Bureau International des Poids et Mesures

Comité International des Poids et Mesures

91st meeting (October 2002)

Note on the use of the English text

To make its work more widely accessible the International Committee for Weights and Measures publishes an English version of its reports.

Readers should note that the official record is always that of the French text. This must be used when an authoritative reference is required or when there is doubt about the interpretation of the text.

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Associates of the General Conference

Chinese Taipei
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THE BIPM AND THE METRE CONVENTION

The International Bureau of Weights and Measures (BIPM) was set up by the Metre Convention signed in Paris on 20 May 1875 by seventeen States during the final session of the diplomatic Conference of the Metre. This Convention was amended in 1921.

The BIPM has its headquarters near Paris, in the grounds (43 520 m^2) of the Pavillon de Breteuil (Parc de Saint-Cloud) placed at its disposal by the French Government; its upkeep is financed jointly by the Member States of the Metre Convention.

The task of the BIPM is to ensure worldwide unification of physical measurements; its function is thus to:

- establish fundamental standards and scales for the measurement of the principal physical quantities and maintain the international prototypes;
- carry out comparisons of national and international standards;
- ensure the coordination of corresponding measurement techniques;
- carry out and coordinate measurements of the fundamental physical constants relevant to these activities.

The BIPM operates under the exclusive supervision of the International Committee for Weights and Measures (CIPM) which itself comes under the authority of the General Conference on Weights and Measures (CGPM) and reports to it on the work accomplished by the BIPM.

Delegates from all Member States of the Metre Convention attend the General Conference which, at present, meets every four years. The function of these meetings is to:

- discuss and initiate the arrangements required to ensure the propagation and improvement of the International System of Units (SI), which is the modern form of the metric system;
- confirm the results of new fundamental metrological determinations and various scientific resolutions of international scope;
- take all major decisions concerning the finance, organization and development of the BIPM.

The CIPM has eighteen members each from a different State: at present, it meets every year. The officers of this committee present an annual report on the administrative and financial position of the BIPM to the Governments of

the Member States of the Metre Convention. The principal task of the CIPM is to ensure worldwide uniformity in units of measurement. It does this by direct action or by submitting proposals to the CGPM.

The activities of the BIPM, which in the beginning were limited to measurements of length and mass, and to metrological studies in relation to these quantities, have been extended to standards of measurement of electricity (1927), photometry and radiometry (1937), ionizing radiation (1960), time scales (1988) and to chemistry (2000). To this end the original laboratories, built in 1876 -1878, were enlarged in 1929; new buildings were constructed in 1963-1964 for the ionizing radiation laboratories, in 1984 for the laser work and in 1988 for a library and offices. In 2001 a new building for the workshop, offices and meeting rooms was opened.

Some forty-five physicists and technicians work in the BIPM laboratories. They mainly conduct metrological research, international comparisons of realizations of units and calibrations of standards. An annual report, the *Director's Report on the Activity and Management of the International Bureau of Weights and Measures*, gives details of the work in progress.

Following the extension of the work entrusted to the BIPM in 1927, the CIPM has set up bodies, known as Consultative Committees, whose function is to provide it with information on matters that it refers to them for study and advice. These Consultative Committees, which may form temporary or permanent working groups to study special topics, are responsible for coordinating the international work carried out in their respective fields and for proposing recommendations to the CIPM concerning units.

The Consultative Committees have common regulations (*BIPM Proc.-Verb. Com. Int. Poids et Mesures*, 1963, **31**, 97). They meet at irregular intervals. The president of each Consultative Committee is designated by the CIPM and is normally a member of the CIPM. The members of the Consultative Committees are metrology laboratories and specialized institutes, agreed by the CIPM, which send delegates of their choice. In addition, there are individual members appointed by the CIPM, and a representative of the BIPM (Criteria for membership of Consultative Committees, *BIPM Proc.-Verb. Com. Int. Poids et Mesures*, 1996, **64**, 124). At present, there are ten such committees:

1. The Consultative Committee for Electricity and Magnetism (CCEM), new name given in 1997 to the Consultative Committee for Electricity (CCE) set up in 1927;

2. The Consultative Committee for Photometry and Radiometry (CCPR), new name given in 1971 to the Consultative Committee for Photometry (CCP) set up in 1933 (between 1930 and 1933 the CCE dealt with matters concerning photometry);
3. The Consultative Committee for Thermometry (CCT), set up in 1937;
4. The Consultative Committee for Length (CCL), new name given in 1997 to the Consultative Committee for the Definition of the Metre (CCDM), set up in 1952;
5. The Consultative Committee for Time and Frequency (CCTF), new name given in 1997 to the Consultative Committee for the Definition of the Second (CCDS) set up in 1956;
6. The Consultative Committee for Ionizing Radiation (CCRI), new name given in 1997 to the Consultative Committee for Standards of Ionizing Radiation (CCEMRI) set up in 1958 (in 1969 this committee established four sections: Section I (X- and γ-rays, electrons), Section II (Measurement of radionuclides), Section III (Neutron measurements), Section IV (α-energy standards); in 1975 this last section was dissolved and Section II was made responsible for its field of activity);
7. The Consultative Committee for Units (CCU), set up in 1964 (this committee replaced the "Commission for the System of Units" set up by the CIPM in 1954);
8. The Consultative Committee for Mass and Related Quantities (CCM), set up in 1980;
9. The Consultative Committee for Amount of Substance (CCQM), set up in 1993;
10. The Consultative Committee for Acoustics, Ultrasound and Vibration (CCAUV), set up un 1999.

The proceedings of the General Conference, the CIPM and the Consultative Committees are published by the BIPM in the following series:

- *Report of the meeting of the General Conference on Weights and Measures*;
- *Report of the meeting of the International Committee for Weights and Measures*;
- *Reports of the meetings of Consultative Committees*.

The BIPM also publishes monographs on special metrological subjects and, under the title *The International System of Units (SI)*, a brochure, periodically updated, in which are collected all the decisions and recommendations concerning units.

The collection of the *Travaux et Mémoires du Bureau International des Poids et Mesures* (22 volumes published between 1881 and 1966) and the *Recueil de Travaux du Bureau International des Poids et Mesures* (11 volumes published between 1966 and 1988) ceased by a decision of the CIPM.

The scientific work of the BIPM is published in the open scientific literature and an annual list of publications appears in the *Director's Report on the Activity and Management of the International Bureau of Weights and Measures*.

Since 1965 *Metrologia*, an international journal published under the auspices of the CIPM, has printed articles dealing with scientific metrology, improvements in methods of measurement, work on standards and units, as well as reports concerning the activities, decisions and recommendations of the various bodies created under the Metre Convention.

CURRENT MEMBERS OF THE INTERNATIONAL COMMITTEE FOR WEIGHTS AND MEASURES

as of 8 October 2002

President

1. J. Kovalevsky, President of the Bureau National de Métrologie, Observatoire de la Côte d'Azur, avenue N. Copernic, 06130 Grasse, France.

Secretary

2. R. Kaarls, Klaverwydenstraat 13, 2381 VX Zoeterwoude, The Netherlands.

Members

3. S. Bennett, Deputy Director and Director International Metrology, National Physical Laboratory, Teddington TW11 0LW, United Kingdom.
4. K.H. Brown, Deputy Director, National Institute of Standards and Technology, Gaithersburg, MD 20899-1000, United States.
5. Chung Myung Sai, President, Korea Research Council of Fundamental Science and Technology, Diplomatic Centre 402, 1376-1, Seocho-2, Dong Seocho-ku, Seoul 137-072, Rep. of Korea.
6. Gao Jie, member, Chinese Academy of Engineering, National Institute of Measurement and Testing Technology, P.O. Box 659, Chengdu 610061, Sichuan, China.
7. E.O. Göbel, President, Physikalisch-Technische Bundesanstalt, Postfach 3345, D-38023 Braunschweig, Germany.
8. E.S.R. Gopal, Emeritus scientist, Department of Physics, Indian Institute of Science, Bangalore 560 012, India.
9. F. Hengstberger, CSIR – National Metrology Laboratory, P.O. Box 395, Pretoria 0001, South Africa.
10. B. Inglis, Director, National Measurement Laboratory, CSIRO Telecommunications and Industrial Physics, P.O. Box 218, Lindfield NSW 2070, Australia. *Vice-President.*
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12. S. Leschiutta, President, Istituto Elettrotecnico Nazionale Galileo Ferraris, Corso Massimo d'Azeglio 42, I-10125 Turin, Italy.
13. J. Lusztyk, Director General, Institute for National Measurement Standards, National Research Council of Canada, Ottawa ON K1A OR6, Canada.
14. G. Moscati, INMETRO and Instituto de Fisica, University of São Paulo, Caixa Postal 66318, 05315-970 São Paulo SP, Brazil. *Vice-President*.
15. W. Schwitz, Director, Swiss Federal Office of Metrology and Accreditation, Lindenweg 50, CH-3003 Bern-Wabern, Switzerland.
16. M. Tanaka, Deputy Director, National Metrology Institute of Japan (NMIJ), AIST Tsukuba Central 3, 1-1-4 Umezono, Tsukuba 305-8563, Japan.
17. H. Ugur, Director, Tubitak Ulusal Metroloji Enstitüsü, P.O. Box 21, 41470 Gebze-Kocaeli, Turkey.
18. J. Valdés, Instituto Nacional de Tecnología Industrial, INTI – Parque Tecnológico Miguelete, av. Gral. Paz e/Albarellos y Constituyentes (B1650KNA), C.C. 157 (B1650WAB) San Martín, Province of Buenos Aires, Argentina.

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1. E. Ambler, The Belvedere (No. 626), 1600 N. Oak Street, Arlington, VA 22209, United States.
2. W.R. Blevin, 61 Boronia Avenue, Cheltenham NSW 2119, Australia.
3. J. de Boer, Institute of Physics, University of Amsterdam, Valckenierstraat 65, Amsterdam-C, The Netherlands.
4. L.M. Branscomb, Box 309, Concord, Massachusetts 01742, United States.
5. J.V. Dunworth, Apt. 902, Kings Court, Ramsey, Isle of Man, United Kingdom.
6. K. Iizuka, adviser to AIST, c/o NMIJ/AIST, Tsukuba Central 3, 1-1-4 Umezono, Tsukuba 305, Japan.
7. D. Kind, Knappstrasse 4, 38116 Braunschweig, Germany.
8. H. Preston-Thomas, 1109 Blasdell Avenue, Ottawa K1K 0C1, Canada.
9. J. Skákala, Professor, Slovak Technical University, Nám. Slobody 17, 812 31 Bratislava, Slovakia.

STAFF OF THE
INTERNATIONAL BUREAU OF WEIGHTS AND MEASURES
on 1 January 2003

Director: Dr T.J. Quinn

Deputy Director, Director designate: Prof. A.J. Wallard

Length: Prof. A.J. Wallard
Mr R. Felder, Dr S. Picard, Dr L. Robertsson, Dr L.F. Vitushkin,
Dr L.-S. Ma[1], Dr M. Zucco[2]
Mr J. Labot

Mass: Dr R.S. Davis
Dr H. Fang, Mrs C. Goyon-Taillade, Mr A. Picard, Dr H.V. Parks[2]
Mrs J. Coarasa, Mr J. Hostache

Time: Dr E.F. Arias
Mr J. Azoubib, Dr Z. Jiang, Dr W. Lewandowski, Dr G. Petit, Dr P. Wolf[6]
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Electricity: Dr T.J. Witt
Mr F. Delahaye, Dr D. Reymann
Mr D. Avrons, Mr R. Chayramy, Mr A. Jaouen

Radiometry and photometry: Dr M. Stock
Mr R. Goebel, Mr S. Solve

Ionizing radiation: Dr P.J. Allisy-Roberts
Dr D.T. Burns, Dr C. Michotte, Dr G. Ratel, Mrs C. Kessler[2]
Mr C. Colas, Mr M. Nonis, Mr P. Roger, Mr C. Veyradier[3]

Chemistry: Dr R. Wielgosz
Dr M. Esler, Dr J. Viallon

Publications: Prof. P.W. Martin
Dr J.R. Miles

BIPM key comparison database: Dr C. Thomas[3]
Dr S. Maniguet[2]

Information technology and quality systems: Dr R. Köhler
Mr L. Le Mée, Mr G. Petitgand

Secretariat: Mrs F. Joly
Mrs D. Le Coz[3], Mrs G. Négadi, Mrs J. Varenne

Finance, administration and general services: Mrs B. Perent
Mr F. Ausset
Mrs D. Etter, Mrs M.-J. Martin, Mrs D. Saillard[3]

Caretakers: Mr and Mrs Dominguez, Mr and Mrs Neves
Housekeepers: Mrs R. Prieto, Mrs R. Vara
Gardeners: Mr C. Dias-Nunes, Mr A. Zongo[4]

Workshop and building maintenance: Mr J. Sanjaime
Mr P. Benoit, Mr F. Boyer, Mr M. de Carvalho, Mr J.-B. Caucheteux, Mr P. Lemartrier, Mr D. Rotrou,
Mr E. Dominguez[5], Mr C. Neves[5]

Director emeritus: Prof. P. Giacomo

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1 Senior Research Fellow.
2 Research Fellow.
3 Also Publications.
4 Also building maintenance.
5 Also caretaker.
6 On secondment at SYRTE, Observatoire de Paris.

International Committee for Weights and Measures

Proceedings of the sessions of the 91st meeting
(8–11 October 2002)

Agenda

1. Opening of the meeting; quorum; agenda.
2. Report of the Secretary and activities of the bureau of the CIPM (October 2001 – September 2002).
3. Membership of the CIPM.
4. Associates of the CGPM.
5. BIPM programme and budget for the years 2005 to 2008.
6. New report on needs for metrology.
7. KPMG study of potential economic benefits of the MRA.
8. The CIPM MRA.
9. The 22nd General Conference.
10. Consultative Committees.
11. Joint Committee for Traceability in Laboratory Medicine (JCTLM).
12. Metre Convention/OIML/ILAC Joint Working Group.
13. Joint Committee on Assistance to Developing Countries in Metrology, Accreditation and Standardization (JCDCMAS).
14. Bilateral contacts with other international organizations.
15. Joint Committee for Guides in Metrology.
16. Work of the BIPM.
17. *Metrologia*.
18. Administrative and financial affairs.
19. Other business.
20. Date of next meeting.

