

CCTF Working Group on MRA
Time and Frequency Supplementary
Guide for Appendix B and C of CIPM MRA

Version 1.0 (May 2017)

Table of contents

1.	Introduction and general consideration.....	3
2.	CMC review procedure.....	3
2.1.	Risk-based procedure.....	4
2.2.	Modification of CMCs already in Appendix C.....	5
2.3.	Submission of new CMCs or of modified CMCs requiring new review.....	6
2.4.	Intra-regional and Inter-regional reviews.....	6
2.5.	Inclusion of the CCTF WG on MRA in the review process.....	7
3.	Structure of the CMC table.....	7
3.1	General Criteria of compilation.....	8
3.2	Language and Symbols.....	8
3.3	Time and Frequency Classification scheme.....	9
3.4	Calibration or Measurement Service (col. A, B, C).....	9
3.5	Measurand Level or Range (col. D, E, F).....	10
3.6	Measurement Conditions / Independent Variable (col. G, H).....	11
3.7	Expanded Uncertainty (col. I, J, K, L, M).....	12
3.8	Reference Standard used in calibration (col. N, O).....	14
3.9	List of Comparisons Supporting the CMC, Internal Comments, Comments for the user (col. P, T, U)14	
3.10	RMO Time and Frequency Services Administration (col. Q, R, S, T), Comments for the user (col. U), Matrices and Tags (col. V, W) and intra/inter RMO review (col. X, Y, Z).....	15
4.	References.....	17
5.	List of Acronyms.....	18
6.	History of changes.....	18
7.	Appendix.....	19
	Appendix: Intra-regional and inter-regional review process.....	19

Scope

This Supplementary Guide reports information on how to draw up Calibration and Measurement Capability (CMC) Excel files in the field of Time and Frequency (TF) and sets out the CMC review procedure to be followed. The Guide is intended to be used worldwide, but makes provision for specific requirements of each Regional Metrology Organization (RMO), particularly concerning the way the information supporting CMCs is gathered and the detailed CMC intra-regional review process.

For general information related to the CMC review process, acceptance criteria, support by key and supplementary comparisons etc. the reader is addressed to a set of JCRB documents, available at: <http://www.bipm.org/en/committees/jc/jcrb/documents.html>.

This Guide is addressed to both the NMIs that have not yet submitted their capabilities and the NMIs that would like to add to or modify their already published CMCs.

1. Introduction and general consideration

This document specifies requirements and the procedures for reviewing calibration and measurement capabilities (CMCs) declared by NMIs/DIs under CIPM's Mutual Recognition Arrangement of national measurement standards and of calibration and measurement certificates issued by national metrology institutes (CIPM MRA).

The measurement capabilities of each NMI are published after final approval in Appendix C of the BIPM key comparison database (KCDB), maintained by the BIPM and publicly available on the Web. In order for CMCs to be approved for publication in Appendix C, they must first be reviewed and approved by the Technical Committees for Time and Frequency of RMOs. Once this approval is obtained, CMCs undergo an inter-regional review, where TC/WGs from other RMOs verify that the JCRB Criteria for acceptance of data for Appendix C have been followed, thus providing the technical confidence required for publication.

TC/WGs play a key role in this process as they conduct the intra-regional and inter-regional technical reviews and eventual approval of each CMC submission. This document specifies the requirements and explains the steps RMO Chairpersons need to follow in order to carry out this process.

This edition is based on the CIPM MRA-D-04 document version 4 (2013), taking into account the Recommendations from the WG on the Implementation and Operation of the CIPM MRA (2016).

2. CMC review procedure

In order for CMCs to be approved for publication in Appendix C, they must first be reviewed and approved by the appropriate Technical Committee for Time and Frequency within an RMO (intra-regional review). Once this approval is obtained, CMCs undergo an inter-regional review, where the TC/WGs from other RMOs verify that the review criteria have been followed, thus providing the

technical confidence required for publication. In the last step before publication, CMCs must be distributed to the CCTF WG on MRA for comments (i.e. risk-based procedure, etc ...).

2.1. Risk-based procedure

Following the recommendations of the Working Group on the Implementation and Operation of the CIPM MRA, the current practices of other CCs and, after discussions within the CCTF WG on MRA, it is proposed to include a risk-based approach in to the procedure for reviewing the CMCs in Time and Frequency.

Time and Frequency accounts for a small fraction of Calibration and Measurement Capabilities (CMCs) registered in the Appendix C of the Key comparison database (KCDB). On 8 February 2017 Time and Frequency had 762 out of the grand total of 24 926 entries, the smallest number of all domains. The cost of reviewing the CMCs is borne by the participating National Metrology institutes (NMIs) and Regional Metrology Organizations (RMOs).

