

The SI in the next ten years

Prof. Richard J. C. Brown
CCU President



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CCU Executive Secretary



Consultative Committee for Units: Mission

- ◆ Maintenance and development of the International System of Units (SI)
- ◆ Preparation of successive editions & versions of the SI brochure
- ◆ Advice to CIPM and stakeholders on units of measurement
- ◆ Preparation of documents to promote and explain the SI

Bureau
International des
Poids et
Mesures

Le
Système
international
d'unités 9^e édition

The
International
System of
Units



SI

A concise summary of the
International System of Units, SI

Metrology is the science of measurement and its application. Metrology includes all theoretical and practical aspects of measurement, whatever the measurement uncertainty and field of application.



The International Bureau of Weights and Measures (BIPM) was established by Article 1 of the Metre Convention, which was signed on 20 May 1875. It is charged with providing the basis for a single, coherent system of measurements to be used throughout the world and it operates under the authority of the International Committee for Weights and Measures (CIPM). The decimal metric system, dating from the time of the French Revolution, was based in 1799 on the metre and the kilogram. Under the terms of the Metre Convention, new international prototypes of the metre and kilogram were manufactured and formally adopted by the first General Conference on Weights and Measures (CGPM) in 1889. In 1960 the 11th CGPM formally defined and established the International System of Units (SI). Since then the SI has been periodically updated to take account of advances in science and the need for measurements in new domains. The last major revision was adopted by the 26th CGPM in 2018, which decided that the SI would be based on the fixed numerical values of a set of seven defining constants, which also defined the SI.

The seven base units of the SI would be deduced. This document is a summary of the BIPM, which gives a detailed explanation of the current status of the SI.

The transition frequency of the caesium 133 atom, $\Delta\nu_{Cs}$, is $9\,192\,631\,770\,Hz$.

$792\,458\,m/s$,

$1.602\,176\,634 \times 10^{-19}\,J$,

$634 \times 10^{-19}\,C$,

$9 \times 10^{-31}\,kg$,

$40\,76 \times 10^{23}\,mol^{-1}$,

the radiation of frequency $540 \times 10^{12}\,Hz$, E_{red} is $683\,lm/W$.

It must, with unit symbols Hz , J , C , lm , and W , respectively, be related to the units

metre, and candela, with unit symbols m , kg , A , K , mol , and cd , respectively,

$1\,lm = cd\,sr$; and $W = kg\,m^2\,s^{-3}$.

Each value of each constant when its value is expressed in the corresponding SI unit

must become defined, since the product of the numerical value and the unit has to

remain constant.

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Measure for measure

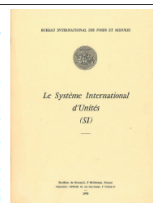
Never judge a book by its cover

The SI brochure has described the global measurement system for more than 50 years, and yet it has kept a low profile. Richard Brown leads through its history.

In English, the word 'brochure' evokes images of glossy promotional documents, perhaps advertising sunny holiday destinations, educational establishments or even new cleaning products. One rarely thinks of the word in relation to a technical reference document of global importance. And yet, the SI brochure is the latter, and perhaps also partly the former.

The International System of Units (SI) – the only universally agreed system of units – has its origins in the changes set in motion by the French Revolution. This development picked up pace after the Metre Convention was signed in 1875 to 'unify the international unification and improvement of the metric system', and when the General Conference on Weights and Measures (CGPM) in plenary, policy-making body of supreme authority created by the Metre Convention began passing resolutions about units. Specifically, it was in 1948 that the CGPM asked for 'recommendations for a single practical system of units of measurement, suitable for adoption by all countries adhering to the Metre Convention'. In 1954, the CGPM adopted as base units for this system (m, kg, s, A, K, cd) – the mole was added in 1971. In 1960, the SI was formally adopted with a description of its base units and rules about the names of SI derived units and SI prefixes.

Initially, the accessibility of the SI was limited to those users prepared to wade through the resolutions of successive meetings of the CGPM. To remedy this, it was decided to publish a document in which these resolutions were systematically collected, together with information about how these theoretical unit definitions could be used for practical measurement, with much of this work done by the Consultative Committee for Units, set up in 1964 principally for this task. And so it was that the first edition of the 'SI brochure' was



published in 1970 as the authoritative document describing the SI, containing definitions, names and symbols for its base units, derived units and prefixes, together with frequently used non-SI units whose value in SI units it was important to recall, all with a gloriously plain cover (pictured) entirely at odds with the importance of the content.

The Consultative Committee for Units continued to build the formal structure of the SI, and as the system evolved and best practice changed, new editions of the SI brochure were published. The first four editions of the SI brochure were published in French only, prompting companion English translations produced by the UK and US National Metrology Institutes. To improve accessibility and remove the need for these additional versions, the 8th edition in 1985 and all later editions have been published bilingually in French and English – with cover pages becoming gradually less understated, but never extravagant.