1 OPENING OF THE MEETING; QUORUM; AGENDA

The International Committee for Weights and Measures (CIPM) held its 91st meeting from Tuesday 8 October till Friday 11 October 2002 at the Pavillon de Breteuil at Sèvres.

Present: S. Bennett, K.H. Brown, Chung Myung Sai, Gao Jie, E.O. Göbel, E.S.R. Gopal, F. Hengstberger, B. Inglis, L.K. Issaev, R. Kaarls, J. Kovalevsky, S. Leschiutta, J. Lusztyk, G. Moscati, T.J. Quinn (Director of the BIPM), W. Schwitz, M. Tanaka, H. Ugur, J. Valdés.

Also attending: P. Giacomo (Director emeritus of the BIPM), A.J. Wallard (Director Designate of the BIPM), B. McGuiness (Director of the NPL, present for part of the meeting), I.M. Mills (President of the CCU, present for part of the meeting); F. Joly and J.R. Miles (secretariat).

Prof. Kovalevsky, President of the CIPM, opened the 91st meeting by welcoming all present, and particularly the three new members, Drs Bennett, Lusztyk and Schwitz. With all members present, the quorum was satisfied according to Article 12 of the Rules annexed to the Metre Convention.

The agenda for the meeting was adopted.

The President then invited the Secretary of the Committee, Dr Kaarls, to present his report.

2 REPORT OF THE SECRETARY AND ACTIVITIES OF THE BUREAU OF THE CIPM
(October 2001 – September 2002)

All the important matters arising in the report of the Secretary are taken up later in the meeting. References are made in this section to the point in the subsequent discussion at which this occurs.

The bureau of the CIPM met three times during the year: twice at the BIPM and once in Ottawa in June 2002 on the occasion of the Conference on Precision Electromagnetic Measurements (CPEM 2002).

2.1 Member States of the Metre Convention

The number of Member States of the Metre Convention remains at fifty-one. Following the decision of the CIPM in 1999 related to non-paying Member States, letters have been written to the embassies in Paris of the Dominican Republic and Iran informing them that they will be excluded from the Convention unless arrangements can be made for the payment of overdue contributions. Correspondence continues and no final conclusion has yet been reached.

2.2 Associates of the CGPM

There are now ten Associate States and Economies of the CGPM, namely Chinese Taipei, Cuba, Ecuador, Hong Kong (China), Kenya, Latvia, Lithuania, Malta, Philippines, and Ukraine. Discussions are under way with a number of other countries with a view to their becoming Associates. So far, the directors of the national metrology institutes (NMIs) of seven new Associates have signed the Mutual Recognition Arrangement of the CIPM (MRA). After approval by the CIPM, a letter will be written to the directors of NMIs of all those members of the APMP, COOMET, EUROMET, SADCMET and the SIM that are not yet members of the Metre Convention or Associates of the CGPM, encouraging them to join. A copy of this letter will also be sent to the embassies in Paris of the countries concerned. Letters with the same message will be sent to the NMIs of countries that are not members of a regional metrology organization (RMO), and to the embassies in France of all other countries.

2.3 Membership and officers of the International Committee

Since the last meeting of the CIPM three new members have been elected: Dr Wolfgang Schwitz, Director of the METAS, Switzerland; Dr Seton Bennett, Deputy Director of the NPL, UK; and Dr Janusz Lusztyk, Director of the INMS (NRC), Canada. These three members fill the vacancies left by

the resignations announced at the last meeting of Paul Pâquet, Andrew Wallard and Roy VanKoughnett.

The bureau has continued to seek suitable candidates for membership of the CIPM and invites members of the Committee and other persons to suggest candidates and submit their curricula vitae for consideration. The policy of the CIPM in relation to elections, and details of how to apply, were presented at the 21st CGPM and are given on the BIPM website.

The resignation of Roy VanKoughnett means that the Committee must consider the appointment of a new Vice-President of the CIPM.

2.4 The Mutual Recognition Arrangement

The bureau has been kept informed of the progress in the implementation of the Mutual Recognition Arrangement (MRA), including the meetings of the Joint Committee of the Regional Metrology Organizations and the BIPM (JCRB) and progress with the BIPM key comparison database (KCDB). The CIPM will be informed about the status of the KCDB and the results of the 9th meeting of the JCRB, which took place at the BIPM on 3 and 4 October 2002.

2.5 BIPM/OIML/ILAC discussions

A meeting of the joint BIPM/OIML/ILAC discussion group took place at the BIPM on 21 February 2002. The principal activities proposed for joint action by the three organizations were the following:

- Mr Magaña (OIML) will continue to lead discussions regarding the proposed model law on metrology and the concept of traceability of measurements.
- A second symposium will be arranged with the same name and aims of the successful one held at, and largely organized by, the PTB in June 1998. Further discussions have been held with the NIST but it was finally agreed that the symposium will not take place there; instead, it will be organized in 2003 by the PTB in collaboration with the NIST and the other three organizations that collaborated with the first symposium, namely the BIPM, OIML and the IMEKO.
- An important initiative was taken in respect of metrology in developing countries: it was agreed to form a new Joint Committee on Coordination

of Assistance to Developing Countries in Metrology, Accreditation and Standardization (JCDCMAS). This new joint committee will include the BIPM, IEC, ILAC, ISO, ITU, OIML, and UNIDO and representatives of some regional metrology organizations concerned with this activity. The first meeting of the JCDCMAS took place in Stockholm in September 2002 and a report will be presented to the CIPM under item 13 of the agenda.

2.6 CIPM/ILAC Memorandum of Understanding (MoU)

The MoU between the CIPM and ILAC has been signed following approval of the text by the CIPM in 2001. Discussions are now under way regarding its implementation on a number of matters:

1. the need to come to a common understanding of certain terms such as "calibration and measurement capability" and "best measurement capability";
2. the need to verify the consistency of the best measurement capability claimed by accredited calibration laboratories with the claimed calibration and measurement capability of the NMI to which the accredited calibration laboratory is traceable; and
3. the need to reach an understanding on how to treat NMIs (particularly those in developing countries) that have been accredited.

It is clear to all concerned that the ILAC Arrangement and the CIPM MRA must be seen to be complementary both in intention and implementation.

2.7 Agreement between the CIPM and the World Meteorological Organization (WMO)

The draft Agreement with the WMO approved by the CIPM at its meeting in October 2001 was approved by the Executive Council of the WMO at its meeting in June 2002. The implementation of the agreement has already begun, with the participation of R. Wielgosz at a meeting of the WMO in September 2002, at which important decisions relating to calibration and measurement were made during discussions of the WMO's strategy and work for the next four years. A representative of a WMO working group will take part in the next meeting of the Consultative Committee for Photometry and Radiometry (CCPR), and other representatives of the WMO will attend

meetings of the Consultative Committee for Amount of Substance (CCQM) and its Working Group on Gas Analysis.

2.8 Agreement between the CIPM and the World Health Organization (WHO)

Following preliminary contacts made in March this year, a draft MoU has been drawn up between the CIPM and the WHO. The draft closely follows that agreed with the WMO and is seen as an important step in setting up a collaboration with the WHO, with which future actions can be pursued to improve traceability in measurements related to health. Notably, it will help the formal operations of the Joint Committee for Traceability in Laboratory Medicine (JCTLM, see below). The MoU has been approved by the WHO and will be presented to the CIPM for approval under item 14 of the present agenda.

2.9 ISO CASCO

The BIPM is now an official Observer at ISO CASCO and we are kept informed of all matters related to traceability and laboratory accreditation that might affect NMIs.

2.10 Traceability in laboratory medicine

The European Directive on *In vitro* diagnostic (IVD) is having an important effect on the medical diagnostics industry. From 2003, it requires all instrumentation used in the European Union to be calibrated against appropriate standards. The NMIs have a responsibility to ensure that the standards used are traceable to the International System of Units (SI), or, if this is not possible, to other internationally agreed references. After preliminary consultations with the International Federation for Clinical Chemistry and Laboratory Medicine (IFCC), the ILAC, the WHO, the main producers of clinical reference materials (the IRMM and the NIST), and the regulatory bodies as well as industry associations in Europe and the United States, a meeting, attended by representatives from Japan, was held in June 2002, at which agreement was reached on the creation of a Joint Committee for Traceability in Laboratory Medicine (JCTLM). The Director informed members of the CIPM of the outcome of this meeting by letter, and full

details, including a list of those present and the text of the memorandum that provides the basis for the JCTLM, have been posted on the BIPM website. It is hoped to exchange and sign letters of cooperation at the next meeting of the JCTLM in the spring of 2003. The Director will keep the Committee informed of progress. Since June 2002, a first meeting has taken place of the working group set up to compile a list of reference materials needed to help satisfy the requirements of the IVD Directive. At this meeting it was suggested that the BIPM make preparations for a new database that would hold details of these reference materials. Taking into account that the BIPM is currently providing the secretariat of the JCTLM, the Director is considering this request. However, in the absence of resources to do this the Director has asked for financial help from the industry associations through the IRMM and the NIST but no response has yet been received.

It is intended that the work of the JCTLM be closely coordinated with that carried out under the CCQM.

2.11 World Trade Organization (WTO)

No progress has been made in our attempt to obtain Observer status in the WTO Committee on Technical Barriers to Trade (TBT Committee). It appears that certain Member States of the TBT Committee are refusing to accept any changes to the list of observers as a negotiating tactic in a dispute in matters quite unrelated to membership of the Committee. This is a political matter upon which we have no influence despite having asked some major NMIs to intervene on our behalf.

2.12 New study of evolving needs in national and international metrology

A draft of the *Report on Evolving Needs for National and International Metrology* was distributed to members of the CIPM early in September 2002 and will be discussed under item 6 of the Agenda.

2.13 Meeting of directors of NMIs, April 2002

A meeting of directors of NMIs took place at the BIPM on 22 and 23 April 2002. The principal item on the agenda was a wide discussion on the future programme and budget of the BIPM. Important inputs to the discussion were

the responses to two questionnaires that had been sent to directors concerning their views on future requirements for metrology, and the value they place on the services currently supplied by the BIPM. Reports of both these questionnaires have been distributed to members of the CIPM.

2.14 22nd CGPM

The 22nd CGPM will take place at the International Conference Centre in Avenue Kléber, Paris, from 13 to 17 October 2003. The Convocation must be sent to member Governments in December 2002 and must, therefore, be agreed by the CIPM at the present meeting. A draft will be presented for discussion.

2.15 *Metrologia*

Following discussions with Institute of Physics Publishing (IOPP) in the United Kingdom, a draft agreement has been drawn up for cooperation between the BIPM and IOPP in which IOPP would be granted a licence to publish *Metrologia* on behalf of the BIPM. IOPP would undertake all of the production, sales and marketing of *Metrologia* but copyright and full editorial control would remain with the BIPM. The refereeing, decisions on whether to publish articles and the commissioning of review articles and special issues would also remain with the BIPM. There are considerable advantages for us in what is proposed:

1. a substantial reduction in editorial and secretarial work at the BIPM, releasing 60 % of the time of the present assistant editor and some time of a senior secretary;
2. IOPP would ensure the on-time production of *Metrologia*, and increase the number of issues per year from six to ten;
3. a significantly higher visibility for the journal resulting from the very much larger sales and marketing operation of the IOPP compared with the BIPM;
4. guaranteed royalty payments to the BIPM from IOPP would cover all remaining staff costs associated with *Metrologia* at the BIPM and the annual average cost to the BIPM budget (over the past eleven years) of some 51 000 euros would disappear.

The detailed proposal will be put to the CIPM with a recommendation that the arrangement be approved.

2.16 BIPM calibration and consultancy services

The bureau discussed the current policy for the BIPM calibration and consultancy services and a note is being put to the CIPM for discussion. This includes consideration of the legal responsibility and liability of the BIPM for the services it supplies.

2.17 BIPM affairs

A draft "Programme and budget of the BIPM for the years 2005 to 2008" was discussed at the meeting of Directors and since then has been the subject of discussion and reflection among members of the bureau. A discussion document will be presented to the Committee on this subject.

A quality system is being put in place at the BIPM to meet the requirements of paragraph 7 of the MRA in respect of the calibration services delivered to NMIs. A report on this will be presented to the Committee under item 16.3.

2.18 Financial report

The table below shows the situation of the assets of the BIPM, in euros on 1 January of the year noted at the head of each column.

	Accounts	1999	2000	2001	2002
I.	Ordinary funds	5 115 891.90	6 291 144.60	6 197 805.86	6 849 066.09
II.	Pension fund	7 568 192.56	8 047 087.14	8 679 664.82	10 547 903.46
III.	Special fund for the improvement of scientific equipment	31 554.04	32 615.36	0.00	0.00
IV.	Staff loan fund	163 608.36	173 976.29	185 723.29	194 983.92
V.	Building reserve fund	2 595 744.53	2 780 504.29	1 216 406.49	0.00
VI.	*Metrologia*	0.00	0.00	0.00	0.00
VII.	Medical insurance reserve fund	543 853.13	584 681.75	625 077.75	653 741.11
	Totals	16 018 844.52	17 910 009.43	16 904 678.21	18 245 694.58

Prof. Kovalevsky thanked Dr Kaarls and invited discussion on the report.

Dr Issaev asked about the status of the BIPM's quality system and the availability of documentation for distribution. Dr Kaarls replied that the quality system will be ready in 2003 and it is too early to consider distributing documents at this stage. Further discussion was deferred to item 16.3 of the agenda.

Prof. Göbel wondered whether it was appropriate for the BIPM to be involved in the production of a catalogue of reference materials. Dr Quinn replied that the BIPM had no intention to publish such a document but noted there was an urgent demand for a database of such materials: the question as to who should develop it remains open. He emphasized that the proposed database is along similar lines to the KCDB, showing the traceability of available reference materials, but he noted that there does not yet exist the technical infrastructure needed to support the validity of the data. Further discussion was postponed until Dr Kaarl's report of the CCQM (item 10.2 of the agenda).

Dr Schwitz asked whether the CIPM could influence the WTO TBT Committee in any way, to overcome the blockade on new Observers. Dr Kaarls confirmed that various other Observers (including the ISO and the ITU) were appealing to the Committee on behalf of the CIPM and Prof. Kovalevsky added that a Resolution on the matter would be discussed under item 9 of the agenda, to be put to the next General Conference.

After minor modifications in the light of the Committee's comments, the report was approved by the CIPM.

