discussion continues until a consensus is reached.
- On receipt of final comments from the participants, Draft B is prepared accordingly. Draft B, which supersedes draft A, is not considered to be confidential and becomes the Final Report. Approval of this Final Report is discussed in section 8.

For comparisons where the procedure mentioned above is not possible or practical (e.g. comparisons similar to CCTF-K001.UTC), an alternative reporting procedure must be proposed during the approval stage.

8. Getting approval of the report of a comparison

In the case of a CCTF comparison (excluding CCTF-K001.UTC), the WGMRA is charged with examining the Draft B prior to its distribution to the CCTF for final approval. It is the decision of the CCTF President whether approval may be given by correspondence (by all CCTF members or a smaller group) or whether the report must be submitted at the next meeting of the CCTF.

For RMO comparisons, the RMO documentation must discuss review and approval of the Final Report. The chairperson of the RMO TC then forwards the report to both the CCTF Executive Secretary and the CCTF WGMRA for further consideration. A six-week period must be allowed for comment and editorial control. If at the end of the period, no objections have been raised within the working group, the final report, accompanied by a statement that the control and comment procedure has been completed, will be sent by the RMO TC chair to the KCDB Office for publication in the KCDB.

9. Publication of the results and entry into the Key Comparison Database (KCDB)

For all KCs, the final report approved by the CCTF forms the basis for the entry of results into the KCDB. The results must be presented in a format required by the KCDB. In addition, an abstract of the final report will be published in the Technical Supplement to Metrologia, a web-only service offered by Metrologia free of cost.

For other comparisons, the final report must be presented to the KCDB according to their guidelines.

With exception of the reference value and degrees of equivalence, the publication of the results in the Draft B Report may take place as soon as Draft B is agreed by the participants. There are different forms in which the results of a comparison may be published, depending on the wider significance of the information. The main publication channels are a scientific journal or the Conference Proceedings following presentation at a conference.

10. Evaluation of comparison data

The degree of equivalence (DoE) of each national measurement standard describes to what degree a standard is consistent with the comparison reference value. It is expressed by the deviation from the comparison reference value and the uncertainty of this deviation is given with a confidence level of about 95%.

RMOs should consider whether linking is required to CCTF comparisons by common participation of some institutes in both CCTF and RMO comparisons. The uncertainty with which comparison data are propagated depends on the number of institutes taking part in the two comparisons and on the quality of the results reported by these institutes.

11. References

[1] CIPM MRA-D-05 Measurement Comparisons in the CIPM MRA. Available online at https://www.bipm.org/utils/common/documents/CIPM-MRA/CIPM-MRA-D-05.pdf

[2] CCTF WGMRA, "*Guideline 6 - Requirements for participation in the computation of UTC at the BIPM*", 2017, Available online at http://www.bipm.org/wg/AllowedDocuments.jsp?wg=WGMRA

[3] CCTF WGMRA, "*Guideline 7 - Participation in the ongoing key comparison in time CCTF - K001.UTC*", 2015, Available online at http://www.bipm.org/wg/AllowedDocuments.jsp?wg=WGMRA

[4] CCTF WGMRA, "*Guideline 8 - Requirements for the time laboratories for the participation in UTC*", 2017, Available online at http://www.bipm.org/wg/AllowedDocuments.jsp?wg=WGMRA

ANNEX I – Flow diagram