The 9th edition of the SI brochure, published in 2019, saw the most significant changes to the SI since its inception. It introduced a new approach to articulating the definitions of the seven SI base units by fixing the

numerical values of seven defining constants (the unperturbed ground-state hyperfine transition frequency of ^{133}Cs , the speed of light in vacuum, the Planck constant, the elementary charge, the Boltzmann constant, the Avogadro constant, and the luminous efficacy of monochromatic radiation of frequency $540\,THz$), including implementing the new definitions of the kilogram, mole, ampere and kelvin agreed at the 26th CGPM meeting in 2018. In more recent times, the flexibility of digital-only publishing has allowed smaller updates to the SI brochure, such as correcting typos, to be made without issuing an entirely new edition. Larger technical changes result in a new version of the current edition, examples being version 2.01 of the 9th edition, which included new SI prefixes approved at the 27th CGPM in 2022, and most recently version 3.01, published in August 2024, which incorporated changes aimed at improving the description and representation of angle and quantities with the unit 'one', both of which have been subjects of vigorous debate in recent years.

An important future task for the SI brochure will be to keep pace with digitalization initiatives by offering machine-readable and interpretable content, but most importantly, it will always continue to provide the authoritative description of our global unit system – a critically important reference, albeit with a modest cover.

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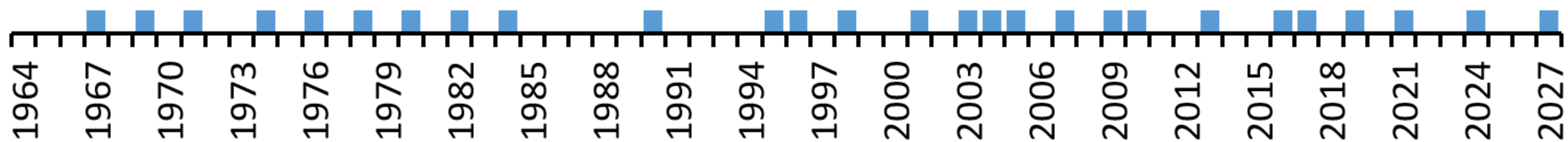
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nature physics

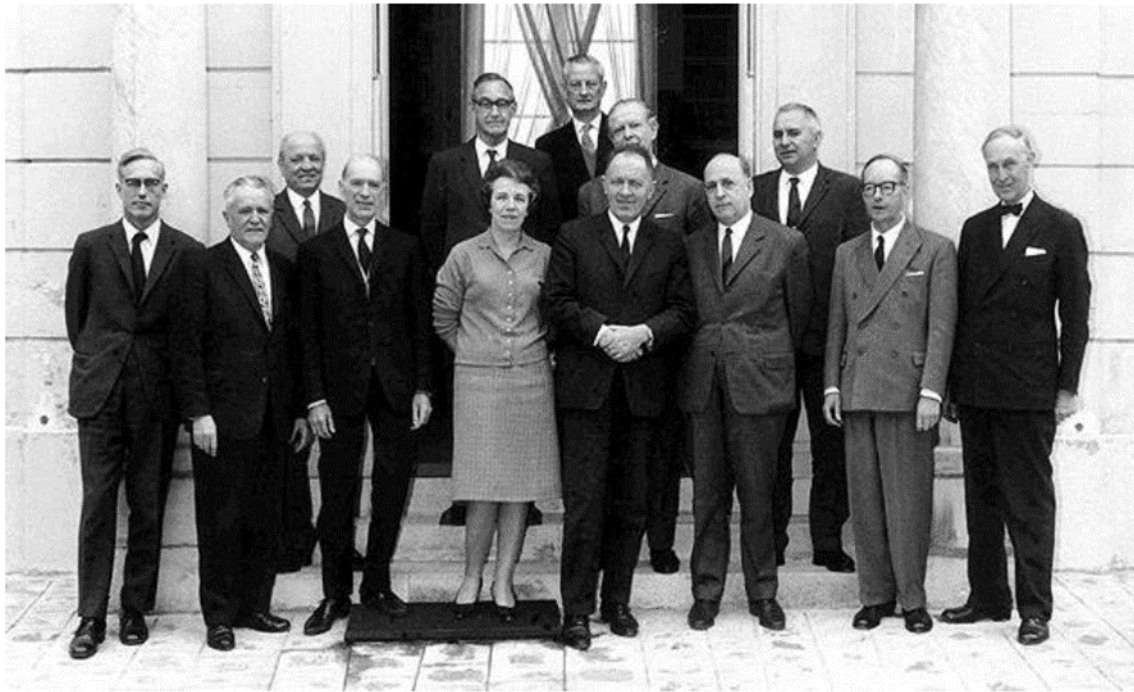
Volume 21 | March 2025 | 487 | 487

The Consultative Committee for Units – the first 60 years

- ◆ The CCU was established in 1964
- ◆ Replaced the “Commission for the System of Units”, set up by the CIPM in 1954
- ◆ The 1st meeting of the CCU was not until April 1967
- ◆ The 25th meeting of the CCU in 2021 was entirely online
- ◆ The 26th meeting of the CCU in 2024 was its first hybrid meeting
- ◆ The 27th meeting of the CCU is planned for 2027