3 MEMBERSHIP OF THE CIPM

3.1 Possible future candidates

Prof. Kovalevsky noted that there were no vacancies on the CIPM, and indeed no absences at the present meeting. He reminded members that, according to the Metre Convention, any vacancies on the Committee at the time of a General Conference may be filled by nomination and vote at that

Conference. He therefore suggested that any forthcoming retirements should be announced after the next CGPM.

He reminded members that they should seek candidates for future membership of the CIPM who were actively involved in the work of their NMIs and to present their curricula vitae at next year's meeting of the CIPM.

There were no suggestions for election of Honorary Members.

3.2 Membership of the bureau of the CIPM

Prof. Kovalevsky reminded the Committee that a vacancy for a Vice-President had been created by the departure of Dr VanKoughnett. Dr Quinn briefly summarized the formalities of the bureau of the CIPM, noting that the Metre Convention stipulated that the posts of President and Secretary of the CIPM and Director of the BIPM should be filled by people of different nationalities. The post of Vice-President is not specified in the Convention but recent practice is that the bureau of the CIPM usually includes one or two Vice-Presidents. All members of the bureau are elected or re-elected by the Committee at a meeting of the CIPM that takes place immediately after the closure of each General Conference.

Prof. Kovalevsky said that the bureau had discussed candidates for the current post of Vice-President taking account of the following criteria: the geographical distribution of the bureau (currently containing two European members and one from the Americas); the age of the candidate (a younger candidate offering greater continuity); and connections with the regional metrology organizations and the metrological world in general. No issues were raised by the CIPM. On the proposal of the bureau, the Committee then elected Dr Inglis who thanked the Committee for their confidence and support, saying that it was a great honour and assuring the CIPM of his commitment to their role and objectives. He noted in particular his wish to bring his experience with regional metrology and developing economies to the activities of the bureau.

Dr Brown suggested that it might be useful for the future President of the CIPM, due to replace Prof. Kovalevsky in 2004, to participate in bureau meetings prior to this time, as a sort of transition period. By acclamation, Prof. Göbel was then made President Elect and will participate in future bureau meetings. He will be elected formally President at the meeting of the CIPM that will take place at the closure of the 22nd CGPM in October 2003,

and will take office on the departure of Prof. Kovalevsky in 2004. Prof. Göbel thanked the Committee for their confidence in him.

4 ASSOCIATES OF THE CGPM

Prof. Kovalevsky invited Dr Quinn to report on the letter being sent out to those members of an RMO that are not yet a Member State of the Metre Convention or an Associate of the CGPM, highlighting the advantages of participating in the Metre Convention, in one or the other category. Dr Quinn circulated a copy of this draft letter (document JCRB/9-13(1b)), which has already received strong support from the chairmen of the RMOs and the members of the JCRB. He emphasized that the aim of the letter was to help those directors of NMIs wishing to join, to obtain the formal approval of their governments. It was important to adopt an appropriate tone in the letter, and Dr Quinn invited the comments of the Committee (Note: the final version of this letter was sent to fifty-three non-Member States in January 2003).

Dr Hengstberger mentioned the recent addition of Kenya to the list of Associates, and said that the SADCMET had widely broadcast congratulations to Kenya on that event. He hoped that other African nations might be encouraged to follow suit. He also noted that some countries, in the early stage of developing a national metrology system, do not yet have a national metrology institute. For some members of SADCMET, for example, their representative in the RMO might instead be a trade metrology organization.

Dr Kaarls added that some NMIs are not a member of a regional metrology organization and asked that these cases should not be excluded. Dr Quinn confirmed that he would also send a copy of his letter to the embassies in France of all such countries, including in these cases a covering note to raise awareness about the Metre Convention in general.

Dr Tanaka noted that the OIML currently has fifty-eight Member States (compared to fifty-one for the Metre Convention), and that its number of corresponding members is much greater than the number of Associates of the CGPM. Dr Quinn agreed that the OIML members or corresponding members

not currently linked to the Metre Convention might indeed be among those most interested in joining.

Prof. Ugur said that he had been contacted by representatives in Palestine asking if they could apply for Associate status. Prof. Kovalevsky and Dr Quinn said they would contact the French Ministère des Affaires Étrangères to check the position.

5 BIPM PROGRAMME AND BUDGET FOR THE YEARS 2005 TO 2008

An extensive discussion took place on the programme and budget of the BIPM for the years 2005 to 2008. The CIPM considered the results of the consultations with directors of NMIs (the questionnaires, the meeting in April and the responses to a document sent to directors in July 2002) on the future programme and budget of the BIPM. The outcome was that the CIPM decided to make some changes to the programme of the work of the BIPM so as to face up to an expected shortfall of income and at the same time to respond to changing needs in metrology. The following is a summary of the discussion and the conclusions.

According to the rules of the CGPM, the official Convocation containing the elements of the agenda, including particularly the CIPM proposals for the dotation for the next four-year period, must be sent to member Governments at least nine months before the opening of the Conference. For the 22nd CGPM that opens on 11 October 2003, the deadline for receipt of this document is thus early in January 2003. In fact, the Convocation is always sent out by the end of December.

The CIPM must, therefore, decide on the dotation to be requested and on the elements of the corresponding BIPM programme of work for the four-year period 2005 to 2008.

5.1 Introduction

Members of the CIPM and directors of national metrology institutes had been informed that an increase in 2005 of 1.1 million euros (some 12 % of the

2004 dotation) would be needed to maintain all of the BIPM's current activities and that an increase of 1.9 million euros (some 20 % of the dotation) would be needed to maintain the current programme and embark upon extensions into organic chemistry, bioanalysis and medicine.

The first reactions from some Member States to these proposals indicated it was extremely unlikely that the 22nd CGPM would agree to vote a step increase in budget for the year 2005 of more than about half of even the 1.1 million euros needed to maintain the current activities, plus a small amount for inflation for that and the succeeding years. We were informed that if, at the time of the Conference, a proposal were made for an increase much greater than this, it would most likely be vetoed.*

The difference between these indications and what was requested was sufficiently large that the bureau recommended to the CIPM that it take strategic decisions at its meeting in October 2002 on how to deal with this and that these not be left until after the CGPM in 2003.

For the purposes of making concrete proposals for the programme of work and budget, the following starting hypothesis was taken: that there will be a 5 % (0.45 million euros) step increase in dotation on 1 January 2005 plus an increase for inflation of 1.5 % in this and the subsequent three years of the quadrennium 2005 to 2008. (Note that in Draft Resolution J approved by the CIPM to be sent to Member States in the Convocation of the 22nd General Conference, these figures were increased from 5 % to 6.7 % and from 1.5 % to 1.8 % to take account of foreseable large building maintenance and latest predictions of price inflation in France.)

5.2 Broad strategic options

Since the 21st CGPM in 1999 the BIPM has been pressed to undertake, and has undertaken, considerably more activities than were envisaged at the time.

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* The formal procedure for adopting the dotation at a General Conference requires it to be adopted with no votes against. Abstentions are allowed but if there is a single vote against, it fails. The consequence of a failed dotation Resolution is that the dotation voted by the preceding General Conference remains unchanged. This is because the successive Resolutions on the dotation simply modify the previous one. Thus, if the proposed modification fails the dotation for the last year of the previous quadrennium continues until such time as agreement to change it is reached.

The role of the BIPM in coordinating international activities in metrology, relations with other organizations as well as the work stemming from the implementation of the MRA have all been much greater than foreseen. The response of the BIPM has been widely welcomed by NMIs and it is clear that all of this must continue.

On the basis of the hypothesis stated above, significant reductions in the current BIPM programme will, however, have to be made.

In deciding how to proceed, the CIPM took a number of considerations into account:

1. The needs of the NMIs in respect of the services supplied by the BIPM as set out in the responses to the second questionnaire to directors; these include all the activities relating to coordination and international relations as well as the KCDB, JCRB and the scientific and technical work in the laboratories that provide calibration and other services to NMIs and the scientific base of the BIPM.
2. There are no across-the-board economies that would have a significant effect.
3. The magnitude of the savings that need to be made is such that one of the large scientific sections will have to be closed.
4. In deciding which of the large sections must be closed, there are strategic decisions that must be taken regarding what should remain as the base for the future core programme of work.
5. The consequences of the changes with respect to the staff of the BIPM.

Much of the thrust of the Report on *Evolving Needs for Metrology in Trade, Industry and Society and the Role of the BIPM,* adopted by the CIPM this year and shortly to be published, relates to the emerging needs for international metrological activity in chemistry, biotechnology and medicine. Contacts we have had with NMIs all over the world confirm this view. It was the opinion of the Committee that while it is clear that a large activity at the BIPM in these fields is for the present not possible, it is essential to have a minimum of two high-level specialists in these fields. If we do not do this, we shall not be present in any of the international forums and we shall not even know how to respond to requests for information to meet the most urgent needs. Even if, as has been suggested by some directors, BIPM activities in these areas can be mainly supported by staff seconded from some NMIs, it will still be necessary to have a minimum of in-house expertise to provide continuity, without which such a programme could not work.

While it is not yet clear how the BIPM will in due course become involved, at the first meeting of a working group of the new JCTLM there was already a call to set up an infrastructure to supply reliable data for an eventual database to hold lists of reference materials and reference methods that will be drawn up by the JCTLM. The BIPM provides the secretariat for this new Joint Committee.

It is widely recognized that the success the BIPM as an intergovernmental organization has had up to now in its international work of coordination rests on its scientific credentials. This was also a clear outcome of the outside consultations made by the private company KPMG. Without a scientific base, it would not be possible to attract high-level specialists, in any field, to come to the BIPM. If it were simply an office it is unlikely that any of the present senior scientific staff would be here. The short experience we have in chemistry indicates that having a specialist on the staff has been an essential support to our coordination work.

Therefore, if the BIPM does not enter in some way into the fields of organic chemistry, bioanalysis and medicine, it is difficult to see how it can play the pivotal role in these new fields of metrology that the recent KPMG study indicated it has in physical metrology. This role is highly valued not only by directors of NMIs but by an increasing number of organizations outside the direct field of metrology with interests closely related to metrology.

The first important decision made by the CIPM was that it is essential to embark on a minimum laboratory programme in the new areas in order to secure the future of the BIPM and to meet the clearly stated requirements of NMIs.

In order to take the decisions necessary to reorientate the BIPM so that it enters at least to a minimum extent into these new fields, it was necessary to have a clear view of the short- and medium-term priorities in respect of each of the current programmes of the BIPM. This was because the new work must be at the expense of some of the existing programme. A high priority in making these decisions was also the importance of making the best use of the highly qualified and motivated staff of the BIPM.

5.3 Priorities in the present programme

It is clear that the BIPM is an essential component of the international metrological infrastructure. Its presence in international activities

representing the interests of NMIs, its role in coordinating international metrology, its contacts with other international organizations directly and through Joint Committees, its support to Consultative Committees and RMOs as well as its key role in the implementation of the CIPM MRA through the KCDB and the JCRB, are all activities having the highest priority.

There is little or no argument that all these activities have to be maintained and developed and that to do this there must be a sound scientific base.

Within the scientific and technical programme there are, however, various levels of priority. These are:

5.3.1 Top priority: The mass and time-scale programmes

These are the central core of the BIPM scientific activities: for the mass work we have a specific mandate in the Metre Convention and for time scales we have a specific mandate through successive CGPM Resolutions. The activities of the mass and time programmes are continually under review, but while small economies can be foreseen in the time work resulting from increasing use of automation, it is the view of the CIPM that the mass programme should expand to include a watt-balance project. This is because a requirement for any future definition of the unit of mass based on atomic or fundamental constants is a long-term commitment to monitoring the mass of present artefact, the International Prototype. The BIPM is uniquely positioned and capable of making such a commitment.

5.3.2 Second priority: Ionizing radiation and chemistry

The ionizing radiation programme at the BIPM provides the principal reference for most national dosimetry and radioactivity comparisons and provides the link to the SI for the extensive network of Secondary Standards Dosimetry Laboratories run by the International Atomic Energy Agency. No economies can be foreseen as the present activities are at the lower limit of viability. The present small chemistry programme is the first step into the new fields discussed above and must have a high priority.

5.3.3 Third priority: The electricity, the laser and gravimetry programmes

The electricity and laser programmes each have particular significance.

The electricity programme would be an essential contributor to any watt-balance project at the BIPM. It also holds the only high-accuracy travelling

standards of the Josephson volt and the quantum-Hall resistance. Both of these are unique and currently provide the only means to check the consistency of NMI standards at the highest level of accuracy. Such a capability is essential (either at the BIPM or elsewhere) for the foreseeable future. There are also proposals, in collaboration with the NML-CSIRO (Australia), to build a new calculable capacitor to be installed at the BIPM to provide one of the few long-term world references in this field. Several NMIs have expressed interest in participating in this project. Note also that half of all the calibration certificates issued by the BIPM are for electrical standards serving nearly half of all the Member States of the Metre Convention. Some capability in electrical measurements is part of the essential core competence of the BIPM.

In the case of the laser programme, the new programme is centred on femtosecond-comb technology. With the development of this new technology, the thirty-year programme of laser comparisons of 633 nm He-Ne lasers using the BIPM lasers as reference has come to an end. This also provides a natural break point for other visible and infrared laser comparisons. The femtosecond-comb work is at the frontiers of science and is in preparation for a possible future BIPM role in comparing optical frequency standards at a level of accuracy beyond that feasible by satellite techniques. The short- and medium-term aim of the new BIPM programme in this field is thus to prepare for optical frequency comparisons, to validate the performance of frequency combs and meanwhile to provide a service of frequency measurement for the 633 nm standards of the smaller NMIs.

The gravimetry programme is very small but is highly valued and increasingly seen as essential by the geophysics community at whose request we recently established a formal working group. A new request has arrived asking for further support from the metrology community to help improve links between all aspects of geophysics and the SI. The long-standing series of comparisons of absolute gravimeters at the BIPM is strongly supported by the International Union of Geophysics and Geodesy. The gravimetry work at the BIPM will contribute to a watt-balance project.

5.3.4 Fourth priority

In the fourth priority we place the photometry and radiometry programme and the small activity in nanometrology. In the case of the photometry and radiometry programme the arguments for work at the BIPM are less compelling than for the other programmes mentioned above. This is because

with the almost universal adoption by NMIs of the cryogenic radiometer as the reference for radiometric and photometric standards, the former role of the BIPM in maintaining the mean world lumen and candela on a set of incandescent lamps has disappeared. Furthermore, there are no BIPM travelling standards that are essential for the comparison of cryogenic radiometers. It is clear, however, that maintenance of the lumen and the candela at the BIPM enables the BIPM to continue its long-standing calibration service that is highly appreciated by many smaller NMIs. However, it should be noted that the present complement of three professionals but no technical staff is not sufficient for the current programme.

