= Proposed redefinition of SI base units =

A committee of the International Committee for Weights and Measures ( CIPM ) has proposed revised formal definitions of the SI base units , which are being examined by the CIPM and which will likely be adopted at the 26th General Conference on Weights and Measures ( CGPM ) in the fall of 2018 . The metric system was originally conceived as a system of measurement that was derivable from nature . When the metric system was first introduced in France in 1799 technical problems necessitated the use of artifacts such as the prototype metre and kilogram . In 1960 the metre was redefined in terms of the wavelength of light from a specified source , making it derivable from nature , leaving the kilogram as the only unit still defined by an artifact . If the proposed redefinition is accepted , the metric system ( SI ) will , for the first time , be wholly derivable from nature .

The proposal can be summarised as follows :

There will still be the same seven base units ( second , metre , kilogram , ampere , kelvin , mole , and candela ) . Of these , the kilogram , ampere , kelvin and mole will be redefined by choosing exact numerical values for the Planck constant , the elementary electric charge , the Boltzmann constant , and the Avogadro constant , respectively . The second , metre and candela are already defined by physical constants and it is only necessary to edit their present definitions . The new definitions will improve the SI without changing the size of any units , thus ensuring continuity with present measurements .

Further details are found in the draft chapter of the Ninth SI Units Brochure .

The last major overhaul of the metric system was in 1960 when the International System of Units ( SI ) was formally published as a coherent set of units of measure . SI is structured around seven base units that have apparently " arbitrary " definitions and another twenty units that are derived from these base units . Although the units themselves form a coherent system , the definitions do not . The proposal before the CIPM seeks to remedy this by using the fundamental quantities of nature as the basis for deriving the base units . This will mean , amongst other things , that the prototype kilogram will cease to be used as the definitive replica of the kilogram . The second and the metre are already defined in such a manner .

A number of authors have published criticisms of the revised definitions ? in particular that proposal had failed to address the impact of breaking the link between the mole and the kilogram , the dalton and the unified atomic mass unit , and the Avogadro constant and Avogadro 's number .

= = Background = =

The basic structure of SI was developed over a period of about 170 years ( 1791 to 1960 ) . Since 1960 technological advances have made it possible to address various weaknesses in SI , notably the dependence on an artifact to define the kilogram .

= = = Development of SI = = =

During the early years of the French Revolution , the leaders of the French National Constituent Assembly decided to introduce a completely new system of measurement based on the principles of logic and natural phenomena . The resulting mètre des Archives and kilogramme des Archives were defined in terms of artefacts that were a " best attempt " at fulfilling these principles .

In 1875 , by which time the use of the metric system had become widespread in Europe and in Latin America , twenty industrially developed nations met for the Convention of the Metre . The result was the signing of the Treaty of the Metre under which three bodies were set up to take custody of the international prototype kilogram and metre and to regulate comparisons with national prototypes . They were :

CGPM ( General Conference on Weights and Measures / Conférence générale des poids et mesures ) ? The Conference meets every four to six years and consists of delegates of the nations who had signed the convention . It discusses and examines the arrangements required to ensure

the propagation and improvement of the International System of Units and it endorses the results of new fundamental metrological determinations .

CIPM ( International Committee for Weights and Measures / Comité international des poids et mesures ) ? The Committee consists of eighteen eminent scientists , each from a different country , nominated by the CGPM . The CIPM meets annually and is tasked to advise the CGPM . The CIPM has set up a number of sub @-@ committees , each charged with a particular area of interest . One of these , the Consultative Committee for Units ( CCU ) , amongst other things , advises the CIPM on matters concerning units of measurement .

BIPM ( International Bureau for Weights and Measures / Bureau international des poids et mesures ) ? The Bureau provides safe keeping of the international prototype kilogram and metre , provides laboratory facilities for regular comparisons of the national prototypes with the international prototype and is the secretariat for the CIPM and the CGPM .

The first CGPM ( 1889 ) formally approved the use of 40 prototype metres and 40 prototype kilograms from the British firm Johnson Matthey as the standards mandated by the Convention of the Metre . One of each of these was nominated by lot as the international prototypes , other copies were retained by the CGPM as working copies and the rest were distributed to member nations for use as their national prototypes . At regular intervals the national prototypes were compared with and recalibrated against the international prototype . In 1921 the Convention of the Metre was revised and the mandate of the CGPM was extended to provide standards for all units of measure , not just mass and length . In the ensuing years the CGPM took on responsibility for providing standards of electric current ( 1946 ) , luminosity ( 1946 ) , temperature ( 1948 ) , time ( 1956 ) and molar mass ( 1971 ) .