Since the beginning of the review of the CMCs, the CCTF collectively reviewed all the submitted CMC sets according to the JCRB procedure. When an RMO submitted a new CMC set, the remaining RMOs, as a rule, accepted its review through the JCRB website and reviewed the entire set. The process is long, particularly, as the submitting RMO needed to collate the receipt of all review reports.

The idea of a risk-based procedure is that the review continues to be shared between the RMOs, but is now conducted on a semi sampling basis, including the CCTF WG on MRA as described in § 2.5, and covering 0 % to 100 % of the submission.

According to the Classification of services in Time and Frequency:

- For Time scale difference, 100 % of the submitted CMCs are reviewed (all RMOs, each reviewing the entire set), with the traceability checked following the CCTF WG on MRA Guideline 9
- For Frequency and Time Interval, 0 % to 100 % of the submitted CMCs are reviewed (2-4 RMOs collectively review the sample). The CCTF WG on MRA recommends that selection of CMCs for review be based on the following criteria:
 - Magnitude of changes;
 - Traceability scheme;
 - History of previous reviews;
 - Coverage by on-site technical visits;
 - High-level technical judgement.

The sharing of reviews remains voluntary. It continues to be the fundamental right of an RMO to review any of the submitted CMCs if it so chooses. Irrespective to the scope of its review, once the RMO agrees to review a part of the submission, it eventually approves the entire set, implicitly trusting the decisions by other RMOs and the sampling suggested by the CCTF WG on MRA Chair.

2.2. Modification of CMCs already in Appendix C

Following the JCRB document “*Procedure for modifying CMCs already in Appendix C*”, modified CMCs fall into three categories:

- a) CMCs corrected for material or editorial errors or for improving the explanatory text; these CMCs do not require a new review;
- b) CMCs modified to increase the uncertainty or to reduce the scope; these CMCs also do not require a new review, but if the change is due to the results of a comparison the other RMOs are to be notified;
- c) CMCs modified to change the method of measurement or to reduce the uncertainty or to increase the scope; these CMCs require a new review.

For CMCs of categories a) and b), modifications must be made to the Excel files corresponding to the published CMCs. Download these files from the restricted access JCRB CMC site (ask your TC chairperson for user name and password). After downloading the file of your Country, modify its name as follows:

RMO_Country_TF_date_mod_ab

where *RMO* is the acronym of the regional metrology organization, *Country* is the ISO two-letter abbreviation for the Country (http://www.iso.org/iso/home/standards/country_codes.htm), and *date* is the date of submission in the form yymmdd. TF stays for Time and Frequency and *mod_ab* is to show the type of file. No other documentation is due to support the proposed changes, unless requested by the TC chairperson.

Modified CMCs in category c) will be reported together with and will follow the same rules as new CMCs (section 2.3).

The following color codes, suggested by the BIPM, will be used in all categories, a), b) and c), to highlight the changes in a CMC entry:

- 1) any modification of an existing entry will be written **in bold red character**;
- 2) in case of cancellation of words in a cell do **not use the strike-through character formatting** but change to **bold red** the remaining cell content;
- 3) in the rare case that the whole cell content is deleted, highlight the now empty cell by a **light pink background**;
- 4) withdrawn CMCs will be highlighted by a **light pink background extending over Columns A to P** and the words “to be deleted from the KCDB” placed in the yellow Comment Column (Column T).

The NMI internal service identification of the modified CMCs (Column Q) will not be changed. Internal service identifications of withdrawn CMCs will not be used for new CMCs. After downloading the file of your Country take care to convert into black, or to delete, all previous color coded entries, as applicable.

2.3. Submission of new CMCs or of modified CMCs requiring new review

New CMCs and modified CMCs under category c) above will be reported in the same CMC Excel file, whose filename will be coded as explained in the following §3. In this file, the modified CMCs will be recognized by the use of the color codes suggested by the BIPM, as explained in the previous section. Care should be taken that new CMCs do not have the same NMI internal identification (column Q) of CMCs already published in the Appendix C.

Each CMC Excel file with new CMCs, or modified CMCs requiring new review, will be accompanied by all information needed to substantiate claims and methods. The way this information is organized is decided by the region. For example it can be reported in a standard questionnaire approved by the region.