The nanometrology programme provides a small but useful support to the work in this field of the Consultative Committee for Length (CCL) but cannot be considered to have high priority at the BIPM as CCL work in this area is still relatively limited.

5.3.5 Core competences

Underpinning all of the above, there are a certain number of core competences that should be preserved at the BIPM. These include a basic knowledge of measurements in electricity, optics, interferometry, pressure and temperature, as well as electronics, mechanical design and a mechanical workshop to build experimental apparatus.

5.4 Programme decisions

The CIPM considered these priorities and made the following decisions:

1. A maximum of two new staff will be recruited for organic chemistry and a small laboratory programme started during the period 2004 to 2006.
2. A watt-balance project will be started and a calculable capacitor project will be pursued in collaboration with the NML-CSIRO.
3. The staff of the KCDB will be re-enforced and provision made for a permanent secretariat for the JCRB.
4. The photometry and radiometry programme will be terminated in 2004. The three professional staff will be transferred to the Electricity section and when the present three professional staff of the Electricity section retire within the next few years, they will become the core of the

Electricity section. The calibration service of incandescent lamps will, therefore, cease but attempts will be made to arrange calibrations for the BIPM's former clients with some NMIs in their local RMOs. (Note: On average a total of about twenty-five lamps are calibrated each year.)

5. The work in the Laser section will be focused solely on the femtosecond laser project and it will continue only until 2006 when it will be closed. Longer-term continuation of the present programme would continue to require heavy investment in both equipment and high-level scientific staff and under the present circumstances this is beyond our resources. The existing four permanent staff of the section will progressively be re-deployed to other areas of work at the BIPM.

5.4.1 Staff

The Committee expects the changes outlined above to be achieved without any forced staff redundancies by taking advantage of retirements, internal transfers from areas being reduced or closed and the completion of all the short-term Research Fellow appointments.

The present staff (October 2002) comprises seventy-one permanent employees plus six Research Fellows. It is planned to reduce this by 2008 to sixty-seven permanent staff and no Research Fellows. Note that staff numbers fluctuate year on year as a result of retirements and overlapping recruitments, and in 2003 there will be up to seventy-five permanent staff but only five Research Fellows.

However, visiting scientists are essential for the scientific programme of the BIPM. They also are needed to provide additional scientific support so that heads of sections can be more visible in RMO technical meetings, an activity we recognize to be of high priority and one that should be increased. The CIPM asks the NMIs to be ready to send suitable people on secondment, at their expense, to the BIPM for periods of one or two years so as to maintain a constant presence of four or five Research Fellows. This is specifically mentioned in the draft Resolution on the dotation given on page 151.

5.4.2 Additional funding

The absence of any additional capital funding for new or updating major equipment or basic infrastructure, over and above the annual dotation voted at successive CGPMs, distinguishes the BIPM from many NMIs. In the

current period of low price inflation, there is no longer the possibility of making savings from the annual budget for these purposes. Such savings of a few percent of the dotation per year had been possible during the 1970s and 1980s when the increases voted by successive General Conferences turned out to be a little larger than the price increases in France that actually occurred. In view of the impossibility of making significant savings from annual budget, the CIPM considered asking Member States at the 22nd CGPM to make a single lump-sum contribution for restructuring during the next four-year period. The sum envisaged would have been about 1 million euros, sufficient to cover the updating of laboratory air conditioning, refurbishment of laboratories, and major renovation of the roofs of the two seventeenth century buildings of the site, the Pavillon de Breteuil and Petit Pavillon. In the end, however, no such request for a single lump sum is being made because it was thought that the chances of success were too remote. These additional costs are, therefore, absorbed into the CIPM's proposed increase in the dotation given below. The possibility of an additional contribution to the BIPM pension fund was also discussed but not pursued.

While considering the consequences of a future shortfall in income from existing Member States and Associates, we must not forget the possibility of a small increase in income from increased membership of the Metre Convention or from other sources, and this must be explored. In this respect, with the letter to non-Member States referred to earlier we are actively pursuing a programme of direct contacts with NMIs of States not yet either Member States of the Metre Convention or Associates of the CGPM. The aim is to inform them of the advantages to be gained by membership and provide information that they can use to persuade their governments of the usefulness of adhering. In this respect we have consulted the RMOs to try to ensure that the contacts are made in the most appropriate way.

5.5 Draft Resolution on the dotation to be submitted to the 22nd CGPM

The starting point for the calculation of the dotation for the next quadrennium is the dotation voted by the previous General Conference for the last year of the current quadrennium. In the present case, this is the dotation for 2004 voted by the 21st CGPM, namely 9 094 000 euros. To this should be added the contributions from the three States, Greece, Malaysia and Yugoslavia, that have joined the Convention since the 21st CGPM. Their

contributions together amount to 1.76 % of the total. Thus, the new starting point for the calculation of the 2005 dotation is 9 254 000 euros.*

The CIPM proposes that this be increased to 10 041 000 euros on 1 January 2005 (i.e. an increase of 8.5 %, comprising a real increase of 6.7 % plus 1.8 % to cover price increases in France) and that on 1 January of each of the three succeeding years of the quadrennium it be increased by a further 1.8 % to cover price increases in France.

The dotations thus requested for each of the years 2005 to 2008, given below in Draft Resolution J, will allow a programme of work to be carried out that will meet the minimum requirements of Member States while allowing a balanced budget to be maintained for the years 2005 to 2008. The programme will, however, still be a smaller programme than that foreseen at the time of the 21st CGPM.

Details of the programme and individual budgets for the four years of the quadrennium are sent to member Governments about six months before the Conference. For the 22nd General Conference these will be in a document entitled "Programme of work and budget of the BIPM for the years 2005 to 2008", that will be sent out in April 2003.

Dotation of the BIPM for the years 2005 to 2008

Draft Resolution J

The 22nd General Conference,

considering

- the increasing importance of metrology for trade, industry, the environment and human health and safety in all Member States of the Metre Convention,
- the corresponding need for an efficient, highly expert, international coordination of metrological activities,

* Note that the subscriptions from Associates of the CGPM are simply to cover the costs of the services offered to Associates and are not part of the dotation voted by Member States.

- the central role played by the International Bureau of Weights and Measures (BIPM) in such coordination and the services it renders to Member States of the Metre Convention,
- the broadened responsibilities given to the BIPM at the 21st General Conference in 1999 but without any corresponding increase in dotation,
- the additional increase in workload, unforeseen at the time of the 21st General Conference, that has also been absorbed by the BIPM since the last General Conference,
- the extension of the range of work under the Metre Convention now carried out in Member States, notably in areas of chemistry, biotechnology and medicine,
- the need to extend the range of expertise among the scientific staff of the BIPM to meet demands for work in these new areas,
- the considerable efforts that continue to be made by the BIPM to enhance the efficiency of its operation, and its commitment to continue these efforts,

invites national metrology institutes

- to arrange, at their expense, a continuing series of short-term placements or secondments of their staff to the BIPM to work on projects of mutual interest integrated into the BIPM programme,
- to accept staff of the BIPM to work in their institutes on programmes of mutual interest,
- to sponsor a permanent programme of Fellowships at the BIPM for suitable staff with a view to establishing four such Fellowships at the BIPM by the end of 2004, and

decides that the fixed part of the annual dotation of the BIPM will be increased in such a way that the fixed part and the complementary part (defined by Article 6, 1921) of the Rules annexed to the Metre Convention (1875) shall, for those States that are members of the Metre Convention at the time of 22nd General Conference, be

10 041 000 euros in 2005
10 222 000 euros in 2006
10 406 000 euros in 2007
10 593 000 euros in 2008.

5.6 Final remarks on BIPM services that will cease

These were hard decisions and the Committee is well aware that they will have an impact on those NMIs that use the services in the fields that are to be reduced. Insofar as it is possible the BIPM will make arrangements with NMIs in the same regions to supply, at least for a limited time, some of these services that will no longer be provided by the BIPM. In due course, the BIPM will be able to supply services (in the new areas) that the NMI directors rated of high potential value.

6 NEW REPORT ON NEEDS FOR METROLOGY

Dr Kaarls presented a draft of his report entitled "Evolving Needs for Metrology in Trade, Industry and Society and the Role of the BIPM", 2003. This report is presented to the Committee for comment and discussion with a view to it being sent to member Governments in the Spring of 2003 as a document for the 22nd CGPM from the CIPM. The Committee examined the draft and discussion took place as a result of which it was agreed that a final, revised, draft would be prepared by Dr Kaarls and be reviewed by the bureau of the Committee.

7 KPMG STUDY OF POTENTIAL ECONOMIC BENEFITS OF THE MRA

Dr Kaarls introduced the report of the private consulting Company KPMG that had been commissioned by the BIPM to make a study of the potential economic benefits of the CIPM MRA. The report had been distributed to members of the CIPM earlier in the year. The bureau of the Committee were of the view that this had been a valuable exercise, particularly as it had been a way of finding out some independent opinions of certain aspects of the work of the BIPM. The full report is openly accessible on the BIPM website.

Dr Lusztyk asked if the BIPM had informed the regulatory bodies about the KCDB. Prof. Wallard replied that this activity was rather more of a national responsibility and had been left to the NMIs, although the BIPM would of course be willing to contact any other organizations on receipt of their names and contact details. The BIPM was, however, in close touch with various projects that were designed to make regulators more aware of the metrological aspects of regulation and the benefits of using the MRA framework in reducing technical barriers to trade.

Dr McGuiness proposed that a high-ranking representative of a large multinational company, perhaps one involved in biotechnology, be invited to the next General Conference to give a talk about the benefits of the MRA. The Committee agreed that this was a good idea and that such a speech could well be inserted near the beginning of the Conference, perhaps just after the address by the French Ministre des Affaires Étrangères. (Dr Brown volunteered that she has contacts at IBM and Procter and Gamble.) Prof. Kovalevsky said that the bureau would give full consideration to the suggestion.

8 THE CIPM MRA

8.1 Report on the present status

Dr Quinn raised the ongoing problem of the choice of statistics used to calculate key comparison reference values (KCRVs). He reported that he had formed a Director's Advisory Group on Uncertainties, comprising Dr Bich (IMGC), Prof. Cox (NPL), Dr Estler (NIST), Dr Nielsen (DFM) and Prof. Wöger (PTB), and asked them to draw up a short guidance document. A draft document has now been compiled, following fairly wide consultation. He understands that there is still some disagreement, however, particularly at the NIST, and proposes that a further discussion group be organized.

Dr Brown concurred that statisticians at the NIST were unhappy with the "Proposed guidelines". The perception should not be that a small number of people in the Director's Advisory Group are pushing forward their own

view. Dr Quinn agreed that this perception did not reflect reality and that it is important to discuss the matter further so that the correct message is given.

Prof. Göbel noted that the present text from the Advisory Group remains a proposal, and that further documents are being produced to deal with more complicated cases. The CIPM agreed that the title of the current document, due to be published in issue **39**(6) of *Metrologia*, should be modified to indicate that it does not constitute formal guidelines. Dr Quinn suggested that the words "Proposed guidelines" be deleted from the title.

He also took the occasion to thank the NIST for providing space on the NIST booth at PITTCON in March 2002 for the BIPM to demonstrate the KCDB. This was a most successful operation and it is planned, with the help once again of the NIST, to repeat it in 2003.

8.2 The end of the transition period

Dr Quinn outlined the report JCRB-8/13 (available on the BIPM website), which included the latest revisions made by the JCRB the previous week. During the transition period of the CIPM MRA, many NMIs are in the process of participating in comparison programmes and establishing their quality systems. Thus, the calibration and measurement capabilities (CMCs) published during this period are based on fulfilment as far as possible of the criteria given in the document JCRB-9/13(1b) "Criteria for acceptance of data for Appendix C". Following the end of the transition period (14 October 1999 to 31 December 2003), the CMCs submitted for publication on the KCDB will be required to have, as their basis, evidence of fulfilment of all these criteria. At the meeting of directors in March 2004, institutes that have not already done so will be asked to set a firm date for having their quality systems in place.

Dr Quinn confirmed that the phrase "… sign this arrangement for an initial period of four years" (in item 11.1 of the MRA text) does not imply that the signatories must sign again after four years. Rather, extension of the arrangement will be approved by general acclamation at the meeting of directors during the week of the CGPM.

8.3 Possible changes to the MRA at the next CGPM

Dr Quinn reported that no changes have been proposed to the text of the MRA and that, although in April 2002 he invited comments for consideration at the next meeting of directors, none was received.

Dr Quinn read out the existing text relating to designated institutes, and the Committee agreed that it is sufficiently clear. Individual countries must appoint their signatory institute, and the signatory should inform the BIPM of any designated institutes.

The Committee was also satisfied with Dr Quinn's assurance that if an institute is no longer "designated", then its name is deleted from Appendix A and its CMCs are removed from the KCDB. If, subsequently, the institute is redesignated, reference can be made to the old data if necessary. Similarly, any changes to the names of signatories are clearly indicated in Appendix A (for example, the Japanese signatory NRLM has since become the National Metrology Institute of Japan (NMIJ/AIST), incorporating two of the previously designated institutes, the ETL and the NIMC).

It was agreed that no changes to the text of the MRA would be recommended by the CIPM in 2003, and that any longer-term changes required could be made at the following CGPM, in 2007.

8.4 Changing role of Consultative Committees

Dr Quinn told the Committee that recent meetings of RMO delegates, held immediately prior to a Consultative Committee meeting, to review related CMCs, had proved very successful. He cited as example the field of amount of substance, where the inter-regional review panel was composed largely of members of the CCQM. Their meeting round a table during the week before the CCQM meeting had greatly increased the speed of decision making compared with the traditional inter-RMO correspondence by e-mail. He said that the JCRB had asked him to bring this to the attention of the CIPM and to suggest that Consultative Committees establish working groups to carry out this CMC review on a regular basis. The CIPM agreed that carrying out related inter-regional reviews at the time of a Consultative Committee meeting should be encouraged. There was, however, a reluctance to formalize such a procedure as a Consultative Committee activity since, according to the MRA, preparation and inter-regional review of CMCs is a responsibility of RMOs. It was also the view of the Committee that such

reviews carried out by a relatively small number of people may not be appropriate in all fields. Prof. Ugur suggested that representatives from the CCs should also be invited to meetings of the JCRB to improve communication between the two bodies. Dr Schwitz added that intra-RMO and inter-RMO interactions were both very important. He emphasized that responsibility for both remained with the RMOs, but agreed that the RMOs and Consultative Committees should be encouraged to establish CMC review services.