Photographs: 1967 → 2024



1st Meeting (0 online attendees!)

- 6 Members
- 5 Liaison organizations: CIE, ICRU, IEC, ISO, IUPAP

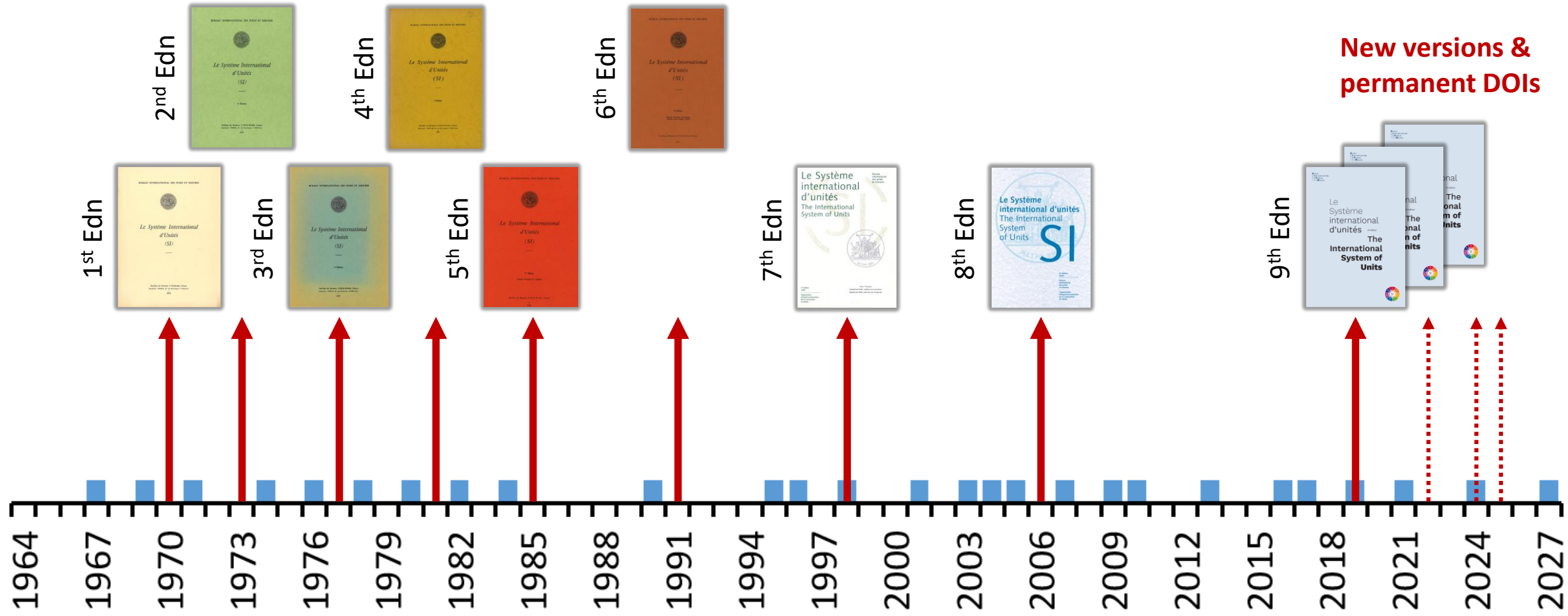


26th Meeting (23 online attendees)

- 13 Members
- 11 Liaison organizations: CIE, CODATA-TGFC, IAU, ICRU, IEC, IFCC, IMU, ISO, IUPAC, IUPAP, OIML



SI Brochures



Digital publishing

- ◆ Digital publishing facilitates updates to the SI Brochure without issuing a new edition
- ◆ Larger changes result in the production of a new version of the current edition
- ◆ Since the 9th edition was first published in 2019, new versions have included:
 - v2.01 contained new SI prefixes approved by the 27th CGPM (2022)
 - v3.01 improved descriptions of angle and quantities with the unit one (2024)
(Subsequently, v3.02 updated the value of the dalton & the binary prefixes, 2025)
- ◆ Future work will rethink how non-SI units are presented in the SI Brochure



The BIPM has published a new version of the SI Brochure

This update gives an improved description of units for angles and quantities with the unit one.