2.4. Intra-regional and Inter-regional reviews

NMIs forward CMCs through their contact persons to the relevant RMO TC Chair. These CMCs must have been approved by the NMI's/DI's management and be fully covered by its Quality Management System (QMS). Some TCs have formed a Working Group for CMC Review and set a fixed date for submission (e.g., the annual TC meeting) and a fixed period for intra-regional review. In this case, the TC Chair collects the CMC sets and sends them to the members of the working group for review. Otherwise, the Contact Persons of the TC are directly involved in this process, and the results of the review will be discussed at the coming TC meeting. The CMC review is performed by direct contact between the reviewers and the persons responsible from the submitting NMIs until a consensus can be reached. In case that not all concerns can be resolved, the TC Chair contacts the reviewers and the submitting NMIs for resolution, the final decision being with the RMO Chairperson. The results of the review together with possible comments of the reviewers and the submitting NMIs are listed in the CMC tables. The intra-regional and inter-regional review process is presented in flowchart form in Appendix 1. The intra-regional review must cover all submitted CMCs, sampled review will only be accepted for the inter-regional review.

For a CMC entry, the statement of an uncertainty must be based on a careful consideration of all uncertainty contributions of Type A and B following the "Guide to the expression of uncertainty in measurement" (GUM). Results of key, supplementary and bilateral comparisons are important information providing evidence for validity of CMC claims. But uncertainties of CMC claims must be equal or larger than the corresponding results of a key comparison, and reference to key, supplementary and bilateral comparisons can only be used to support uncertainties that are larger or equal than those stated for the corresponding measurement in the key comparison. A laboratory may, however, wish to re-evaluate the uncertainties after a successful key comparison or because of changes and improvements in the technical equipment, methods and procedures, staff education, or other conditions. In this case a new uncertainty budget must be drawn up.

The inter-regional review procedure is explained in a JCRB- document [9], which is also presented in flowchart form [10]. The CMC review process is carried out through a password-protected web page which can be entered via the JCRB section of the BIPM site (<http://www.bipm.org/JCRBCMCs/>) by clicking on the link labelled "JCRB CMC website". TC Chairs can obtain a username and a password

from the JCRB Executive Secretary. The CMC files to be reviewed can be downloaded from this page. The JCRB requires that CMCs submitted for publication in Appendix C are accompanied by an RMO report indicating that the local TC/WG has approved the range and uncertainty of said CMCs and that each of them is supported by a fully implemented Quality Management System reviewed and approved by the local RMO. Once the files are posted for review, the corresponding technical contacts in each area get in touch directly with each other to exchange comments or concerns.

2.5. Inclusion of the CCTF WG on MRA in the review process

Claimed Calibration and measurement capabilities (CMCs) are developed by the participating institutes and submitted for first-stage review by their regional metrology organization. At this stage, the intra RMO review should be performed according to the CCTF WG on MRA Time and Frequency Supplementary Guide for Appendix B and C of the CIPM MRA. Once this review process has been completed, the regional metrology organization submits the CMCs to a second-stage inter-regional peer-review process.

Once posted on the JCRB webpage, the CMCs are distributed by the JCRB secretary to the CCTF WG on MRA for comments via the Executive Secretary of the CCTF. The WG on MRA will meet when necessary for comments on the CMCs concerning the point illustrated in section 2.1, the information given about traceability to UTC (w.r.t. the Guideline 9) and the units declared. A report on status of the declared CMCs should be provided in about 2 to 3 weeks. If, at the end of the review period, the JCRB secretary has not received any feedback from the CCTF WG on MRA, he will consider that there is no objection and continue the process.

Having successfully completed both peer-review processes, the CMCs are published in the BIPM KCDB.

3. Structure of the CMC table

The Excel template for the compilation of a CMC table is given in the Excel file named:

RMO_Country_TF_date

This template is only to be used if an NMI declares CMCs for the first time. In all other cases, the Excel table of already existing CMCs shall be used instead of the template, see the end of this section. Only one file per Country must be submitted. The submitting NMI will change the name of the file by introducing the acronym of the regional metrology organization for RMO and the ISO two-letter abbreviation for Country. For date the form yymmdd will be used.

Header and footer are provided in the Excel template to help to identify the table when printed. In the header the acronyms of the NMI and of the Country must be introduced. In case of more than one NMI per Country, all the NMI acronyms will be reported in the header.

In the table, at the right side of the white columns, there are three blue, five yellow (divided by two white columns for Comments and Uncertainty matrix to be published via the database) and three green columns. The blue columns are for supporting the CMC traceability. The yellow columns are for

the administration of the table and for the names of the uncertainty matrices and of the tags for closely related CMCs. The green columns are to be used during the review processes. The white columns and the blue and yellow columns, not the green ones, are to be filled in by the submitting NMI.

