

Strategy for the Consultative Committee for Units, CCU, for the period up to 2030

1. General Information:

Name:

Consultative Committee for Units (CCU)

Working Groups:

Working Group on Strategy (CCU WG-S) and task groups when necessary, on a temporary basis, currently Task Group on Fundamental Concepts in Metrology (TG-FCM, formerly Task Group on Core Metrological Terms (TG-CMT)) and Task Group on Key Topics in the SI Brochure (TG-KTSIB)

Date established:

1964, to replace the Commission for the System of Units, set up by the CIPM in 1954

Number of Members:

13 Members, 11 Liaisons, 2 Personal Members

Number of participants at last meeting:

58 (35 on site, 23 online)

Periodicity of meetings:

2 to 3 years

Date of last meeting:

9-10 April 2024, 26th meeting (hybrid meeting)

President:

Prof. R.J.C. Brown (from June 2024)

2. Terms of Reference

The work of the CCU is concerned with matters related to:

- The development and improvement of the International System of Units (SI), the preparation of successive editions of the SI Brochure and supporting documents, and any other summaries relevant for metrology institutes, industry, academia and schools, etc.
- Ensuring the overall consistency of the SI and providing advice to the CIPM about this and also about measurement units in general.
- Providing information and advice on units, their definition and their use to a wide range of stakeholders.

3. Description of activities and achievements up to and including 2024

From its creation in 1964 the main task of the CCU has been to oversee the development of the SI and to prepare the successive editions of the SI reference document, the SI Brochure, now in its 9th edition. In its early years the CCU made many important recommendations and took the initiative to build what is now the formal structure of the SI, with its base and derived units, units with special names, prefixes, and the formalism of their use. Beginning in 1970, the SI Brochure was published in French only in its first four editions, but since the 5th edition, in 1985, it has been published bilingually in French and English.

Great care is taken with the language, not only for the accuracy of the terms used and their meanings, but also because the SI Brochure is translated into many other languages as well as being used by people whose mother tongues are neither French nor English. The current edition, the 9th, was published in 2019 together with a four-page Concise Summary. The SI Brochure is the most important and widely used publication of the BIPM and is freely available on the BIPM website. Since 2023 the BIPM has been preparing a “Digital SI Reference Point”, which is a suite of tools making the information of the SI Brochures, from the 1st to the 9th edition, available in machine readable form.

The most important activity of the CCU in recent years has been the preparation of a major revision of the SI, which has been referred to as the “Revised SI”. This revision was adopted by the 26th CGPM on 16 November 2018 and came into force on 20 May 2019. The revision includes new definitions of the kilogram, ampere, kelvin and mole, the reformulation of the definitions of the second, metre and candela (in order for all of them to appear consistent in form) and a new way of presenting the entire system by fixing the numerical values of a set of seven “defining constants”.

The revision of the SI was the subject of Resolution 1 of the 26th CGPM. The proposed changes embodied in Resolution 1 were widely discussed in the respective Consultative Committees, in the CCU and in scientific meetings outside the BIPM. The CCU had the responsibility of bringing together the views of the individual Consultative Committees with the many international bodies represented on the CCU and arriving at a consensus. This was achieved in 2017 when the CCU supported the decision of revising the SI, embodied in a draft proposal which became Resolution 1 of the 26th CGPM.

As part of the task of informing the public about the revision of the SI, a special page of the BIPM website was created. This was not only to inform but also to stimulate discussion and encourage awareness of the changes. It included a file of Frequently Asked Questions (in French and in English), the rationale behind the change as well as the present SI Brochure and Concise Summary.

In its meeting in 2019 the CCU discussed the necessity to expand the range of SI prefixes from 10^{24} up to 10^{30} and from 10^{-24} down to 10^{-30} to respond to advances in science and technology. In response to a CIPM decision, the CCU developed a position paper and a roadmap for the introduction of the new prefixes into the SI Brochure. Following this, a draft resolution for the 2022 CGPM was prepared by the CCU which was adopted without change. A new version 2.01 of the 9th edition of the SI Brochure with an updated list of prefixes was published on the BIPM web site on 15 December 2022.