Finally, in conclusion, it was agreed that:

- meetings of RMO representatives to review CMCs should take place at the time of Consultative Committee meetings;
- they should not be formal working groups of the Consultative Committees;
- it remains up to the President of each committee to make the most appropriate arrangements depending on the field.

9 THE 22nd GENERAL CONFERENCE

9.1 Arrangements for the General Conference

Prof. Kovalevsky reminded the Committee that the 22nd General Conference will take place from Monday 13 to Friday 17 October 2003, and that the CIPM will meet on the Thursday and Friday of the preceding week (9 and 10 October), then briefly at the end of the Conference in the afternoon of Friday 17 October. The Conference will be hosted by the French Government at the International Conference Centre (Avenue Kléber, Paris).

9.2 Draft Convocation

Dr Quinn reminded the CIPM that the Convocation for each General Conference is sent to Governments of Member States in the December of the year preceding the Conference. The present (91st) meeting of the CIPM must therefore approve the text for the Convocation to the 22nd CGPM (2003) in

order that it may be sent to the Governments of the Member States and Associates in December 2002.

This Convocation is a formal document and its preparation requires a fairly long time scale. In 1948 it was agreed that a Member State wishing to submit a proposal for discussion at the Conference must do so at least six months in advance of the meeting. This is necessary for the proposal to be received and translated and distributed not less than four months before the Conference. It is to allow Member States sufficient time to react and indeed to submit new proposals for discussion, that the Convocation is distributed about nine months prior to the CGPM. The dotation voted by the Conference is for the four-year period starting on 1 January of the year following the previous period of dotation. Thus, for the 22nd CGPM in October 2003, the dotation will start on 1 January 2005.

9.3 Discussion of the Draft Resolutions

The Committee discussed and made various changes to the proposed Draft Resolutions to be included in the Convocation. These were (after re-ordering) Draft Resolution A (on links with other organizations), B (on metrology and trade), C (on the coordination of the initiatives to support the implementation of metrology, accreditation, and standardization in developing countries and economies), D (on the value and benefits of the Metre Convention for Member States and for Associates of the General Conference), E (report on evolving needs for metrology in trade, industry and society and the role of the BIPM), F (on the importance of the CIPM MRA), G (on the involvement of NMIs in the complete range of work of the Metre Convention), H (on the revision of the *mise en pratique* of the definition of the metre), I (on requirements for cross border transport of measurement standards, metrological equipment and reference materials) and, finally, Draft Resolution J on the annual dotation of the BIPM for the years 2005 to 2008.

Draft Resolution G stimulated much discussion, some of which was included under item 8 of the agenda. Dr Quinn reminded members that only NMIs and other laboratories designated in the MRA can include their CMCs in Appendix C; the same rule applies for the results of key and supplementary comparisons appearing in Appendix B. Some members called for clarification on which laboratories should be "designated" but Dr Quinn reiterated that this is a matter for individual States to resolve, and in the

MRA all designations are made via one signatory NMI which is clearly defined.

Draft Resolution C on the work of the JCDCMAS was drafted by the CIPM following discussion under agenda item 13 (see below). Dr Brown anticipated that it might pose a problem for the US State Department, but said she would try to iron out any difficulties. She agreed that the intention was good, but said that the problem was that all the component members are policy committees rather than technical committees. As a result of subsequent correspondence, the draft terms of reference of the JCDCMAS were modified to address the potential difficulties mentioned by Dr Brown.

10 CONSULTATIVE COMMITTEES

10.1 Consultative Committee for Units

Prof. I.M. Mills, President of the Consultative Committee for Units (CCU), updated the Committee on the CCU's recent discussions on the neper and bel.

In the SI Brochure, 7th edition (1998), the radian and steradian are listed as coherent derived dimensionless units in Table 3, whereas the neper and the bel are listed in Table 6 as non-SI units accepted for use with the SI. At its 11th meeting in April 2001 (reported to the 90th CIPM meeting) the CCU proposed that it would be more logical to list the neper as a coherent derived unit in Table 3, considering the close relation between the neper and the bel discussed previously. Since that meeting the majority of the CCU has agreed that it would be better to include both the neper and the bel as coherent derived dimensionless units in Table 3, in view of the widespread use of the decibel. Recommendation U 1 (2002) was presented to the CIPM to this effect.

The proposal sparked lively discussion. Dr Valdés presented a paper (*Metrologia*, 2002, **39**, 543-549) arguing that confusion is generated by the use of dimensionless units. Prof. Giacomo agreed with Dr Valdés, saying that it was not consistent to apply units to pure numbers at all. He conceded that the neper was less incoherent than the bel, but argued that this still does not make it coherent. Prof. Leschiutta pointed out that the decibel is widely used,

both in teaching and in technical documents (including those of the ITU). Dr Brown noted that the CCU had not formally approved this Recommendation and that approval by the CIPM might influence their decision. Prof. Göbel said that he had received an urgent note from PTB representatives of the relevant International Electrotechnical Commission (IEC) and International Organization for Standardization (ISO) committees requesting that the discussion be postponed because the matter had not yet been discussed by these committees. Dr Quinn said that at the meeting of the Consultative Committee for Acoustics, Ultrasound and Vibration, these same representatives had said they could accept the current proposal of the CCU for the CGPM, but that it would also be quite acceptable to the IEC and ISO to leave things as they are. Prof. Issaev said that he hoped to stimulate discussion in a Russian journal that has printed a Russian translation of the paper by Mills, Taylor and Thor (*Metrologia*, 2001, **38**, 353-361). Dr Tanaka welcomed further discussion by the CCU and Prof. Ugur suggested they should also seek the view of the other Consultative Committees.

Finally, there was general agreement among members of the CIPM that the Recommendation should not be presented as a Resolution to the 22nd CGPM and the proposed draft Resolution was deleted. Prof. Kovalevsky thanked Prof. Mills and the CCU for all their hard work but asked them not to proceed with these discussions concerning the neper.

10.2 Consultative Committee for Amount of Substance: Metrology in Chemistry

Dr Kaarls, President of the Consultative Committee for Amount of Substance (CCQM), presented his report on the 8th meeting of the CCQM, which was held at the BIPM on 18 and 19 April 2002.

10.2.1 CCQM working groups

Dr Kaarls began by summarizing the activities of the various CCQM working groups, most of which had met twice during the preceding twelve months.

The working groups on organic, inorganic, gas and electrochemical analysis are progressing well with their programmes of key comparisons and pilot studies. Some of the studies organized by the CCQM Working Group on Inorganic Analysis have been carried out in close connection with

comparisons including many other laboratories, and interesting deficiencies have been discovered in comparisons organized among wine producers. The most recent meeting of the Working Group on Gas Analysis was also attended by a representative of the WMO.

A pilot study is under way in surface analysis to compare eleven different measurement techniques used for surface and micro/nanoanalysis. This study includes many non-NMIs, as not many NMIs have capabilities in the field. The study is expected to lead to a significant reduction in the uncertainty of the best surface analysis measurements and will prepare the ground for a key comparison among NMIs.

The most recent meeting of the new CCQM Working Group on Bioanalysis was attended by representatives from eighteen NMIs. They discussed the future programme of work, including DNA testing, fluorescence methods, and rapid protein measurements. The group plans to establish cooperation with Codex Alimentarius, the WHO, and the IFCC, and will also seek the advice of experts in radiometry (from NMIs and the CCPR). A "think-shop" will be held at the IRMM at the end of 2002.

10.2.2 Calibration and measurement capability claims

Immediately prior to the CCQM meeting, an inter-regional meeting of experts was held at the BIPM to review related CMCs. Some 3000 CMCs in amount of substance have already been reviewed or are undergoing review.

The CCQM has decided to make a systematic study of which key comparisons are essential for making decisions with respect to the judgement of CMC claims. However, since it is impossible for all the CMCs to be underpinned by key comparisons, it is essential that the reviewers are aware of the capabilities and competencies of the various NMIs and designated institutes, with knowledge of the processes carried out in these laboratories, and acquaintance with their quality systems. Peer review (possibly as part of accreditation) is strongly recommended. Several peer reviews in chemistry have already been carried out, and others are planned.

The experts agreed that although the working groups of the CCQM will inevitably be involved to some extent in the review of CMCs, they should not become overburdened with administrative activities. Also, activities in molecular spectroscopy will be reviewed by the CCPR, and activities in viscosity by the *Ad Hoc* CIPM Working Group on Viscosity.

10.2.3 Criteria for CMC claims including certified reference materials

The CCQM established a set of criteria for the certified reference materials (CRMs) used to disseminate traceability to customers and included in the column "Mechanism(s) for measurement service delivery" of Appendix C of the CIPM MRA. Dr Kaarls presented these criteria and requested the approval of the CIPM.

The question was raised of whether the CRMs mentioned in Appendix C are prepared, characterized and assigned a value in accordance with ISO Guides 34 and 35. In particular, the ISO Committee on Reference Materials (REMCO) has also expressed concerns about the approach taken by the CCQM and the CRMs mentioned in Appendix C. Dr Kaarls confirmed that these Guides must be followed when a CRM is characterized, and the CCQM recommended that conformity with the ISO Guides be added to the requirements of the CIPM MRA. Dr Kaarls has also attended an ISO REMCO meeting and given a presentation on the work of the CCQM, the criteria it applies, and the CIPM MRA. Closer cooperation between the two organizations has been agreed.

Dr Kaarls also noted that Appendix C is not to be seen as a catalogue of CRMs that can be delivered by an NMI, adding that many CRMs needed in practical laboratory work are unclassified and there seems to be a need for a second database listing other reliable CRMs available to the user.

After discussion and slight modification of the proposed criteria, the CIPM approved the following CCQM text for the acceptance of CRMs in Appendix C:

1. The NMI concerned shall be a signatory to the CIPM MRA.

   In the case where the country/economy has a decentralized system of NMIs, the participating laboratory can be a designated laboratory being responsible for establishing traceability and delivering calibration services in a defined (by quantity and measurement range) area of measurements in chemistry.

   The designation has to be done by a formal decision of the Government of the country concerned or by the NMI of that country in the case where the authority to designate has been delegated to the NMI. The designation has to be announced by the responsible authority by written letter to the Director of the BIPM.

2. The NMI takes full responsibility and liability with respect to the quality and characterization (stability, homogeneity, etc.) of the CRM and the value(s) assigned to the CRM mentioned in this column.
3. The NMI claiming capabilities of dissemination of traceability via deliverable CRMs must have own competence and measurement capabilities in the field concerned and must be involved in the measurement and characterisation of the claimed CRM.
4. The NMI concerned has to fulfil all criteria mentioned in the MRA, including the necessary competence, capabilities to determine and verify all the characteristics and values of the CRM mentioned by itself in its own laboratory, an implemented quality assurance system reviewed by peer and/or accreditation assessments, participation in RMO activities and CCQM and RMO key comparisons and RMO supplementary comparisons.
5. Production of CRMs is not necessarily a task to be carried out by the NMI, but characterization and value assignment has to be carried out by the NMI claiming the CRM capability.
6. The NMI or designated laboratory may make use of the competence and capabilities of other non-NMI laboratories for verification of their own analysis.

   Values obtained by other non-NMI laboratories involved in the value assignment process of a CRM can only be used as a verification of the value obtained by the NMI. In general consensus values are not acceptable. However, a consensus value may be taken if all contributing values are traceable to the SI (or another internationally agreed reference in case traceability to the SI is not (yet) possible) and the claimed uncertainty is sufficiently wide to include the spread in all the measurement results and their stated measurement uncertainties. The NMI has to prove that the participating non-NMI laboratory is fully traceable to the SI (or another internationally agreed reference).
7. Claiming a smaller uncertainty than the NMI's own capabilities and claiming a smaller uncertainty as a result of applying statistics in the case of participation of other laboratories with better capabilities is not permitted.
8. Only those CRMs delivering traceability in certain areas may be mentioned, for which at least some evidence of international

comparability exists, for example by results of a key comparison or a study.

Note. The criteria mentioned above lead to the following conclusions with respect of existing CRMs:

(a) The NIST traceable reference materials (NTRM) under the NIST programme are acceptable.

(b) The BCR reference materials whose values have been determined on the basis of IRMM's actual measurement and characterization involvement and fulfilling the conditions mentioned above are acceptable.

(c) The BCR reference materials whose values have been determined by non-NMIs are not acceptable.

(d) The NMIs actually involved in the characterization and in the assignment of values of BCR reference materials, taking into account the criteria mentioned above, may claim the BCR reference materials as one of their capabilities in disseminating traceability. Stability and homogeneity checks have to be carried out by the NMI concerned or have to be guaranteed via an agreement with IRMM, which then will monitor the stability and homogeneity.

10.2.4 Participation of other institutes and designation of NMIs

Taking into account the development of metrology in chemistry at different NMIs, it is essential that broader networks of designated institutes be created. Moreover, there are several examples of non-NMIs having special costly facilities (for instrumental neutron activation analysis (INAA), for example), which would be of great value to the work of the CCQM. The possibility of subcontracting under certain conditions has to be considered.

In general it is felt that further guidance is necessary on the participation of non-NMIs in the work of the CCQM.

10.2.5 Costs of bilateral comparisons

In certain cases, such as when a laboratory needs to repeat its measurements due to unsuccessful participation in a key comparison, the CCQM considers it justified to make a charge for the extra comparison. However, it wants developing countries to be treated fairly.

The CIPM clarified the wording, in that the key comparison itself is not being repeated; in such cases, the extra measurements represent a subsequent bilateral comparison. Dr Brown appealed that the NIST should not be burdened with supplementary comparisons as a result of initially substandard measurements in a key comparison, and Dr Inglis concurred that this problem affected all regions. There was general agreement that "newcomers" should first participate in studies rather than key comparisons, and key comparisons themselves should be restricted to fully qualified participants.

10.2.6 CCQM workshop on traceability

During the week of the CCQM meeting, a very successful two-day workshop was held on traceability. This workshop was attended by some 100 participants, all active in the CCQM working groups, and included presentations by representatives from the food, health and environmental sectors, as well as from the ILAC. Several participants presented their national systems for disseminating traceability. It is clear that much work remains to be done in order to deliver traceability to the workshop floor.