Only the white columns, the yellow columns “NMI Service Identifier”, “NMI”, and “Uncertainty Matrix” will be reported, with attached uncertainty matrices, into the Appendix C. Of course also the columns “Service category” and “Tag for closely related CMCs” are essential for a correct transfer of the table into the Key Comparison Database.

If the NMI has already CMCs in the KCDB, all changes (additions, modifications, deletions) shall be made in the Excel table of the existing CMCs. This file can be downloaded from the JCRB CMC website using the “get published CMCs” link. All changes shall be made on this file, using the color codes described in section 2.2. Before submission, all CMCs which are unchanged shall be hidden by using the Excel “hide” function, so that only the changes are visible to the reviewers.

3.1 General Criteria of compilation

- 3.1.1 The MRA Appendix C submission is an Excel spreadsheet where separate NMI services are listed in rows, and columns are used to organize the attributes of the services.
- 3.1.2 The CMCs will be reported in a single spreadsheet, following strictly the order of the TF Classification of services. A disordered list would give unnecessary, additional work to the TC chairperson.
- 3.1.3 Make a separate CMC entry in case of a distinct measurand or a distinct calibration procedure or a distinct uncertainty declaration. If the uncertainty depends on two variables (like the range of the measurand and the range of a parameter) use can be made of an uncertainty matrix to reduce the number of entries.
- 3.1.4 Each entry must correspond to only one classification category and to only one measurand.
- 3.1.5 Each CMC entry should be self-consistent, without reference to other entries, because each CMC will be usually displayed alone by the database.
- 3.1.6 For each CMC, multiple entries in the two columns on Measurement Conditions (i.e. when CMC has more than one parameter) must be separated vertically into separate cells.
- 3.1.7 Do not insert headings nor blank rows in the table. Do not merge any cells vertically and do not use symbols of repetition (“”), to show that the information is the same as in the previous CMC, but repeat the information.
- 3.1.8 Do not use the Excel facility to append comments to the cells, but use the Comments columns on the right side of the table (see §§ 3.9.2 and 3.9.3).

3.2 Language and Symbols

- 3.2.1 Detailed writing rules for preparing the CMC files are given in the BIPM Instructions. These Instructions must be carefully read and the rules carefully applied. If too many violations are found, the CMC file will be sent back to the submitting NMI for correction.

Compliance with the writing rules will greatly help the BIPM in the importation of the Excel files into the database.

3.2.2 The following rules complement the BIPM Instructions:

- as unit for day use the symbol d; do not use: day
- use SI accepted prefixes for decimal multiples and sub-multiples; they must be written close to the symbol of the unit of measurement, in the appropriate columns, and not close to the numerical values
- when reporting a list of items in the same cell use the comma (,) as the separation character [e.g.: clock, frequency offset multiplier, counter]
- use a colon (:) to introduce a specification of a previous text-item of information [e.g.: link stability: frequency]

3.3 Time and Frequency Classification scheme

3.3.1 The Classification of Time and Frequency CMCs, approved by the CCTF, provides the NMIs with uniform and world-wide agreed terminology for the classification of their services.

3.3.2 These are divided into major headings, sub-headings and categories. For each category, characterized by a 3-number classification, a list of instruments/artefacts is given.

3.3.3 Usually it should be possible to find classified denominations for the quantity of interest and the instrument/artefact, to be reported in columns A and B. In case applicable terms cannot be found in the classification (new quantity or instrument/artefact) follow § 3.4.1.

3.3.4 At the time of writing this Guide, the more recent, approved, classification version is 1.1.

3.4 Calibration or Measurement Service (col. A, B, C)

3.4.1 The Quantity and the Instrument/Artefact names will usually be found in the Classification. If this is the case, use the given terms as explained in § 3.4.2 and § 3.4.3, then take note of the corresponding 3-number classification for introduction in column R (§ 3.10.3). If this is not the case, discuss with the TC chairperson about entering your own English term for Quantity or Instrument/Artefact or both and about assigning to your service a provisional three-number classification (in the form: *heading.sub-heading.x*) in column R. This case should be an absolute exception, given the extensive revision that has led to the present version of the classification.

3.4.2 In column A, insert the appropriate description of the Quantity. This is usually given in the *Classification* by the names of the heading, sub-heading and category. Because combining heading, sub-heading and category could lead to a cumbersome and unnecessarily long definition of the Quantity, you are required to use one of the standardized wordings reported in the classification file *with column A definitions*, provided with this Guide.