DOIs for the SI Brochure

- ◆ Each SI Brochure edition now has its own DOI and landing page
- ◆ Great improvement for referencing and citation
- ◆ For the 9th Edition the page also includes the version history
- ◆ Many thanks to Michael Stock and the BIPM Publications Team

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The International System of Units - 9th edition (2019)

Bureau International des Poids et Mesures
Published in May 2019 - Revised in August 2025

Citation Bureau International des Poids et Mesures. (2025). *Le Système international d'unités/The International System of Units* [Brochure]. 9th edition. <https://doi.org/10.59161/AUEZ1291>

Abstract

The International System of Units (SI) has been used around the world as the preferred system of units, the basic language for science, technology, industry and trade since it was established in 1960 by a resolution at the 11th meeting of the Conférence Générale des Poids et Mesures (CGPM).

This brochure is published by the Bureau International des Poids et Mesures (BIPM) to promote and explain the SI.

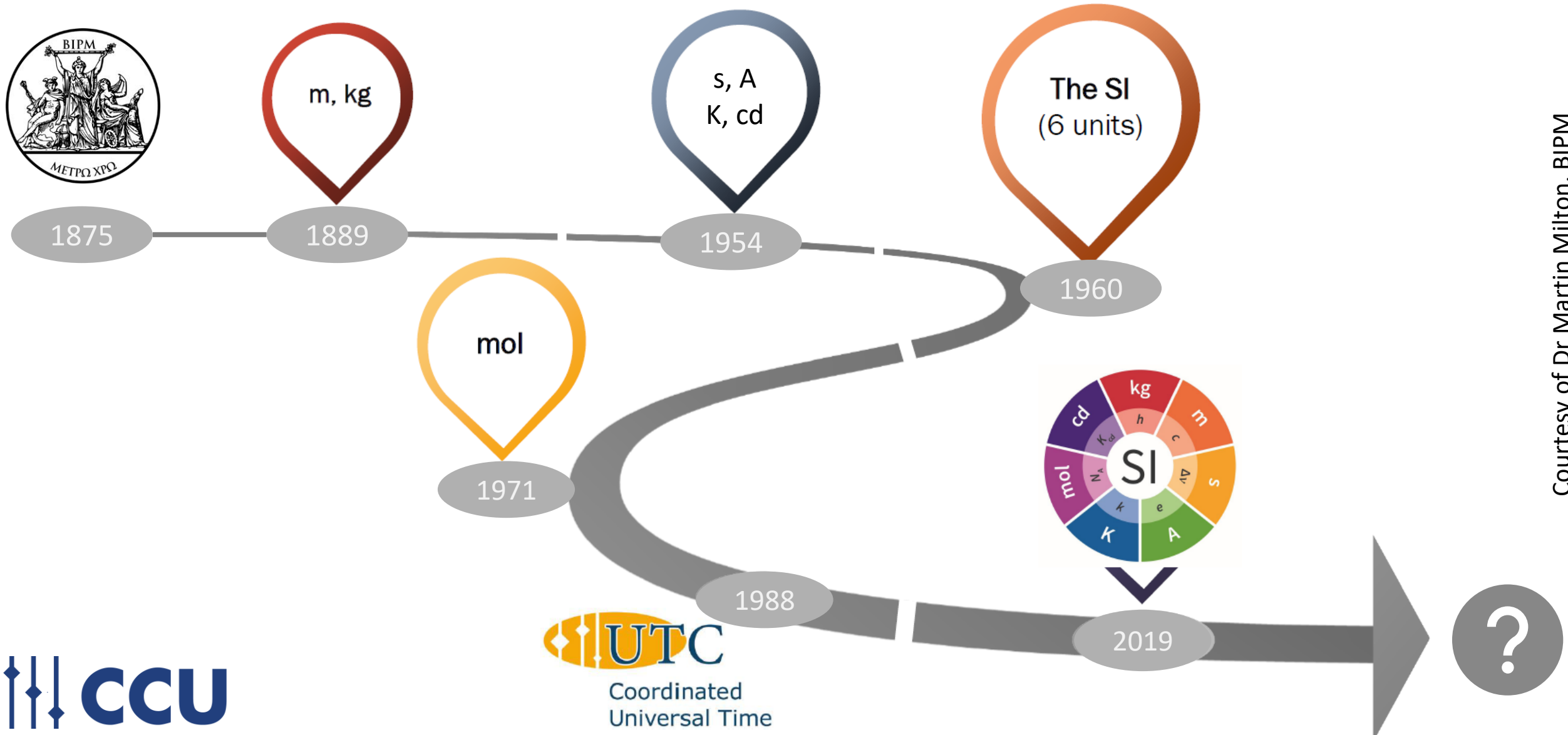
[COMPLETE BROCHURE](#)