10.2.7 BIPM Chemistry section

The CCQM Working Group on Organic Analysis discussed possible programmes of work to be carried out at the BIPM. Purity analysis has been mentioned as a possible niche activity. Following consultation with experts from the CCQM, a programme of work in the field of organic pure substance reference materials will be undertaken. The programme is in response to the requirement to demonstrate the traceability of measurement results as formulated in international standards such as ISO/IEC 17025 and ISO 15915. The laboratory programme at the BIPM will concentrate on validated methodologies for determination of purity, including an initial study on direct assay methodologies such as nuclear magnetic resonance (NMR) and differential scanning calorimetry. The programme will be linked to activities of NMIs with the formation of network activities in fields of interest. A consultation process with the institutes has identified the following areas where a network activity would be of benefit to the NMIs: pharmaceuticals; antibiotics; hormones; mycotoxins; pesticides, herbicides and dioxins; volatile organic hydrocarbons; organometallic species; clinically relevant analytes as a component of a reference measurement system for laboratory medicine. Liaison with the international standardization bodies will be

established to disseminate information on these activities, which will allow the international requirements for traceable measurement results to be met in these fields of application.

Prof. Issaev asked if in the discussions with ISO REMCO, sharing of the ISO COMAR database had been suggested. He added that REMCO plan to adapt part of this database for metrological purposes. Dr Kaarls replied that a new column was being added to COMAR to indicate whether or not the institute in question was accredited, but the database was not currently qualified for use as a base for accreditation.

10.3 Consultative Committee for Electricity and Magnetism

Prof. Göbel, President of the Consultative Committee for Electricity and Magnetism (CCEM), presented his report on the 23rd meeting of the CCEM, held at the BIPM on 12 and 13 September 2002. The CCEM Working Groups on the ac Quantum Hall Effect, Radiofrequency Quantities, and Key Comparisons, met earlier the same week; the Working Group on Monitoring the Stability of the Kilogram by Electrical Methods met in June 2002, immediately after the CPEM.

Concerning the last mentioned working group, an order of magnitude improvement over the most accurate methods presently available is still required to begin monitoring the stability of the kilogram.

A survey on the present status of the SI values of the Josephson and von Klitzing constants, K_J and R_K, based on estimates made by CODATA in preparation for a new adjustment at the end of 2002, indicates that $K_{J\text{-}90}$ may agree less well with the new estimate of K_J than the 1998 estimate. However, the difference remains within the uncertainties. The present best estimate of R_K is in satisfactory agreement with $R_{K\text{-}90}$.

Concerning the realization of $R_{K\text{-}90}$, minor revisions to the "Guide to Reliable Measurements of the Quantized Hall Resistance" have been proposed and approved by the CCEM. The next step is to make the revisions publicly available and to solicit comments from a wide audience. As for ac measurements of the quantized Hall resistance (QHR), the working group took note of the confirmation by the METAS of the BIPM scheme for significantly reducing the frequency dependence by the use of gates. However, the formulation of guidelines for ac measurement of the QHR should not proceed at the present time.

A survey of advances in various laboratories of single-electron tunnelling work aimed at achieving accurate current and capacitance standards shows interesting progress but the present relative uncertainties are still of the order of one part in 10^4 and several parts in 10^7, respectively.

The KCDB now lists the results of four CCEM key comparisons, as well as those of seven BIPM ongoing key comparisons in electricity. An important element in the key comparison scheme is linking the results of CCEM and RMO key comparisons, which has been the subject of much discussion. A link has successfully been completed between two relatively large-scale key comparisons, a CCEM comparison and a EUROMET comparison, demonstrating that the key comparison scheme can be brought from its theoretical model to a practical realization.

In response to the concern expressed by various laboratory managers that key comparison activities consume too much staff time, the CCEM has decided to take measures to limit the number of key comparisons and to lighten the work for pilot laboratories and participants. Henceforth it will have two working groups operating in parallel to treat its key comparisons: the Working Group for Low-Frequency Quantities (WGLF), treating comparisons at eight defined quantities at low frequencies, and the Working Group on Radiofrequency Quantities (GT-RF), treating comparisons at seven defined quantities at high frequencies. The CCEM agreed that only one key comparison at a time would be allowed for a given quantity.

In discussing the work of the BIPM, the CCEM was of the opinion that the BIPM should have a watt balance.

Dr Quinn said he fully agreed with the CCEM's decision to limit the number of key comparisons being undertaken, and to lighten the work for both pilot laboratories and participants. He added that supplementary comparisons should take less effort and that their reports can be published in the KCDB without a reference value. The CIPM agreed that the wording of Section 12 of the “Guidelines for CIPM Key Comparisons” should be softened slightly, to read “supplementary comparisons… should be carried out following the spirit of the guidelines” rather than “must be carried out following these guidelines.” This rewording will be transmitted to the RMOs via the JCRB.

Concerning the proposal that the BIPM should develop a watt balance, Dr Quinn said that both the BIPM and the bureau of the CIPM were very much in favour.

10.4 Consultative Committee for Acoustics, Ultrasound and Vibration

Dr Valdés, President of the Consultative Committee for Acoustics, Ultrasound and Vibration (CCAUV), presented a report of the 3rd meeting of the CCAUV, held at the BIPM on 1 and 2 October 2002.

He summarized progress with the various CCAUV key comparisons, saying that the final report on CCAUV.U-K1 had been approved by the CCAUV, two other draft B reports (CCAUV.A-K1, CCAUV.V-K1) were approved in principle, subject to minor modification, and the reports of CCAUV.U-K2 and CCAUV.W-K1 were awaiting the last results. Once ready, the last two will be circulated to the CCAUV for approval by e-mail. One other key comparison (CCAUV.A-K3) is under way, and the protocols for two others (CCAUV.A-K2, and CCAUV.A-K4) are being finalized.

Guidelines for linking regional comparisons to CCAUV comparisons were discussed. Dr Von Martens reported that a robust linkage had been demonstrated between the results of CCAUV.V-K1 and APMP.AUV.V-K1, through the results of four laboratories that participated in both comparisons.

Proposals for future key comparisons were discussed and it was agreed that a comparison request/status form would be completed for each proposal and submitted to the Executive Secretary for follow-up action.

Dr Valdés's report sparked a discussion on the calculation of KCRVs. Some members called for guidance to the CCs on this subject, but it was generally accepted that there should be no entrenched position (see discussion under 8.1). Dr Valdés cited the report by Dr Von Martens (CCAUV.V-K1) as a model; this initially proposed five methods for calculating the key comparison reference value, and the final choice of method was based on feedback from the participants.

10.5 Consultative Committee for Mass and Related Quantities

10.5.1 Report of the 8th meeting

Dr Tanaka, President of the Consultative Committee for Mass and Related Quantities (CCM), presented a report on the 8th meeting of the CCM, which was held at the BIPM on 23 and 24 May 2002. He summarized the reports of the various working groups and listed the key comparisons under way or newly approved.

Dr Kaarls suggested that members of the *Ad Hoc* Working Group on Viscosity should be consulted as to which Consultative Committee (CCM or CCQM) they think the group should be affiliated. Dr Tanaka agreed to consult the participants in key comparisons in viscosity, and it was agreed to postpone any action until the CIPM meeting in 2003.

10.5.2 CCM Working Group on the Avogadro Constant

Prof. Göbel presented a summary of a new project proposal that has been sent to the directors of the various NMIs involved in the Avogadro project. This aims to achieve a relative standard uncertainty in N_A of 2 parts in 10^8 after six years. Having highlighted the risks and target milestones, he asked the CIPM for their recommendation to proceed with the project or not. Dr Inglis agreed that the working group would take heart from the CIPM's encouragement, and said that this proposal's more formal, structured outline would improve its rate of progress.

Dr Brown noted that the major problem was not structure but funding. Dr Schwitz commented that it was an important project and that the METAS would support an invitation to all NMIs to participate in its funding. He asked on what timescale the money would be required, to which Dr Göbel replied that the PTB had already purchased the first batch of enriched silicon. He agreed that a CIPM recommendation inviting financial participation from all NMIs would be helpful, and a small group was formed to draft the text. The CIPM approved Recommendation 3 (CI-2002) on the Avogadro constant.

10.6 Membership of Consultative Committees

The CIPM approved the following changes to membership of the Consultative Committees.

Committee	**New member**	**New observer**
CCRI	Section II: ENEA	Section I: SPRI (previously member)
	Section III: INMETRO	
CCAUV	INMETRO	
CCQM	SMU (previously observer)	
	SL (Ireland)	

CCU	Marc Himbert
CCM	CSIR (previously observer)

In addition, Prof. Moscati informed the Committee that Section I of the CCRI have invited the METAS to apply for membership. Pending receipt of the institute's official application, the CIPM approved it in principle to take effect on receipt of the formal application (which was received in February 2003).

10.7 Future meetings

The following dates were established for future meetings of the Consultative Committees, CIPM and CGPM.

2003

CCQM:	7-11 April
CCU:	17-18 April
CCT:	12-16 May
CCRI:	30 May
CCRI(I):	21-23 May
CCRI(II):	28-30 May
CCRI(III):	26-27 May
CCPR:	16-20 June
CCM working group chairmen:	24-27 June
CCL:	8-11 September
JCRB:	6-7 October
CIPM:	9-10, 17 October
CGPM:	13-17 October
CCEM working groups:	3-7 November

2004

CCEM:	September 2004
CCAUV:	October 2004
CCTF	2004 (at the time of the EFTF)

2005

CCM

11 JOINT COMMITTEE FOR TRACEABILITY IN LABORATORY MEDICINE (JCTLM)

Dr Kaarls presented a report on the work of the JCTLM (details of which are on the BIPM website). Two JCTLM working groups have been formed (one on CRMs and the other on reference laboratories), and the JCTLM will collaborate closely with the CCQM.

Dr Brown commented that the European Union (EU) Directive caused a major problem for the United States, where it is considered a deliberate ploy to create a barrier to trade. Dr Quinn said that he hoped the presence of an EU representative at meetings of the JCTLM would encourage the EU to refer to this Joint Committee in future. The Committee already has four primary outlets of influence through its four promoters: the BIPM, the IFCC, ILAC and the WHO (not yet confirmed). Dr Kaarls added that the deadline stated in the Directive must be flexible.

Dr Lusztyk expressed his full support for the BIPM's role in the JCTLM, but said it was difficult to see to what extent the BIPM could deal with the problem posed by the EU Directive. There was general agreement from the other CIPM members that the BIPM should not be drawn into commercial battles or assume a "rubber stamping" role, and Dr Kaarls agreed that it was not up to the BIPM to define reference materials.

12 METRE CONVENTION/OIML/ILAC JOINT WORKING GROUP

Prof. Wallard reported that the Joint Working Group of the CIPM, OIML and ILAC met in February 2002 at the Pavillon de Breteuil. One of the

important outcomes of this meeting was the decision to launch a new joint committee: the Joint Committee on Assistance to Developing Countries in Metrology, Accreditation, and Standardization (JCDCMAS), described more fully below in Section 13.

In the case of third party accreditation of NMIs there was a feeling that it would increase international confidence if the relevant accreditation bodies could release the names of the assessors. The NMIs would, he believed, be happy for the names to be made available, and the accreditation bodies would not break any commercial confidence normally required by private sector customers. Dr Inglis told the Committee that, in the APMP, NMIs were required to reveal the names of assessors. Dr Kaarls added that he did not see why the NMI itself should not provide a list of experts, but that this was a decision for the NMIs to take, not the BIPM.

The working group also reviewed the activities of the Joint Committee for Guides in Metrology (see Section 15).

13 JOINT COMMITTEE ON ASSISTANCE TO DEVELOPING COUNTRIES IN METROLOGY, ACCREDITATION, AND STANDARDIZATION (JCDCMAS)

Following the February 2002 meeting of the Joint Working Group of the ILAC, OIML and Metre Convention, representatives of the BIPM, IAF, IEC, ILAC, ISO, OIML, UNIDO and several RMOs met in April 2002 at the invitation of the BIPM. They discussed the setting up of a joint committee to help coordinate their work in support of "MAS" in developing countries. The suggestion met with widespread support and the JCDCMAS itself, enlarged through the participation of the ITU, met on 30 September 2002, just after the ILAC/IAF meetings in Berlin and the ISO Assembly in Stockholm.

The first task of the Committee was to define its terms of reference and outline a number of actions to be pursued over the next year.

The terms of reference are still being drafted but the central theme is that of coordination and expert advice. The Committee itself will not be a source of funding – that is properly the domain of funding and aid or donor agencies such as the World Bank, the European Commission, or other

international/intergovernmental organizations such as the World Trade Organization. However, several of the JCDCMAS partners are already active in providing help, advice and documentation to developing countries. The consensus of the meeting was that this work would be more effective and would present a much-needed coherent picture to countries and donor organizations if it could be coordinated. In particular there was enormous benefit if the component parts of MAS could be treated as a whole and any implementations in developing countries be planned logically and in a way that best met the strategies and development priorities of the countries concerned. The Committee believed that all too often a piecemeal approach served only to pursue narrow interests and that this was a disservice to the countries concerned. It could also give the impression that it was necessary to invest only in one aspect of MAS whereas, of course, an integrated MAS system is needed to provide effective support for developing countries.

The first meeting of the JCDCMAS therefore concluded that:

- All participants are invited to join a current ISO initiative to promote MAS.
- The involvement of the WTO is crucial, and a coherent MAS infrastructure helps applicant countries meet WTO requirements for membership. Current members of the WTO's Committee on Technical Barriers to Trade (TBT) will lobby for the BIPM and the ILAC to become Observers, and the WTO's attention will be drawn to the existence of JCDCMAS in a joint letter from all the organizations represented.
- The initial priority is to present MAS at a regional level, to be followed by sectoral and country-based initiatives.
- All partners will work on a set of presentation modules that set out the key elements and benefits of the part of MAS for which they have prime responsibility; these modules, together with one from the WTO on the relationship between MAS and trade, will be launched at a SADC event in Zambia in 2003. The presentations can then be repeated on suitable occasions, backed up by a MAS primer coordinated by the BIPM.
- Donor awareness needs to be raised. A meeting of national representatives of the World Bank, expected to take place in the autumn of 2003, would be an ideal opportunity to lobby this particular group and to seek liaisons with it, similar agencies, and the Committee.

The BIPM website now acts as host to the JCDCMAS and will provide links to databases and sources of information on the topic.