3.4.3 In column B, insert the appropriate name for the Instrument/Artefact. Because combining heading, sub-heading and category could lead to a cumbersome and unnecessarily long definition of the Quantity, you are required to use one of the standardized wordings reported in the classification file *with column B definitions*,

provided with this Guide. If a symbol referring to the measurand is used in one of the subsequent columns, introduce this symbol, *in Italics*, in column B as the last piece of information, separated from the previous item(s) by a specification or separation character, whatever is more convenient. Do not use the symbol *k*, as this symbol is reserved for the uncertainty coverage factor.

- 3.4.4 In column C, a short but clear definition of the method of measurement must be reported. This information, combined with that in column N about the standard(s) used as the reference(s), is of fundamental importance to allow an expert to identify the measurement technique.

Example:

A	B	C	R
Time scale difference	Remote clocks vs. UTC	GPS common view	1.2.2
Time interval	Time difference source	Time interval counter	3.2.3

3.5 Measurand Level or Range (col. D, E, F)

- 3.5.1 In column D, insert the minimum value of the range of the measurand as a single numerical value. If you introduce zero for this number, check that the expression for the uncertainty, reported in column I, is still meaningful.
- 3.5.2 In column E, insert the maximum value of the range of the measurand as a single numerical value. If your measurement refers to a single value of the measurand, column D and E will report the same number.
- 3.5.3 In column F, report the unit of measurement that applies to the minimum and maximum values in the two previous columns. Use accepted SI prefixes if needed.
- 3.5.4 Usually it is possible to understand from the quantity if measurements can be performed on both positive and negative values. Only if this is not the case report explicitly negative range limits.

Example:

A	B	C	D	E	F	R
Time scale difference	Remote clocks vs. UTC	GPS common view	-0.5	0.5	s	1.2.2
Time interval	Time difference source	Time interval counter	1×10^{-9}	1 000	s	3.2.3
Frequency	General frequency source	Clock, counter	0.1	1.3×10^9	Hz	2.2.1
Frequency	Remote frequency standard	GPS common view	1	1	Hz	2.1.2

3.6 Measurement Conditions / Independent Variable (col. G, H)

- 3.6.1 In column G, report any condition, which imposes limitation or optional restriction to the measurement, in the form of the name of the parameter that describes this condition. If several conditions apply, the names of the parameters will be entered into separate cells in the column. If a symbol referring to the value of a parameter is used in one of the subsequent columns, report this symbol, *in Italics*, after the name of the parameter, using the specification character [e.g.: frequency: *f*]. Do not use the symbol *k*, as this symbol is reserved for the uncertainty coverage factor.
- 3.6.2 In column H, report the range of the parameter or other pertinent information that defines the restriction. If column G has several parameters, report in column H the corresponding ranges of variation, or pertinent information, in the corresponding cells.
- 3.6.3 When indicating a range in column H use the notation *minimum* to *maximum* [e.g.: 0.1 s to 100 s or (0.1 to 100) s]. If only one limit needs to be specified, use the notation *up* to (for maximum) or *down* to (for minimum).
- 3.6.4 When a parameter takes discrete values, report these values separated by commas (,) [e.g.: (1, 2, 5, 10, 100) MHz].
- 3.6.5 In some cases the measurand takes only discrete values. In this case the range columns D and E report the minimum and maximum values, while the parameter columns G and H report, respectively, the symbol of the measurand (previously defined in column B) and the list of values.
- 3.6.6 Usually do not report as parameters the ambient conditions of the measurement. These are intended to be standard laboratory conditions, whose limits of variation are taken into account in the reported uncertainty. Report the temperature, or temperature range, of the measurement or other ambient conditions only if it is relevant to the identification of the measurement service: column U is usually more appropriate for this type of information (see § 3.9.3).