In previous years the former CCU Working Group on Angles and Dimensionless Quantities (WGADQ) had met on several occasions to examine the treatment that should be given in the 9th edition of the SI Brochure to the quantities traditionally called “dimensionless” such as angles, frequency rates, ratio quantities and quantities which are a number of entities. The possible introduction of the radian as a base unit was considered as well as the introduction of the dimension “number” along with the unit “one”. No consensus was reached on these subjects, so, after consideration, the issues were brought to the CIPM which decided that the 9th edition of the Brochure should treat both topics according to CGPM decisions currently in force. At its meeting in 2019 the CCU members discussed the question of units for angles and dimensionless quantities again. No consensus could be found and the WGADQ was closed. All members and liaisons were asked to discuss the question within their institutions and to present the official view at the 2021 CCU meeting. Written replies were received from six NMIs and four liaison organizations. The opinions ranged from introducing the radian as the 8th base unit to keeping the status quo, with a majority in favour of the latter option. The CCU decided to form a new Task Group on Angle and Dimensionless Quantities in the SI Brochure (TG-ADQSIB). Its main task was to propose updated entries for those parts of the SI Brochure related to angle and dimensionless quantities which could be improved to aid understanding, without changing the status of the radian being a derived unit. The Task Group achieved consensus on a set of suggestions for improving and clarifying the text of the SI Brochure which were presented to the CCU WG-S in September 2023 and to the CCU in April 2024. The CCU approved the proposal for publication of version 3.01 of the 9th edition of the SI Brochure, which was published on the BIPM web site in August 2024.

In 2021 the CCU made a survey amongst NMIs, liaison organizations and teaching organizations to gather feedback on the implementation of the Revised SI. Replies were received from 18 NMIs, 7 liaison organization and 17 teaching organizations. No great difficulties in implementing the revised SI were reported.

During the drafting process of the 9th edition of the SI Brochure, there was an intense debate within the CCU on the correct definition of the concept ‘unit’ in the SI Brochure. At its meeting in 2019 the CCU set up the Working Group on Core Metrological Terms (WG-CMT). The first task of the WG was to propose definitions for the concepts represented by the English terms “quantity”, “quantity value” and “unit” to the CCU. During 2020 and 2021 the WG met three times and developed a proposal which was supported by the majority of its members, but no consensus was achieved. At the 2021 CCU meeting it was proposed that the WG should also take into consideration quantities which are a number of entities, and the requirements concerning machine-readability of the definitions. In response to this, the WG-CMT invited several experts on digitalisation, semantics and mathematics to join the group. The experts recommended developing an axiomatic system based on mathematical formulations. During 2023 a demonstration of such a mathematical formulation of CMTs was provided by a dedicated Focus Group which was presented to the WG-S in September 2023 and to the CCU in April 2024. The CCU decided that the work should be continued in the form of a Task Group, TG-CMT. The TG was renamed Task Group for Fundamental Concepts in Metrology (TG-FCM) in July 2024.

The WG-CMT also initiated the organization of a joint CCU-CCQM workshop on “Metrology of quantities which can be counted”. The workshop took place in March 2023 with more than 300 participants. It covered aspects of quantities with the unit one and especially quantities that are a number of entities within several different fields of metrology. Some areas for clarification relating to the treatment of counting as a measurement and the description of

quantities with the unit one in the SI Brochure and in the International Vocabulary of Metrology (VIM) were identified. The TG-ADQSIB created a Focus Group for making suggestions on how the text of the SI Brochure related to these topics could be improved. The suggestions were presented to WG-S in September 2023 and to the CCU in April 2024. The CCU approved the proposal and the changes were incorporated into version 3.01 of the 9th edition of the SI Brochure, which was published on the BIPM website in August 2024.

4. Stakeholders (who they are and their level of involvement)

The bodies having a direct interest and concern in the activities of the CCU, are:

1. the CIPM, which must be properly advised on matters related to the SI;
2. the National Metrology Institutes and the Designated Institutes, which use the SI every day in their business, and
3. the international organizations that are in *liaison* with the CCU, which disseminate the SI to their members.