Prof. Wallard said that the BIPM's resources in this area are of necessity limited, and its future strategy is foreseen to be that of collaborating with initiatives taken by other bodies with better resources, helping to present a coherent position. This will meet the BIPM's primary objective of raising the profile of metrology, demonstrating the benefits of membership of the Metre Convention and increasing its close working partnerships with ILAC and OIML. As a result, the BIPM's profile, together with that of metrology as an essential element of MAS, will be raised within key bodies like the WTO and other donor agencies. This will also enable the BIPM to speak with additional authority and recognition when dealing with international and intergovernmental bodies on behalf of NMIs, especially in areas such as food and medicine, which are clear priorities for developing countries.

Prof. Kovalevsky invited comments from the CIPM. Dr Brown opened the discussion by pointing out that the BIPM, as a treaty organization, had no formal authority to represent its Member States' policies, nor to agree policies on their behalf in the JCDCMAS. The United States has not for example, delegated authority to the BIPM for discussions with the World Bank. And indeed the United States and the NIST have their own initiatives regarding developing countries, and independent interactions with the World Bank. Prof. Göbel agreed that as the JCDCMAS' terms of reference have not yet been finalized, it is impossible to judge whether or not there is a conflict of interests. Dr Quinn answered that the BIPM must be careful to show that its role in the JCDCMAS is to support the coordination of international organizations, not to act as a representative of the Member States of the Metre Convention.

Prof. Ugur expressed concern that the BIPM was establishing new services for States that are not yet members, at the same time as cutting important services for Member States.

The Committee agreed that role of the BIPM (and Metre Convention) in the JCDCMAS should be approved by the CGPM, and Prof. Wallard, Dr Brown, Prof. Kovalevsky and Dr Quinn were charged with formulating a Resolution for the Committee's approval. This new Resolution was labelled X pending its insertion into the Convocation (see Section 9.3 above).

Prof. Göbel requested that a document be prepared, outlining the BIPM's interactions with other organizations.

14 BILATERAL CONTACTS WITH OTHER INTERNATIONAL ORGANIZATIONS

14.1 World Health Organization

The Committee authorized Dr Quinn to sign the Memorandum of Understanding (MoU) between the CIPM and the WHO, already signed on behalf of the WHO by Dr Asamoa-Baah, Executive Director.

14.2 World Meteorological Organization

Further to the Secretary's report (section 2.7) Dr Quinn told the Committee that initial contact had been established with the WMO. Prof. Issaev commented that the terminology in their document No. 8 was poor, and Dr Quinn expressed his hope that close contacts between the two organizations would improve that.

14.3 World Trade Organization

The BIPM's application for observer status of the WTO TBT Committee had already been discussed under items 2.11 and 13 of the agenda. Prof. Issaev noted that the OIML already has observer status, and he and Prof. Göbel suggested that the BIPM could form a link with the OIML in this respect. Prof. Kovalevsky said that this matter would be discussed in February, at the next meeting of the CIPM/OIML/ILAC Working Group.

14.4 International Laboratory Accreditation Cooperation

Prof. Wallard reminded the CIPM than an MoU with ILAC was signed in November 2001 and the text is available on the BIPM website. He attended and made a presentation to the ILAC General Assembly in September 2002.

He reported that the JCRB felt that a number of issues needed attention, particularly as regards CMCs. For example, some of the services offered by laboratories accredited through ILAC are not coherent with the CMCs declared in the KCDB; sometimes a laboratory with traceability through a second laboratory, will quote a smaller uncertainty than that second

laboratory. Part of the problem may be that "best CMCs" are quoted rather than "routine CMCs".

Prof. Wallard summarized by saying that this problem must be looked at carefully by the RMOs, and that ILAC and the JCRB had therefore decided to form a joint working group. It is important to coordinate the key comparisons and CMCs.

Dr Inglis agreed that close collaboration between metrology institutes and accreditation bodies is essential and should be encouraged at the national level. Important interactions extend up through the regional level (such as between the APLAC and APMP) right up to the BIPM and ILAC. Dr Kaarls concurred that the CIPM MRA was there also to serve accreditors, and Dr Quinn added that the initial idea for the MRA stemmed from an ILAC meeting ten years ago, at which the mutual recognition of calibration certificates was discussed. The CIPM MRA answers that need, as well as the mutual recognition of NMIs.

Several members of the Committee raised the problem of "competition" between accreditation bodies and NMIs. Dr Brown said she would not like to see the BIPM recommending that RMOs include accreditation bodies as participants in their key comparisons. She accepted that each region was different, but said that in the United States the accreditation bodies want to participate with the NIST to a much greater extent than the NIST can afford.

Prof. Issaev encouraged the establishment of a document elaborating the interface between accreditation, legal metrology and metrology systems and Prof. Kovalevsky agreed that this was a very useful project which would be discussed by the group. Dr Hengstberger added that a clear message about established working practice was particularly important for developing countries.

15 JOINT COMMITTEE FOR GUIDES IN METROLOGY

Dr Quinn reported that the Working Group 2 of the Joint Committee for Guides in Metrology (JCGM), on the International Vocabulary of Basic and General Terms in Metrology (VIM), has reached consensus on the revisions to be made to Chapter 1. He hopes that a new draft of the VIM will be ready

for distribution in the spring of 2003. The working group is meeting again at the BIPM in November 2002.

The JCGM Working Group 1, on the Expression of Uncertainty in Measurement (GUM), has circulated additional documents and hopes to have a text ready for distribution in 2003.

16 WORK OF THE BIPM

16.1 Director's report on the scientific work of the BIPM

The Director introduced his report in the following terms:

In the past, the annual Director's Report on the Activity and Management of the BIPM has made little mention of a number of services supplied by the BIPM, not directly related to the scientific work, that in recent years have become of increasing importance and take up a growing proportion of the time of the senior staff. I shall begin this year's report with some remarks concerning these other services.

In a questionnaire to directors of NMIs in November 2001 concerning the services supplied by the BIPM, the different types of service were listed under the following headings:

A the two specific services related to mass and time;

B calibrations for other quantities;

C ongoing key comparisons with respect to BIPM reference standards;

D transfer of technology and experience;

E research and development aimed at unique reference standards or materials and transfer standards;

F support to Consultative Committees and working groups;

G the BIPM website;

H the BIPM key comparison database;

I publications;

J representation on behalf of NMIs to other international organizations;

K establishment of formal links with other organizations;

L other services and activities.

The services not directly related to the scientific work are essentially those coming under the headings D, F, J and K in the above list. The replies of directors of NMIs to the November 2001 questionnaire clearly highlighted the importance that these services now have and the value placed on them by directors.

The support to Consultative Committees, F, is one that takes up a very significant proportion of the time of the heads of the scientific sections at the BIPM but it is one that often saves a great deal of time within the Consultative Committees and contributes to their efficiency. This year much effort has been devoted to dealing with the final stages of reports of key comparisons and with the linking of CIPM and regional metrology organization (RMO) key comparisons. As regards technology transfer, D, this takes place during calibrations of standards or during comparisons and is an effective way of distributing to many NMIs the expertise and experience of the scientific staff of the BIPM.

The other two activities, J and K, are time-consuming ones for the Director of the BIPM, but are tasks that the directors of NMIs see as of escalating importance. Examples this year have been the participation of the BIPM in the creation of two new Joint Committees: one for Traceability in Laboratory Medicine, principally in collaboration with the IFCC, the ILAC and the WHO; and one on Coordination of Assistance to Developing Countries in Metrology, Accreditation and Standardization, principally in collaboration with the IEC, ISO, OIML and the UNIDO. In their own ways, each of these new Joint Committees is a significant pointer for future responsibilities of the BIPM. In addition, formal agreements have or are being made between the CIPM and the World Meteorological Organization in respect of reliability of data for global climate studies and with the WHO with regard to traceability in laboratory medicine.

For all of the activities and services included under the headings D, F, J and K, whatever success we have in carrying them out stems from the scientific expertise and credibility that come only from the active participation of the BIPM staff in laboratory work. It is for this reason that future extensions of the BIPM laboratory work into organic chemistry and bioanalysis will be essential.

The following is a summary of the scientific work of each section on 1 July 2002:

Length: The work of the Length section has been profoundly affected by recent developments in optical frequency comb metrology. These have made it possible to make direct frequency calibrations, related to primary frequency standards, of visible laser frequencies at levels of accuracy that far exceed those that could be achieved by beat-frequency or frequency-chain techniques.

As a result we have reoriented our activities: the traditional BIPM programme of heterodyne calibrations of red iodine-stabilized lasers has been terminated, and a state-of-the-art comb-based facility completed with which we can make absolute frequency measurements on a wide range of NMIs' laser systems. The BIPM's green iodine-stabilized Nd:YAG system continues to offer exceptional short-term stability and has been used in several comparisons between the BIPM and NMIs.

I am pleased to take this occasion to acknowledge the work of J.-M. Chartier who retired as head of the Length section in February 2002 just thirty years after he started the long series of comparisons of He-Ne lasers at a wavelength of 633 nm. For all of this time, the BIPM comparisons of these lasers provided the basic reference for uniformity of length measurements throughout the world.

We have already completed a number of comparisons and calibrations of NMI laser systems whilst continuing to improve the performance of the BIPM comb generator. A second comb is under construction so that the BIPM can investigate systematic effects and learn from its experience so as to prepare a portable system which can meet future needs from NMIs for on-site calibrations and comparisons.

We also are establishing whether the frequency-comb techniques can be extended to the near infrared by a variety of methods. If successful, we have the possibility of checking the frequency of the methane-stabilized He-Ne laser system obtained from complex frequency-chain measurements. This is of interest to NMIs that maintain traditional frequency-chain capabilities in which the methane-stabilized laser is a key reference point.

A small dimensional metrology programme maintains the BIPM's core competence in displacement interferometry. It continues to enable us to improve the performance of gravimeters and other in-house applications. In gravimetry itself, the sixth international comparison of gravimeters was completed in the Summer of 2001 and included absolute as well as relative

gravimeters. In addition to establishing high-accuracy measurements of g throughout the BIPM reference gravimetry micronetwork, we learned much about the performance of these instruments and how to improve them.

Mass: Recalibration of national prototypes of the kilogram are of continuing interest to members of the Metre Convention. Since the third periodic verification of national prototypes of the kilogram (1988-1992), fourteen such standards have been returned to the BIPM for recalibration. In contrast to the third verification, cleaning and washing of the prototypes by the BIPM is at the discretion of each national laboratory. Only six laboratories have chosen to have their standards cleaned and washed. The results to date have been summarized in a recent CCM document. The BIPM's own 1 kg prototypes are used as reference standards for these calibrations and, consequently, the importance of maintaining these standards is crucial. Our comparisons of air-density measurements determined simultaneously by the CIPM-recommended equation-of-state and by buoyancy artefacts lead us to conclude that: 1) the air density determined by the artefacts method is systematically offset by about 1 part in 10^4 from the air density inferred from the equation-of-state; 2) the artefacts method has a potential accuracy of 1 part in 10^5; and 3) great attention must be paid to the artefacts in order for them to achieve their potential. Much of this work was done in collaboration with the PTB. The observed discrepancy between the two methods is consistent with the uncertainty usually assigned to the equation-of-state. The new hydrostatic balance is now fully operational. Last year, the apparatus was used in a slightly different mode to determine the vertical gravitational gradient *in situ*. A new ellipsometry facility has been built to study surface changes of mass standards as a function of humidity and time.

An improved apparatus for the determination of G, the Newtonian constant of gravitation, has been designed and is being constructed. Some components of the new apparatus have already been tested. By comparison with our previous instrument, parasitic modes have been greatly reduced and the servo-control is improved through digital filtering.

Time: The process of calculation of International Atomic Time (TAI) has been automated to a large extent, thus speeding up the publication of the monthly BIPM *Circular T*. The medium-term stability of TAI, expressed in terms of an Allan deviation, is estimated to be about 0.6×10^{-15} for averaging times of 20 d to 40 d, and its accuracy is based on the measures of six primary frequency standards which include two caesium fountains (NIST-F1 and PTB CSF1). The scale unit of TAI has been estimated to match the SI

second to within 2×10^{-15} since August 2001. An important part of the activity of the section deals with studies of time and frequency comparison using navigation satellite systems such as GPS and GLONASS, with particular emphasis on multi-channel multi-system techniques, and on the use of GPS carrier-phase measurements. The network of international time links, classically relying only on the GPS common-view technique based on C/A-code measurements obtained from one-channel receivers, has been enriched by the introduction of six GPS multi-channel links and nine two-way time-transfer links. Calibration programmes for GPS receivers have been organized and run by the section. Two active hydrogen masers have been installed in the TAI laboratory since the end of 2001 ; they are used for time- and frequency-transfer experiments and they provide the frequency reference to the Length section.

Research work is also dedicated to space-time reference systems, particularly to the relativistic framework for defining and realizing coordinate times. Since January 2001 the BIPM Time section and the USNO have jointly taken responsibility for establishing conventions for space-time reference systems for the Conventions Product Centre of the International Earth Rotation Service. Other research subjects include pulsars, future clocks in space and atom interferometry.

Electricity: The Electricity section continues its participation in key comparisons and in the evaluation of their results, contributing also to the task of linking the results of CIPM and RMO key comparisons. This year we completed two new bilateral comparisons as part of the BIPM ongoing key comparison of voltage standards and participated in CCEM-K10, a comparison of 100 Ω resistance standards. In addition, a bilateral comparison was carried out as a follow-up to the CCEM-K4 and EUROMET.EM-K4 comparisons of 10 pF and 100 pF capacitance standards. We are participating in a EUROMET project designed to investigate the qualities of 1 V programmable arrays of Josephson junctions that show significantly improved performance compared with conventional arrays. We demonstrated that the programmable arrays can be used to measure a standard cell directly without fear of modifying the emf of the cell. Work is under way to achieve a higher level of automation in the BIPM voltage measurements, a project that involves the development of high-quality switching networks. We estimate the relative uncertainty of our present realization of a representation of the farad based on the recommended value of the von Klitzing constant to be about 4 parts in 10^8. A programme has been started aimed at reducing this

uncertainty. Our goal is to improve the performance and characterization of the calculable ac-dc resistance that links measurements at kilohertz frequencies to those made at very low frequencies (1 Hz). This year, considerable effort was devoted to the complete renovation of the three thirty-year-old oil baths that maintain our resistance standards at constant temperature. In collaboration with a colleague from the METAS and at the request of the CCEM, a new version of the 1988 document "Technical Guidelines for Reliable dc Measurements of the Quantized Hall Resistance" has been prepared for discussion at this year's meeting of the CCEM. Work continues on the characterization of stability and noise of voltage standards and nanovoltmeters. Calibrations were carried out for the NMIs of eight Member States.