Example:

A	B	C	D	E	F	G	H
Time scale difference	Remote clocks vs. UTC	GPS common view	-0.5	0.5	s	Averaging time	1 d
Time interval	Time difference source	Time interval counter	1×10^{-9}	1 000	s	Pulse amplitude	> 1 V
						Rise time	< 1 ns
Frequency	General frequency source	Clock, counter	0.1	1.3×10^9	Hz	Averaging time	100 s, 10 measurements
Frequency	Remote frequency standard	GPS common view	1	1	Hz	Averaging time	1 d
Frequency	Local frequency standard	Clock, frequency offset multiplier, counter	10	10	MHz	Averaging time, t	$0.1 \text{ s} \leq t < 100 \text{ s}$
						Relative frequency difference	$< 1 \times 10^{-11}$

3.7 Expanded Uncertainty (col. I, J, K, L, M)

- 3.7.1 A Calibration and Measurement Capability is the highest level of calibration or measurement normally offered to clients. This implies that the global uncertainty associated with a CMC should consider the contribution (noise, short term instability, resolution etc., but not transport) of the instrument/artefact under calibration, usually the best available. The uncertainty is usually expressed in terms of a confidence level of about 95 %.
- 3.7.2 In column I, the expanded uncertainty value (without \pm) must be entered. This may be a fixed value, valid over the entire range of the quantity, a range of values or a mathematical expression.
- 3.7.3 In general when the uncertainty depends on two variables, usually the range of the quantity and the range of one parameter, it is recommended to use the presentation of the uncertainty in a two-dimensional matrix, following the rules given in the BIPM document [11], listed in References of this Guide. This technique will reduce the number of lines in the table and will improve presentation. In this case, column I will report the minimum and maximum uncertainty values. It is intended that the unit of measurement of the uncertainty values in the matrix is the one given in column J.
- 3.7.4 With the exception of presentation in matrices, if a range of values is given in column I, the uncertainty is considered to be varying linearly within the range, in correspondence to the variation of the measurand or of a parameter from the lower to the higher limits reported in columns D and E (for the measurand) or in column H (for the parameter). The functional dependence, if not clear, should be specified in the same column I after the

- uncertainty expression [e.g.: $(1 \times 10^{-6}$ to $1 \times 10^{-12})$, depending on the frequency]. If the uncertainty variation is not linear, the user must be informed by introducing a comment in column U, for example specifying that the given values only define the minimum and maximum uncertainties. In this case however, the range of variation should be limited, otherwise the CMC entry would become useless.
- 3.7.5 Uncertainty by formula. When using a mathematical expression, defined symbols referring to the measurand or to the parameters will be entered. The units of measurement of the symbols will be specified in the same Column I after the expression. Do not introduce units of measurement within the expression. The unit for the resulting uncertainty is to be reported in column J (see § 3.7.11).
- 3.7.6 Uncertainty by formula: quadratic summation. Following the ISO GUM, the composition of a constant uncertainty term and of a range dependent (proportional) uncertainty term, is done by quadratic summation. This can be written with the expression $Q[a, bt]$, where a is the numerical value of the constant term and bt is the variable term proportional to t .
- 3.7.7 Uncertainty by formula: linear summation. In other cases the uncertainty may be given by the linear summation of a constant and a variable term, like $(d + ct)$.
- 3.7.8 Uncertainty by formula: 2nd degree polynomial. This type of uncertainty declaration will be used if it is of help with covering an extended range of the quantity or of the parameter by a single uncertainty declaration. Use of polynomials of degree higher than 2 or of other non-elementary functions is strongly discouraged, as they are difficult to understand by the user and very often prone to errors, also due to the very limited capability of Excel in equation editing. For uncertainties depending on two variables the use of matrices (see § 3.7.3) should always be preferred.
- 3.7.9 When an explanation is necessary in order to allow a correct interpretation of the uncertainty expression, add a separation character (,) after the uncertainty value or expression and write the comment [e.g. for the relative uncertainty of a frequency source: $(8.5 \times 10^{-13} + 1.5 \times 10^{-6} / f)$, f frequency in Hz].
- 3.7.10 In column J, report the unit of measurement for the uncertainty. In case of relative uncertainties for quantities with dimensions, express the unit as a ratio of different multiples of the same pertinent unit. [e.g. $\mu\text{Hz}/\text{Hz}$] or, if the unit is an expression involving other units, use a negative power of 10 or use the symbol %. For quantities without dimensions, column M is essential for the correct interpretation of the uncertainty.
- 3.7.11 Do not use as unit of measurement the symbols ppt, ppm, ppb or similar.
- 3.7.12 In column K, report the coverage factor k .
- 3.7.13 In column L, report the probability corresponding to the declared uncertainty and coverage factor k , following the ISO GUM. A probability of about 95 % should in general be considered, but exceptions are allowed. The percentage sign must be reported close to the number.
- 3.7.14 In column M answer *Y* or *N*, thus specifying if the given uncertainty is to be interpreted as a relative or an absolute one (with respect to the measurand whose units are given in column F). Column M must always be filled in, even if the nature of the uncertainty seems to be already clear.