[FRENCH TEXT](#) [ENGLISH TEXT](#)

Version	Publication date	Changes
3.02	August 2025	Revision of the value of the dalton, update of the list of binary prefixes
3.01	August 2024	Improvements to the descriptions of angle and quantities with the unit one
2.01	December 2022	Introduction of the new SI prefixes adopted by the CGPM at its 27th meeting (November 2022)
1.01 to 1.08	May 2019 to September 2021	Editorial changes

Note for translators and editors: Details on changes made since May 2019 are available on request to the [BIPM Webmaster](#).

The development of the SI Base Units



The next ten years

“The SI has developed not only through technological advance but also as a result of cultural and political compromise. It must continue to evolve to meet stakeholder needs whilst recognizing that its most important qualities are stability and consistency.”

Richard J. C. Brown, President's Report to 26th CCU, April 2024

CCU Strategy

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

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.

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:

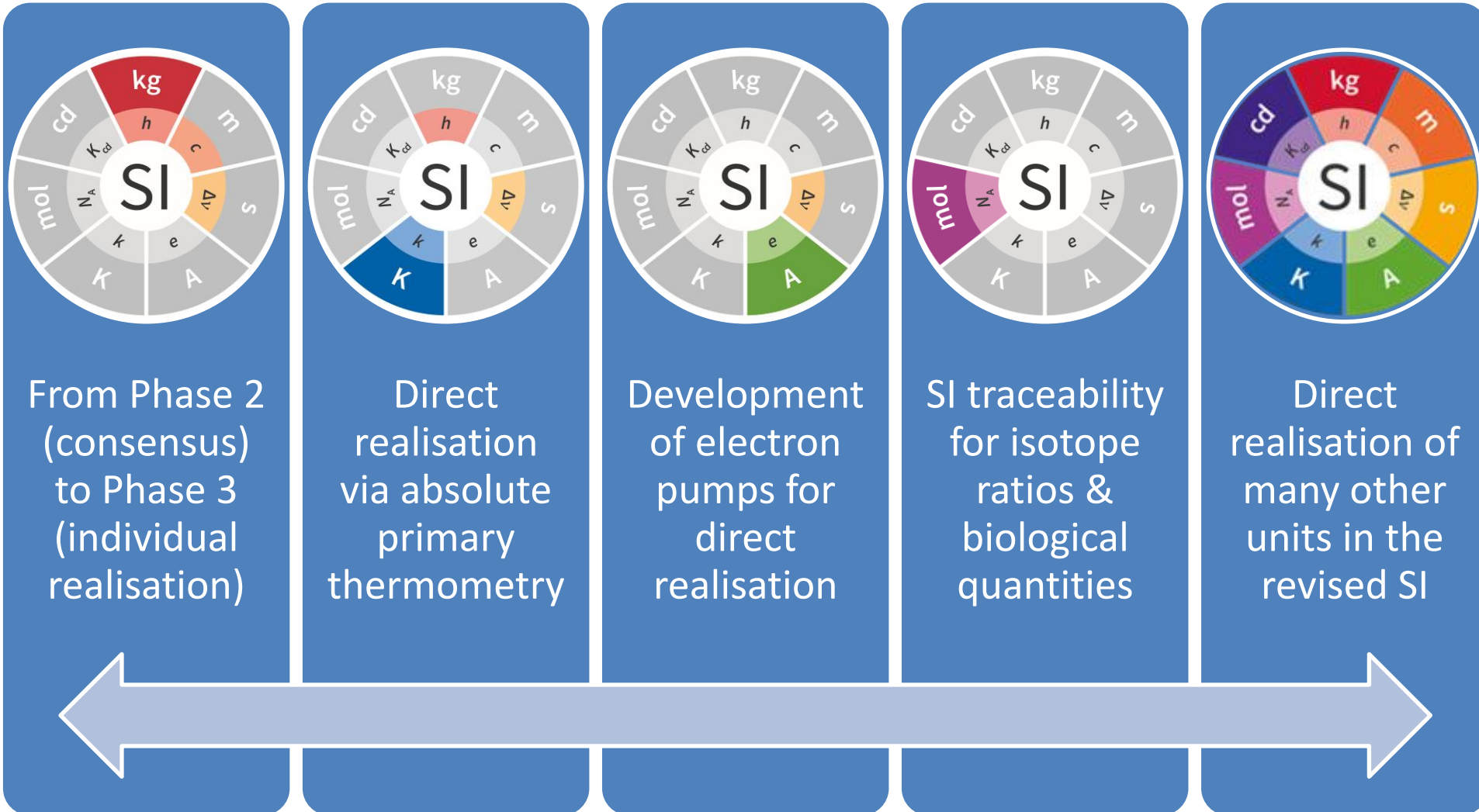
Prof. R.J.C. Brown (from June 2024)

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.