On a much wider scale, a clear and accessible statement of the SI and how it should be used is essential not only for scientific, technical, industrial and educational communities but also for society as a whole. Research and development, manufacturing, trade, medicine, protection of the environment and consumer protection all depend on accurate, reliable and comparable measurements, hence on the proper application of the SI. For all these reasons an authoritative guide to the SI is required, which is provided by the SI Brochure. These days, such information is sought online and thus the BIPM website plays and will play in the future an increasingly important role. The number of questions from the general public related to SI and non-SI units received by the BIPM demonstrates the great interest of the wider community in these topics.

5. Future Scan (2023-2030)

The decision for the revision of the SI that took place in November 2018 and came into force in May 2019 has closed a very intense phase of activity over the last decade in which the CCU was mostly devoted to this revision. Therefore, in the years following the redefinition, the CCU was expected to reorient its scope and activities, within its terms of reference, to fulfil its mission of developing and improving the SI in all areas. In parallel, the CCU will naturally monitor the implementation of the revised SI.

Specific tasks for the years up to 2030:

- The main tasks expected for the CCU in the period up to 2030 will concern time and frequency metrology and will be carried out in close collaboration with the CCTF. In particular:

The performance of optical clocks has surpassed that of the best primary caesium clock fountains and keeps improving. A roadmap was developed by the CCTF to specify the timeline and the necessary milestones to be achieved before a redefinition of the second in terms of an optical transition can take place. The earliest date for the adoption of the new definition by the CGPM is expected to be 2030. The CCU will provide input into this process and other concepts highlighted in the CCTF strategy

(e.g., high accuracy measurements of optical frequency ratios, definition based on an ensemble of transitions, close connection between the dissemination of the time unit and the timescales, etc.). The CCU will also review the impact of proposals for the redefinition of the second on other fields of metrology.

- Outside time metrology, one of the major tasks for the CCU in the years following the redefinition will be to monitor the implementation of the revised SI in the different areas of metrology, in close collaboration with the relevant CCs. In this respect:

Reviewing and updating as necessary the list of frequently asked questions concerning the 2019 revision of the SI maintained on the BIPM webpage. In the longer term, after the redefinition, new realisations of the definitions of the units in terms of the defining constants will emerge along with new proposals for the *mises en pratique*. The CCU will monitor these developments, document any improvements they allow, take care of the consistency of the overall system and provide scientific advice to the CIPM accordingly. The CCU will propose appropriate updates of the SI Brochure to the CIPM, along with any other updates that might become necessary.

- During recent years several issues relating to the SI have been of debate and for some of them further consideration is needed. In particular:

The work initiated by the WG-CMT to propose definitions for the concepts designated by the English terms “quantity”, “quantity value” and “unit” will be continued by the newly formed Task Group on Fundamental Concepts in Metrology (TG-FCM). Its principal tasks are to identify the key fundamental concepts in the understanding of metrology and to characterize such concepts and their interrelations in mathematical or logical terms where possible. Two members of the CCU were nominated to represent the BIPM in the JCGM-WG2:VIM to ensure a strong link between both committees.

At the 26th meeting of the CCU in April 2024 a new Task Group on Key Topics in the SI Brochure (TG-KTSIB) was created. Its objectives are to discuss key topics for the future 10th edition of the SI Brochure. The Task Group will review the current treatment of non-SI units in the 9th edition of the SI Brochure and recommend criteria for how the SI Brochure should address this topic in future. In the revised SI, the distinction between base units and derived units has been kept, both for historical reasons and for practical usefulness when carrying out dimensional analysis. The Task Group will review the current treatment of base and derived units in the 9th edition of the SI Brochure to determine if any improvements to their presentation could be made.

The CCU will participate in the work of the Forum on Metrology and Digitalization (FORUM-MD) and support the further development of the SI Reference Point, providing advice on all matters relating to units and ensuring that the SI Reference Point remains consistent with the SI Brochure.