NOTE: do not use the symbol k in the mathematical expression of the uncertainty, to avoid confusion with the uncertainty coverage factor.

Example:

A	B	D	E	F	I	J	K	L	M
Time scale difference	Remote clocks vs. UTC	-0.5	0.5	s	10	ns	2	-95%	N
Time interval	Time difference source	1×10^{-9}	1 000	s	2	ns	2	-95%	N
Frequency	General frequency source	0.1	1.3×10^9	Hz	$(8.5 \times 10^{-13} + 1.5 \times 10^{-6} / f)$, f frequency in Hz, values range from 1.5×10^{-5} to 8.5×10^{13}	Hz/Hz	2	-95%	Y
Frequency	Remote frequency standard	1	1	Hz	1×10^{-13}	Hz/Hz	2	-95%	Y
Frequency	Local frequency standard	10	10	MHz	$(3 \times 10^{-13} + 2.7 \times 10^{-13} / t)$, t in s, values range from 3×10^{-12} to 3×10^{-13}	Hz/Hz	2	-95%	Y

3.8 Reference Standard used in calibration (col. N, O)

- 3.8.1 In column N, the reference standard(s) used in the measurement and making the link in the traceability chain to the SI unit, must be reported. In case several references are used for a certain measurement, these must be reported in the same cell, as a list of items separated by commas.
- 3.8.2 In column O, identify the laboratory (ies) which is (are) the source of traceability for the calibration of the reference standard(s) in column N. In case of more than one laboratory, the list of laboratories should correspond to the list of the standards in column N.

Example:

A	B	N	O	S
Time scale difference	Remote clocks vs. UTC(k)	National Time scale, Local Time scale	NMI1, NMI2	NMI1

3.9 List of Comparisons Supporting the CMC, Internal Comments, Comments for the user (col. P, T, U)

- 3.9.1 In column P, enter the correct identification of one or more comparisons sufficiently related to the service being submitted, in order to demonstrate equivalence. Different types of comparisons can be considered:
- CCTF key comparisons;
 - supplementary comparisons;

- past CIPM, regional or other (e.g. pilot, ...) comparisons;
- Bilateral comparisons.

In this column only comparisons for which measurements are completed and at least a draft report is available must be considered. Comparisons still running, even if close to completion, will be reported in the *Internal Comment* (yellow) column T.

3.9.2 In column T (yellow column) report comments related to the CMC and useful to the reviewer (this column will not be included in the Appendix C). Examples are: comparisons planned or still running, more details about traceability etc. General information supporting the CMCs (e.g. quality system, equipment, technical publications, etc.) will be reported separately, in the form established by the RMO. More detailed information will be given to the reviewer under request.

3.9.3 In column U (white column) report comments useful to the user, as this column will be included in the Appendix C. Examples are: specific limitations to the CMC, details about the conditions of measurement, options etc.

Example:

A	B	C	P	T	U
Time scale difference	Remote clocks vs. UTC	GPS common view	CCTF-K001.UTC	Results published monthly in the BIPM KCDB	Approved on 2 March 2017
Time interval	Time difference source	Time interval counter			Approved on 2 March 2017
Frequency	General frequency source	Clock, counter			Approved on 2 March 2017
Frequency	Remote frequency standard	GPS common view			Approved on 2 March 2017
Frequency	Local frequency standard	Clock, frequency offset multiplier, counter			Frequency instability measurement, Approved on 2 March 2017

3.10 RMO Time and Frequency Services Administration (col. Q, R, S, T), Comments for the user (col. U), Matrices and Tags (col. V, W) and intra/inter RMO review (col. X, Y, Z)

3.10.1 Columns Q, R, S are of particular importance for the management of the CMC table: they allow the experts to easily refer to a certain CMC, which facilitates, for example, email

discussions. Also, it is possible to merge rows from tables of different laboratories, for example for comparison purposes, without losing knowledge of the service identification and originating NMI.