Monitoring implementation of the revised SI



The direct linking of SI units with defining constants

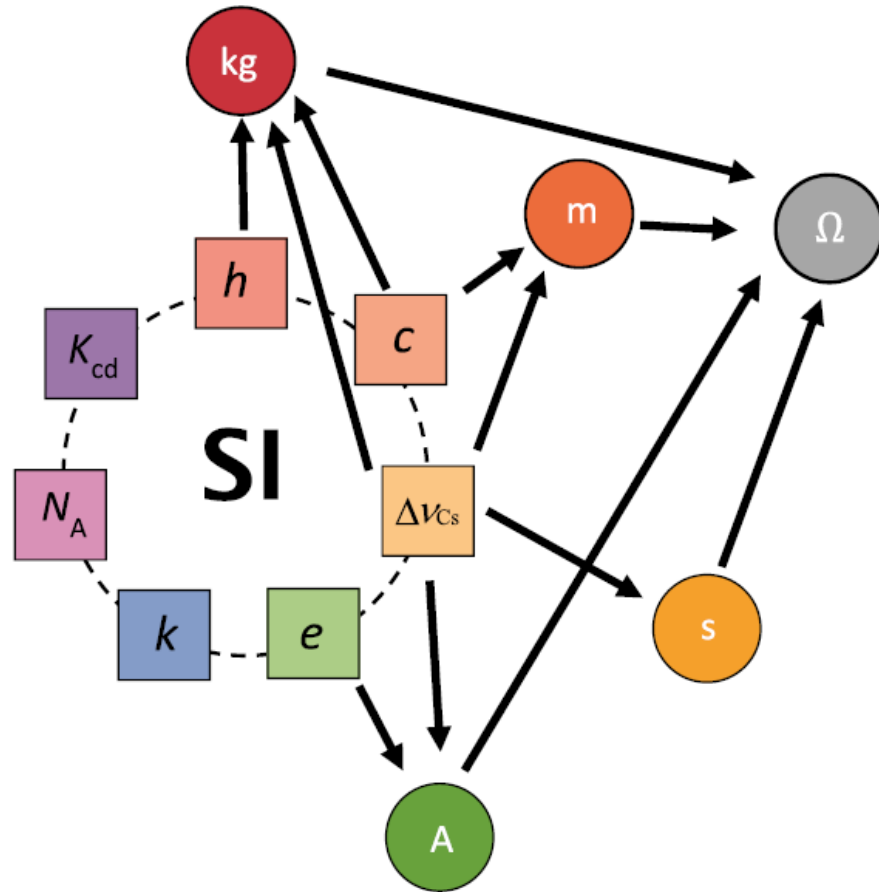


Figure 1. Schematic representation of the relationship between the ohm and the SI base units, $\Omega = \text{kg m}^2 \text{s}^{-3} \text{A}^{-2}$.

