

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), Working Group on Core Metrological Terms (CCU WG-CMT) and *ad-hoc* working groups and task groups when necessary, on a temporary basis, currently Task Group on Angles and Dimensionless Quantities in the SI Brochure (TG-ADQSIB)

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 and 1 Honorary Member

Number of participants at last meeting:

70

Periodicity of meetings:

1 to 3 years

Date of last meeting:

21-23 September 2021, 25th meeting (online meeting)

President:

Prof. Joachim Ullrich, from 1st January 2014

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 supportive documents, and any other summaries relevant for metrology institutes, industry, academia and schools, etc.
- Providing advice to the CIPM about units of measurement in general, overall consistency and harmonisation.
- Providing information and advice on units and their use to a wide range of stakeholders.

3. Description of activities and achievements up to and including 2023

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. The first four editions of the Brochure, beginning in 1970, were published in French only 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 meaning, but also because it 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, has been published in 2019 together with a four-page Concise Summary. The Brochure is freely available on the BIPM website. The SI Brochure is the most important and widely used publication of the BIPM. In 2023 the BIPM is 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 rewording 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 is 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 the draft 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.

The CCU working group on angles and dimensionless quantities (WGADQ) met on several occasions to examine the treatment that should be given in the 9th edition of the SI Brochure to “dimensionless quantities” as angles, frequency rates and counting quantities. 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 either subject, 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 is 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 which will be presented to the CCU in April 2024.

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 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 2021 the CCU made a survey amongst NMIs, liaison organizations and teaching organizations to gather feedback on the implementation of the revised SI. Replies have been 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 SI Brochure, there was an intense debate within the CCU on the correct definition of the term “unit” in the 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 is to propose definitions for the 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 counted, and the requirements concerning machine-readability of the definitions. In response to this, the WG-CMT invited a number of experts on digitalisation, semantics and mathematics. 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 will be presented to the CCU in April 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 counting and number quantities within several different fields of metrology. Some areas for clarification relating to the treatment of counting as a measurement process and the description of number quantities in the SI Brochure and in the 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 will be presented to the CCU in April 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 the 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 is 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 most likely 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:

In addition to the survey about the implementation of the SI carried out in 2021, the CCU will also collect the list of frequently asked questions that CCU members and liaisons have received from their stakeholders related to the adopted changes. Longer term, after the redefinition, new realisations 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 updates of the SI Brochure to the CIPM accordingly along with other updates that might become necessary.

- During the years that have preceded the revision of the SI, several issues have been object of debate and for some of them further consideration may be needed. In particular:

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. Nevertheless, it is acknowledged in the current 9th edition of the SI Brochure that this distinction is, in principle, not anymore necessary. The CCU will review the advantages and drawbacks if this distinction were to be removed in a future edition of the SI Brochure, including the consequences for dimensional analysis.

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.

Appendix 1: Details of CCU Working 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 Joachim Ullrich

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 working group on Core Metrological Terms, WG-CMT

Date established:

2019

Number of Members:

14

Number of participants at last meeting:

13

Periodicity of meetings:

at least one per year, several meetings in 2021 and 2022

Date of last meeting:

22 June 2023 (virtual meeting)

Chairperson:

Prof. Pavel Neyezhmakov

Terms of Reference

The Terms of reference of the WG-CMT are the following:

- Identify core metrological terms that enter into CGPM Resolutions and national legislation and which are therefore in the interest of Member States.
- Propose definitions/explanations for these core metrological terms:
 - Considering translation into other languages, in particular into French,
 - Considering requirements concerning machine readability of these terms,
 - Aiming at finding consensus definitions in particular with OIML and involving other NGO stakeholders.
- Ensure proper representation of these findings in the JCGM WG2 (VIM) upon approval by the CIPM.
- Make proposals to ensure proper and harmonized representation of CIPM-approved statements in relevant Liaison Organization committees.

CCU task group on angle and dimensionless quantities in the SI brochure, TG-ADQSIB

Date established:

2021

Number of Members:

17

Date of last meeting:

16 March 2023

Chairperson:

Dr. Richard 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.