- 3.10.2 Column Q is provided for numerical identification of each service of an NMI. If an entry is a modified CMC, aimed at substituting a CMC already published in the database, the published service identification number will not be changed. If an entry is new, it will have a new identification number, which, in case the submitting NMI has already TF CMCs published in the database, should not be equal to numbers already used in the published set. If an NMI is submitting its CMC set for the first time, progressive numbering starting from 1 will preferably be attributed to the CMCs. If an Excel formula is used to generate these progressive numbers, the Excel command “Copy+Paste-special|Values” must be used at the end to leave only numbers in column Q. In case a CMC extends over more than one line, only the first line will be numbered.
- 3.10.3 In column R report the service category, which can be found in the *Classification* and depends on the Quantity and the Instrument/Artefact reported in columns A and B (see § 3.3). In case of lack of applicable terms see § 3.4.1. If more than one classification applies, one CMC entry for each classification must be provided, in order to have only one category per entry.
- 3.10.4 In column S, report the acronym of the submitting NMI. In case of more than one NMI per Country, the acronym pertinent to each CMC will be reported. It is not possible to have in the same Country two or more NMIs submitting the same CMC.
- 3.10.5 Columns T and U were covered in §§ 3.9.2 and 3.9.3.
- 3.10.6 In column V report the name of the matrix, included in the Excel file, where the uncertainties corresponding to the CMC are reported. This Column shall be displayed between Columns J and K in the database. If the uncertainty declaration has not used a matrix presentation, this column will be left blank (see document [11] listed in References of this Guide for details).
- 3.10.7 In column W report the tag chosen to identify the CMC as closely related to the previous or the following one having the same tag. This tag will alert the BIPM that these closely related CMCs must be presented close-by in the database (see document [12] listed in Reference of this Guide for details).
- 3.10.8 Columns X, Y, Z are reserved for the review processes and should not be used during the preparation of the CMC tables.

Example:

A	B	Q	R	S	T	U
Time scale difference	Remote clocks vs. UTC(OP)	2	1.2.1	LNE-SYRTE	Results published monthly in the BIPM KCDB	Approved on 2 March 2017
Time Interval	Time difference meter		3.4.3	NRC		Stopwatch Approved on 16 September 2009
Frequency	Local frequency standard		2.1.1	TL		Included best DUT's effect Approved on 10 March 2015

4. References

Num ber	Document name	Title / Comment
1	CIPM MRA-G-03	Guidelines for the review of CMCs and the monitoring and reporting of the operation of quality systems by international intergovernmental organizations who are signatories of the CIPM MRA.
2	CIPM MRA-D-04	Calibration and Measurement Capabilities in the context of the CIPM MRA.
3	ISO 80000-1:2009 Annex B Rule B	Quantities and units -- Part 1: General
4	http://kcdb.bipm.org/appendixC/TF/TF_services.pdf	Classification of services in Time and Frequency
5	http://www.bipm.org/utis/common/pdf/CC/CC_TF/CCTF-WGMRA-Guideline_9.pdf	CCTF WGMRA Guideline 9: CCTF criteria for obtaining traceability in time and frequency
6	BIPM JCGM 100:2008 - 1st edition September 2008	Evaluation of measurement data - Guide to the expression of uncertainty in measurement (GUM)
7	BIPM JCGM 106:2012 – October 2012	Evaluation of measurement data – The role of measurement uncertainty in conformity assessment
8	BIPM JCGM 200:2012 - 3rd edition	International vocabulary of metrology – Basic and general concepts and associated terms (VIM)
9	JCRB-14/06(1)	JCRB Rules of Procedure for CMC entry into Appendix C
10	JCRB-12/06a_rev	JCRB CMC review process
11	Instructions for uncertainty matrices in CMC files	Excel file with example on how to prepare an uncertainty matrix, downloadable from the JCRB open access documents web page.

12	Instructions for closely related CMCs	Excel file with example on how to tag closely related to CMCs, to have them close-by in the database, downloadable from the JCRB open access documents web page.
13	http://www.bipm.org/utis/common/pdf/CC/CC_TF/CCTF-WGMRA-Guideline_5.pdf	CCTF WGMRA Guideline 5 (Rev. 201509) The prediction uncertainty of [UTC-UTC(k)]

5. List of Acronyms

BIPM	Bureau International des Poids et Mesures
CCTF	Consultative Committee for Time and Frequency
CCTF WG on MRA	CCTF Working Group on MRA
CIPM	Comité International des Poids et Mesures
CIPM MRA	Mutual Recognition Arrangement
CMC	Calibration and Measurement Capability
DI	Designated Institute
GUM	Guide to the expression of Uncertainty in Measurement
JCGM	Joint Committee for Guides in Metrology
JCRB	Joint Committee of the RMOs and the BIPM
KCDB	Key Comparison Data Base
NMI	National Metrology Institute
QMS	Quality Management System
RMO	Regional Metrology Organization
TC/WG	Technical Committee / Working Group
TC-TF	Technical Committee for Time and Frequency
TF	Time and Frequency
SI	International System of Units

6. History of changes

Version number	Date of Issue/Revision	Summary of change

7. Appendix

Appendix: Intra-regional and inter-regional review process