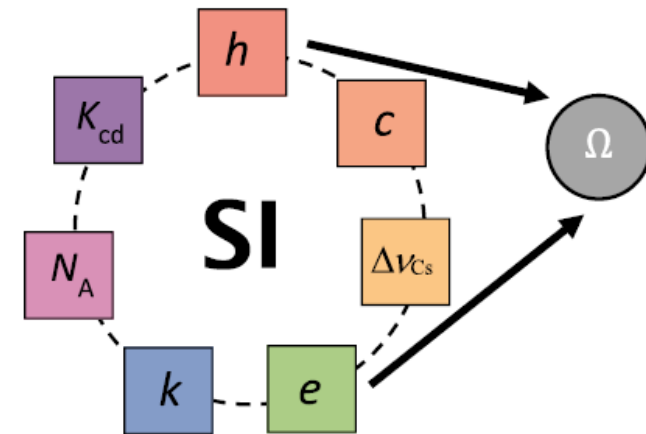
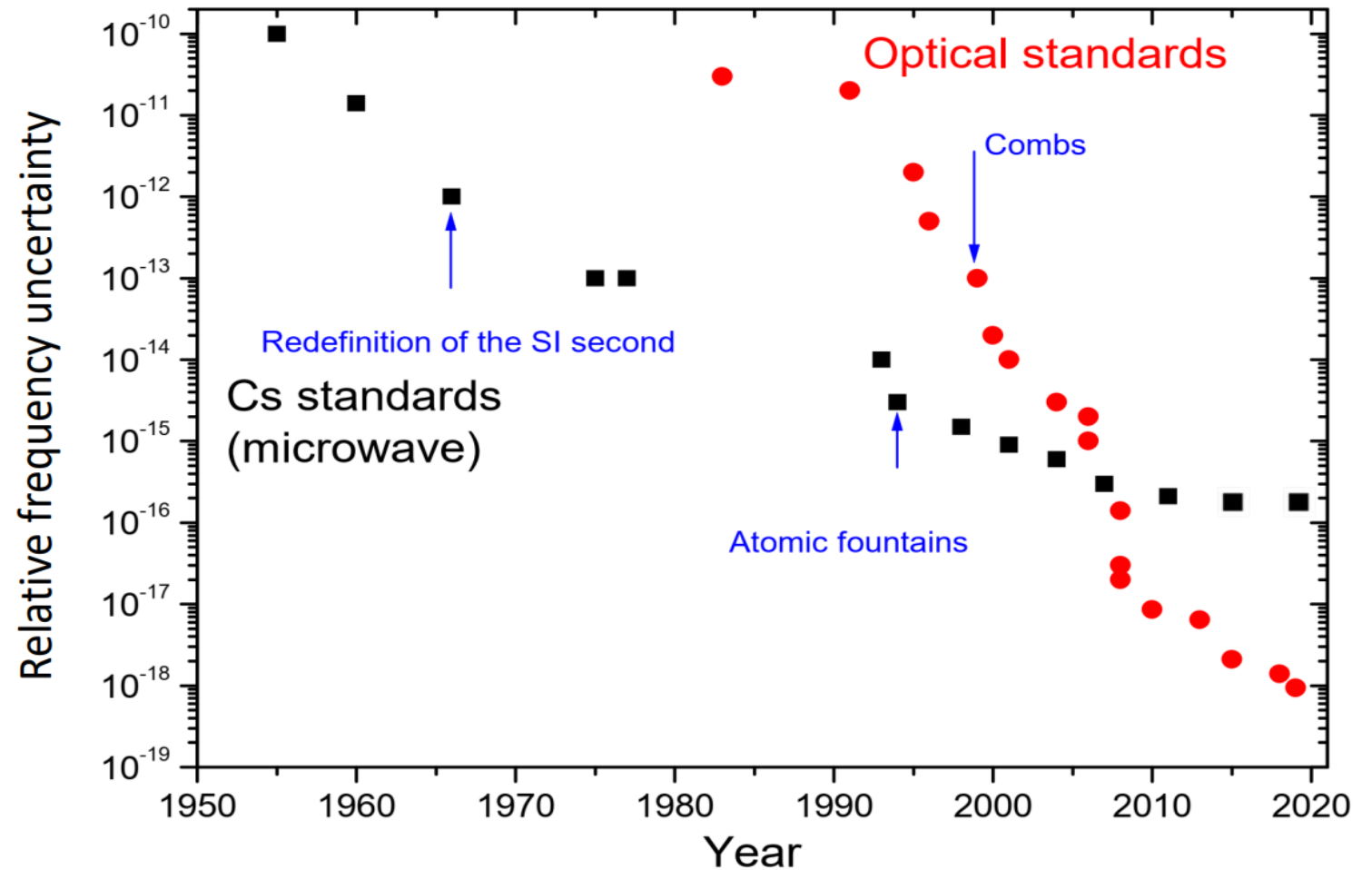


Figure 2. Schematic representation of the relationship between the ohm and the defining constants, $\Omega = [h] [e]^{-2}$.