The 9th CGPM ( 1948 ) instructed the CIPM " to make recommendations for a single practical system of units of measurement , suitable for adoption by all countries adhering to the Metre Convention " . The recommendations based on this mandate were presented to the 11th CGPM ( 1960 ) where they were formally accepted and given the name " Système International d 'Unités " and its abbreviation " SI " .

= = = Impetus for change = = =

Changing the underlying principles behind the definition of the SI base units is not without precedent . The 11th CGPM ( 1960 ) defined the SI metre in terms of the wavelength of krypton @-@ 86 radiation , replacing the pre @-@ SI metre bar . The 13th CGPM ( 1967 ) replaced the original definition of the second ( which was based on a back @-@ calculation of the Earth 's rotation in the year 1900 ) with a definition based on the frequency of the radiation emitted between two hyperfine levels of the ground state of the caesium 133 atom . And the 17th CGPM ( 1983 ) replaced the 1960 definition of the metre with one based on the second , by giving an exact definition of the speed of light in units of metres per second .

Over the years , drifts of up to 2 × 10 ? 8 kilograms per annum in the national prototype kilograms relative to the international prototype kilogram have been detected . There was no way of determining whether the national prototypes were gaining mass or whether the IPK was losing mass . At the 21st meeting of the CGPM ( 1999 ) , national laboratories were urged to investigate ways of breaking the link between the kilogram and a specific artefact . Newcastle University metrologist Peter Cumpson has since identified mercury vapour absorption or carbonaceous contamination as possible causes of this drift .

Independently of this drift having been identified , the Avogadro project and development of the Watt balance promised methods of indirectly measuring mass with a very high precision . These projects provided tools that would enable alternative means of redefining the kilogram .

A report published in 2007 by the Consultative Committee for Thermometry ( CCT ) to the CIPM noted that their current definition of temperature has proved to be unsatisfactory for temperatures below 20 kelvins and for temperatures above 1300 kelvins . The committee was of the view that the Boltzmann constant provided a better basis for temperature measurement than did the triple point of water , as it overcame these difficulties .

At its 23rd meeting ( 2007 ) , the GCPM mandated the CIPM to investigate the use of natural constants as the basis for all units of measure rather than the artefacts that were then in use . The following year this was endorsed by the International Union of Pure and Applied Physics ( IUPAP ) . At a meeting of the CCU held in Reading , United Kingdom , in September 2010 , a resolution and draft changes to the SI brochure that were to be presented to the next meeting of the CIPM in October 2010 were agreed to in principle . The CIPM meeting of October 2010 found that " the conditions set by the General Conference at its 23rd meeting have not yet been fully met . For this reason the CIPM does not propose a revision of the SI at the present time " ; however , the CIPM presented a resolution for consideration at the 24th CGPM ( 17 ? 21 October 2011 ) to agree the new definitions in principle , but not to implement them until the details have been finalised . This resolution was accepted by the conference , and in addition the CGPM moved the date of the 25th meeting forward from 2015 to 2014 . At the 25th meeting ( 18 ? 20 November 2014 ) , it was found that " despite [ the progress in the necessary requirements ] the data do not yet appear to be sufficiently robust for the CGPM to adopt the revised SI at its 25th meeting " , thus postponing the revision to the next meeting in 2018 .

= = Proposal = =

In this section , an " X " at the end of a number means one or more final digits yet to be agreed upon .

In 2011 the CCU published a draft of the proposed change in the form of an amendment that should be made to the 8th edition of the SI Brochure . In it they proposed that in addition to the speed of light , four further constants of nature should be defined to have exact values :

The Planck constant h is exactly 6.62606X × 10 ? 34joule second ( J · s ) .

The elementary charge e is exactly 1.60217X × 10 ? 19coulomb ( C ) .

The Boltzmann constant k is exactly 1.38065X × 10 ? 23joule per kelvin ( J · K ? 1 ) .

The Avogadro constant NA is exactly 6.02214X × 1023reciprocal mole ( mol ? 1 ) .

These constants were described in the 2006 version of the SI manual ; the latter three were defined as " constants to be obtained by experiment " .

The CCU also proposed that the numerical values associated with the following constants of nature be retained unchanged :

The speed of light c is exactly 299792458metres per second ( m · s ? 1 ) .

The ground state hyperfine splitting frequency of the caesium @-@ 133 atom ?? ( 133Cs ) hfs is exactly 9192631770 hertz ( Hz ) .

The luminous efficacy Kcd of monochromatic radiation of frequency 540 × 1012Hz is exactly 683 lumen per watt ( lm · W ? 1 ) .

The seven definitions above are rewritten below after converting the derived units ( joule , coulomb , hertz , lumen and watt ) into the seven base units ( second , metre , kilogram , ampere , kelvin , mole and candela ) . In the list that follows , the symbol sr stands for the dimensionless unit steradian .