The CCU will consider the necessity of providing more information in the SI Brochure on units for physiological quantities, than presently available in Appendix 3.

08/11/2024

Finally, the CCU President and Executive Secretary will continue to implement editorial changes that improve the text of the SI Brochure without affecting its meaning.

Appendix 1: Details of CCU Working Groups and Task Groups

CCU Working Group on Strategy, WG-S

Date established:

2017

Number of Members:

8

Number of participants at last meeting:

10

Periodicity of meetings:

1 year

Date of last meeting:

20 and 21 September 2023 (virtual meeting)

Chairperson:

Prof. R.J.C. Brown

Terms of Reference

The terms of reference of the CCU-WG-S are to:

- Ensure that relevant developments in science, particularly in areas not covered by other CCs, are monitored by the CCU and propose suitable actions.
- Propose a long term vision for the CCU covering the next ten years and to establish and maintain a strategic planning document.
- Advise the CCU on the optimal operational structure of the CCU and its working groups.
- Establish practices to ensure an effective linkage between organizations in liaison and in cooperation with the CCU.
- Suggest to the CCU possible future revisions, additional Annexes to the SI Brochure or other supporting documents, as appropriate.

CCU Task Group on Fundamental Concepts in Metrology, TG-FCM (formerly Task Group on Core Metrological Terms, TG-CMT and Working Group on Core Metrological Terms, WG-CMT)

WG-CMT was transformed into TG-CMT at the 26th CCU meeting, 9-10 April 2024.

TG-CMT was renamed TG-FCM in July 2024.

Date established:

2019

Number of Members:

17

Number of participants at last meeting:

13

Periodicity of meetings:

at least one per year

Date of last meeting:

20 September 2024 (virtual meeting)

Chairperson:

Prof. L. Mari

Terms of Reference

The Terms of Reference of the CCU TG-FCM are the following:

- Considering the outcomes of the CCU-WG-CMT, identify the key fundamental concepts in the understanding of metrology.
- Characterize such concepts and their interrelations, in formal (mathematical or logical) terms where possible, also enabling their machine-readability and actionability.
- Provide the outcomes of the TG to the JCGM-WG2:VIM and other relevant stakeholders.
- Report progress to the CCU-WG-S and the CCU.

CCU Task Group on Key Topics in the SI Brochure, TG-KTSIB

Date established:

2024

Number of Members:

16

Date of last meeting:

12 November 2024 (virtual meeting)

Chairperson:

Prof. R.J.C. Brown

Terms of Reference

The Terms of Reference of the TG-KTSIB are the following:

- To review the current treatment of non-SI units, and base and derived units, in the 9th edition of the SI Brochure.

- To review historical perspectives, existing authoritative documentation, and current stakeholder needs relating to these topics.
- To recommend criteria for how the SI Brochure should address these topics in future.
- To provide updates to CCU WG-S and present progress to the next CCU meeting in 2027.

CCU Task Group on Angle and Dimensionless Quantities in the SI Brochure, TG-ADQSIB (closed)

The TG-ADQSIB was closed at the 26th meeting of the CCU in 2024.

Date established:

2021

Number of Members:

17

Date of last meeting:

16 March 2023

Chairperson:

Prof. R.J. C. Brown

Terms of Reference

Acknowledging the current status of angle within the SI Brochure as not being a base unit (Section 2.3.3), the Task Group will:

- Review the 9th edition of the SI Brochure and highlight the parts (text, tables, footnotes, etc) relevant to angle and dimensionless quantities.
- Decide whether the parts identified could be improved to aid understanding.
- Attempt to reach consensus on updated entries for those parts where improvement would be beneficial.
- Consider whether a new, additional Appendix to the SI Brochure would be useful to explain more fully the special considerations for angle and dimensionless quantities.
- Review the historical use of SI supplementary units and consider whether reintroduction would be of benefit (for the units radians, steradians and one).
- Present the outcomes in the form of a short report and list of proposals to the next CCU meeting and also provide progress updates to the CCU Working Group on Strategy.