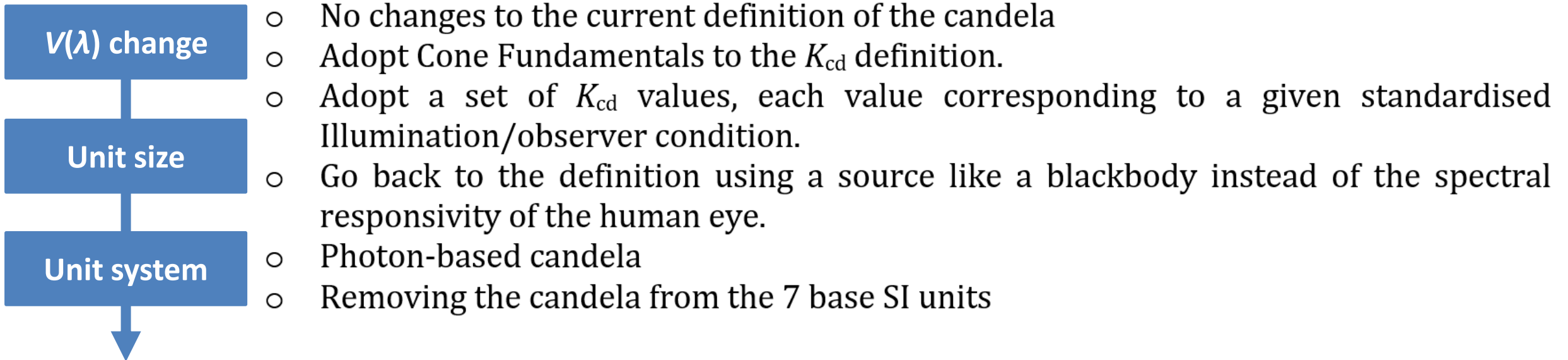
Re-definition of the second

- ◆ Discussions are ongoing within CCTF
- ◆ A re-definition of the second is expected on or after 2030
- ◆ CCU will provide input and review impact on other metrology areas
- ◆ It is likely that this will trigger the 10th Edition of the SI Brochure



Discussions about the future of the candela

- ◆ A workshop in 2024 considered future scenarios for the candela



Increasingly strong drivers, problem statements & evidence bases required for making a change

- ◆ Research needed to understand the requirements, benefits and impact across application areas

Mises-en-pratique (practical realisations)

- ◆ Appendix 2 of the SI Brochure contains the practical realization of the definition of important units
- ◆ New versions were produced for the 2019 revision of the SI
- ◆ Continually updated as technologies and methods of realisation develop
- ◆ Most recently, the MeP for the definition of the mole was updated in 2025
- ◆ Updates for all units expected over the next 10 years

Mise en pratique for the definition of the mole in the SI

Consultative Committee for Amount of Substance – Metrology in Chemistry and Biology (CCQM)

1. Introduction

The purpose of this *mise en pratique*, prepared by the Consultative Committee for Amount of Substance: Metrology in Chemistry and Biology (CCQM) of the International Committee for Weights and Measures (CIPM), is to indicate how the definition of the SI base unit, the mole, symbol mol, may be realized in practice.

In general, the term “to realize a unit” is interpreted to mean the establishment of the value and associated uncertainty of a quantity of the same kind as the unit that is consistent with the definition of the unit. The current definition of the mole does not imply any particular experiment for its practical realization. Any method capable of deriving an amount of substance value traceable to the set of seven defining constants could, in principle, be used. Thus, the list of methods given is not meant to be an exhaustive list of all possibilities, but rather a list of those methods easiest to implement or that provide the smallest uncertainties and which are recognized as primary methods by the relevant Consultative Committee.

A primary method is a method having the highest metrological properties; whose operation can be completely described and understood; for which a complete uncertainty statement can be written down in terms of SI units; and which does not require a reference standard of the same quantity.

2. Definition of the mole

The definition of the mole, SI base unit of amount of substance, is as follows [2.1]:

The mole, symbol mol, is the SI unit of amount of substance. One mole contains exactly $6.022\,140\,76 \times 10^{23}$ elementary entities. This number is the fixed numerical value of the Avogadro constant, N_A , when expressed in the unit mol⁻¹ and is called the Avogadro number.

The amount of substance, symbol n , of a system is a measure of the number of specified elementary entities. An elementary entity may be an atom, a molecule, an ion, an electron, any other particle or specified group of particles.

As a consequence of the definition of the mole, the numerical value of the Avogadro constant is fixed with no uncertainty. The numerical value itself was known historically as the Avogadro number.

The current definition of the mole was agreed by the 26th General Conference on Weights and Measures (CGPM) in 2018, and took effect on 20 May 2019. The mole is defined in terms of a fixed number of elementary entities [2.2]. It replaces the definition adopted in 1971 that defined the mole as “the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon 12”.

Digitalisation

- ◆ The SI Reference Point & SI Digital Framework continue to develop
- ◆ Provides the authoritative digital reference for the SI and PIDs for the named SI units, SI prefixes, and defining constants
- ◆ Will affect how values of quantities are controlled, represented and communicated, for instance via DCCs
- ◆ Digital connectivity offers new ways to represent and process data
- ◆ Opportunities to embed the SI digital framework in other parts of the global QI via the 'Joint Statement of Intent' with partners
- ◆ It is important for the SI to ensure its own digital references are FAIR



New developments in science and technology

The CCU will continue to monitor new developments in science and technology that could challenge the orthodoxy surrounding measurement units and traceability



Local realisation of measurement units and shortening of traceability chains



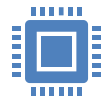
Portable & ultra-stable standards replacing traditional calibration artefacts



Measurement units adapting to local environments (e.g. timing in space)



AI models used for predictive calibration and uncertainty estimation



Digital twins and modelling used to describe complex systems



Biometric and personalized ‘pseudo-units’ in healthcare and personal medicine



Real-time global comparison & synchronization of standards via cloud platforms

Thank you

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