Radiometry, photometry, thermometry: The international comparison of spectral responsivity measurements in the visible piloted by the BIPM is completed. Draft A of the report was recently circulated among the participants. A supplement presenting the results using additional methods for the calculation of the reference value is in preparation. The cryogenic radiometer facility was used to continue the regular calibration of our reference detectors which form the basis for the absolute measurements in photometry and radiometry.

A cooperation has been started with the NMIJ (Japan) on the characterization of metal-carbon eutectic fixed points, which might in the future lead to an improved temperature scale. One guest scientist from the NMIJ will stay for a total period of one year at the BIPM to set up a high-temperature furnace with fixed-point crucibles to realize melting plateaus. It is planned to measure their thermodynamic temperatures with filter radiometers calibrated against our cryogenic radiometer.

Following the decision of the CIPM in 2001, the photometric units maintained by the BIPM were adjusted to the key comparison reference values of the previous comparisons for luminous intensity and luminous flux. The calibrations of photometric lamps for the NMIs of several Member States of the Metre Convention have been resumed after a break to complete renovations to the laboratory.

In September 2001 the CCT decided to carry out a key comparison of water triple-point cells and charged the BIPM with its organization. A technical protocol was drawn up in close cooperation with the BNM-INM and the NIST. The objectives of the comparison are a direct comparison of high-quality water triple-point cells, showing the reproducibility of the water

triple-point temperature, and a comparison of the various national reference cells. The comparison will be organized in a collapsed star form with each cell measured by its corresponding laboratory and then sent to the BIPM for comparison. Two staff members of the BNM-INM and the UME will support us during the six months of measurements. In view of this comparison the thermometry laboratory was modernized to reduce the measurement uncertainty.

Ionizing Radiation: Equipment renewal is continuing with the design and construction now completed of a voltage divider for the negative polarity high-tension generator for the medium-energy x-ray tube. The new ^{60}Co source, for which the protection systems are now in place, is currently being characterized. A new Monte Carlo code is being used to simulate the ^{60}Co radiation beam as an aid for the determination of beam characteristics and appropriate correction factors. Eight dosimetry comparisons with six NMIs and twenty-nine calibrations for nine NMIs have also been undertaken this year in the various photon beams. Following decisions of the CCRI, the dosimetry comparison results have been reanalysed prior to entry in Appendix B of the KCDB and, once approved by the participants, will appear in the database. In the radionuclide field, five key comparisons are under way with the results already analysed for the ^{238}Pu comparison. The other four comparisons of activity measurements are for ^{204}Tl, ^{32}P, ^{65}Zn and ^{241}Am with up to twenty-two NMIs participating in each comparison. Reports of two earlier comparisons of ^{152}Eu and ^{89}Sr are in preparation. Twelve laboratories have submitted eighteen different radionuclides to the International Reference System (SIR) this year and the total number of comparisons is now sixty-two, including two new radionuclides, ^{18}F (which has a half-life of less than two hours) and ^{222}Rn, which is a gas. The Key Comparison Working Group is preparing all the radionuclide data for entry in the KCDB. Work continues on the SIR efficiency curves to reduce the uncertainties. Impurity activity levels were measured using the BIPM Ge(Li) gamma spectrometer for five radionuclides that had been submitted to the SIR. Characterization continues of both the HPGe spectrometer and the improved triple-to-double coincidence method that is being developed for absolute measurement of pure beta emitters.

Chemistry: The collaboration between the NIST and the BIPM on ozone standards is continuing. Two standard reference photometers (SRP 27 and 28) have been characterized against the instruments operated at the NIST and installed at the BIPM. The instruments have shown agreement that is

consistent with the evaluated uncertainty of the measurements. The PTB has loaned SRP 19 to the BIPM, and the stability of the three instruments currently at the BIPM is being evaluated in readiness for CCQM-P28. In preparation for this pilot exercise and an eventual key comparison, a study to determine the level of national activity and facilities for primary ozone standards is under way.

A facility for gas-phase titration, as an alternative method for the determination of ozone concentrations, is under development. A primary facility for the dynamic preparation of nitrogen dioxide gas standards is being established. To this end a balance with a magnetic suspension system to measure mass loss from permeation tubes has been installed and an evaluation of the stability of the system is being carried out. A facility for the comparison of nitrogen monoxide standards is being set up, and an auto-sampler system will be integrated into the facility towards the end of 2002.

Information technology and quality systems: The number of consultations of the BIPM homepage from the outside is still increasing with on average about 1350 connections per day being made to the BIPM website. In view of the importance of the information made available on-line, a back-up system was installed. As part of a general improvement programme, more features were made available to internal and external users of the BIPM homepage. Following the Director's decision to establish a quality system, work on the initial documentation has started. The first procedures and forms have been issued.

BIPM key comparison database: The BIPM key comparison database (KCDB) is fully operational. Appendix B covers some 450 key and supplementary comparisons conducted under the auspices of Consultative Committees and of Regional Metrology Organizations of which thirty-six now have final results published. Results are now being published in Appendix B at a rate of about two new results each month. Appendix C presently contains some thirteen thousand calibration and measurement capabilities of national metrology institutes covering nearly all metrology areas. In addition to the publication of data, considerable efforts are being devoted to the improvement of the underlying database structure and development of web programming. The KCDB website receives an average of 2500 visits each month.

Joint Committee of the Regional Metrology Organizations and the BIPM (JCRB): The JCRB meets twice a year; it is the forum in which issues relating to the implementation of the MRA are being aired and operating

decisions taken. A BIPM interactive website was put in place for the RMO representatives to the JCRB, who use it to manage the review of the CMCs submitted by member NMIs. Dr Angela Samuel is provisionally on secondment at the BIPM from the NML-CSIRO to serve as Executive Secretary of the JCRB.

16.2 Present and future scientific work

Prof. Kovalevsky thanked the scientific staff of the BIPM for their interesting presentations to the CIPM and Dr Quinn said he was proud to be the Director of a lab with such a wide range of activities. He renewed his thanks to the NIST for their help and support in setting up the Chemistry section.

Looking ahead, he said that two major new projects for the BIPM will be the construction of a Watt balance and the development of a calculable capacitor. The Electricity section is also investigating the possibility of a programmable Josephson array.

The Mass section is undertaking a study of surfaces in vacuum and in air, which is of relevance to the Avogadro project.

16.3 Quality system

Dr Quinn told the Committee that a quality system is being put in place for calibration services at the BIPM and the first internal reviews will take place early in 2003. The system will meet the requirements of ISO/IEC 17025 and will include peer reviewers from NMIs. He said that services such as the calculation of TAI and the running of the KCDB are not currently included, although procedures for these are of course also in place. He reminded the Committee that very close peer review is already in place for UTC, and the CCM Working Group on Mass Standards has a review process in place for the mass standards produced at the BIPM. Other Consultative Committees might like to put review procedures in place for other BIPM services.

16.4 Legal liability

Dr Quinn then raised the question of the legal liability of the BIPM for the services it provides. He cited the example of the GALILEO project, which is committed to using UTC and the question has been raised as to what is the legal liability of the BIPM for the content of *Circular T.* The principal data in

Circular T are the differences [$UTC - UTC(k)$] where UTC (k) is the time scale maintained by laboratory k.

Prof. Göbel noted that the same question applies to all NMIs for the calibration services they offer. Dr Brown added that individual employees at the NIST are held legally responsible, but no action can be taken against the NIST itself. Many employees therefore have their own legal advisor.

For the case of the BIPM, Dr Quinn said he was seeking advice from other international organizations and legal sources.

16.5 BIPM website

Dr Quinn reported that a new version of the BIPM website is being developed and is expected to be launched in 2003. At the suggestion of Dr Valdés, he agreed that the text of the Metre Convention would be added.

16.6 Depository of the metric prototypes

On 9 October 2002, at 17 h 15, in the presence of the President of the International Committee for Weights and Measures (CIPM), the Director of the International Bureau of Weights and Measures (BIPM) and the representative of the Curator of the Archives Nationales de France, the visit to the depository of the metric prototypes at the Pavillon de Breteuil took place.

The three keys necessary to open the depository had been assembled: the key entrusted to the care of the Director of the BIPM, the one deposited at the Archives Nationales in Paris which Mr M. Rousseau, at the Direction of the Archives Nationales, had brought, and finally the one kept by the President of the International Committee.

The doors of the vault having been opened as well as the safe, we observed the presence in the safe of the international prototype of the kilogram and its official copies.

The following indications on the measuring instruments placed in the safe were noted:

temperature:	22 °C
maximum temperature:	24 °C
minimum temperature:	21.5 °C
relative humidity:	59 %

We then locked the safe as well as the doors of the vault.

The Director	for the Curator	The President
of the BIPM	of the Archives de France	of the CIPM
T.J. Quinn	M. Rousseau	J. Kovalevsky

17 *METROLOGIA*

Dr Quinn gave the CIPM a brief background to the proposal that Institute of Physics Publishing (IOPP), UK, be licensed to publish *Metrologia* on behalf of the BIPM, He reiterated the main points, which are that:

(a) the BIPM would retain the ownership, copyright and editorial control of *Metrologia*;

(b) the BIPM would receive articles submitted, arrange for refereeing and decide whether or not an article should be published;

(c) the IOPP would then deal with editing, proofs, printing, distribution, marketing and all matters related to subscriptions.

A deal has been negotiated in which the BIPM would receive a guaranteed annual royalty based on subscriptions sales.

One possible disadvantage is that *Metrologia* might be perceived as a European journal; care would have to be taken in designing the cover page of the journal in this respect. The Editorial Board would be fully involved with setting policy and annual review meetings would take place between IOPP and the BIPM. Dr Quinn noted that the International Atomic Energy Agency has recently entered into a similar agreement with IOPP for its journal *Nuclear Fusion*, and they have informed the BIPM that this new arrangement has proved wholly satisfactory.

Prof. Wallard informed the Committee that he is a member of the IOP Council, which has overall responsibility for IOPP and that, due to the potential conflict of interests, he has not taken part in the negotiations.

Dr Lusztyk noted that *Metrologia* had previously been published by Springer, and asked whether the problems encountered there would not be encountered with IOPP. Prof. Ugur also recommended that the publication

section at the IMEKO be contacted, in the light of their recent experiences with Elsevier. He pointed out that knowledge of the problems IMEKO has encountered might be of benefit when negotiating with IOPP.

Prof. Mills said he hoped that IOPP's estimates about subscriptions were correct, but noted that it is very rare these days for a library to be able to start a new subscription. Dr Quinn explained that IOPP hoped to encourage new subscriptions by offering a favourable package deal with *Measurement Science and Technology*.

After checking that the BIPM would retain an influence on the journal pricing the Committee approved the proposal. The contract will be signed with a start date of 1 January 2003 for an initial period of five years.

18 ADMINISTRATIVE AND FINANCIAL AFFAIRS

Mrs B. Perent, Administrator of the BIPM, was invited to join the CIPM for the discussions on administrative and financial matters.

18.1 *Rapport annuel aux Gouvernements* for 2001; quietus for 2001

Dr Quinn confirmed that the *Rapport annuel aux Gouvernements des Hautes parties contractantes sur la situation administrative et financière du Bureau International des Poids et Mesures en 2001* had been distributed in March 2002, and the CIPM duly approved the accounts for 2001. The required formal discharge was given to the Director and Administrator of the BIPM.

18.2 Progress report on the 2002 exercise; budget for 2003

Dr Quinn presented a summary of the BIPM's accounts for 2002 and the proposed budget for 2003. Both were approved. Dr Quinn added that the BIPM hoped soon to receive Italy's contributions for 2002.

Budget for 2003

Income		
		euros
Budgetary income:		
1. Contributions from the States		9 117 696
2. Interest on capital		285 000
3. Miscellaneous income		21 000
4. Subscriptions from the Associates		137 984
5. *Metrologia*		73 000
6. Transfer from account I		202 020
Total		**9 836 700**

Expenditure		
A. *Staff expenses:*		
1. Salaries	4 297 000	
2. Family and social allowances	868 900	5 633 500
3. Social expenses	467 600	
B. *Contribution to the pension fund:*		1 438 000
C. *Operating expenses:*		
1. Heating, water, electrical energy	159 200	
2. Insurance	31 000	
3. Publications	108 000	
4. Office expenses	150 000	1 194 200
5. Meeting expenses	182 000	
6. Travel expenses and freight charges	349 000	
7. Library	177 000	
8. Bureau of the CIPM	38 000	
D. *Laboratories:*		1 211 000
E. *Buildings* (major maintenance and renovation)*:*		300 000
F. *Miscellaneous and unforeseen expenses:*		60 000
Total		**9 836 700**

Dr Hengstberger asked if the cost of producing reports of the various Committees could be reduced by providing electronic-only (CD-ROM) versions. The Director explained that all official reports were indeed available in electronic form on the website, but that the most significant costs in the production of these reports relate to the editorial input (including translation).

18.3 BIPM staff

The Committee approved the Director's proposal that Dr E.F. Arias, Head of the Time section, be promoted to *Physicien Chercheur Principal*.

Dr Lusztyk requested that more information about the BIPM staff structure and career progression be distributed before next year's CIPM meeting.

18.4 Efficiency initiatives

Mrs Perent reported that the BIPM had already made a number of improvements in terms of its efficiency but that it did not seem possible to reduce further the expenditure on cleaning, caretaking, maintaining the gardens, or electrical and air-conditioning maintenance.

She explained that various options have been considered, but hiring outside contractors to look after the garden would in fact increase costs by about 20 %. Replacing the man on-site who looks after electrical and air-conditioning maintenance by repair men on call would significantly increase delays and not prove much cheaper. Cleaning is already mostly done by an outside contractor. She recommended no further changes.

19 OTHER BUSINESS

19.1 BIPM metrology summer school 2003

Dr Quinn reported that preparations for the BIPM Metrology Summer School are well under way. He is co-directing the school with Prof. Marc Himbert

from the BNM-INM, and the scientific secretary is Dr C. Thomas from the BIPM.

The School will take place at the BIPM from 21 July to 1 August 2003, and lectures will be given by a large number of high-level scientists, including two Nobel laureates. The travel and lodging costs of the teachers will be paid for by the BIPM. There will be places for about eighty students, who will be asked to cover their own expenses (with the help of their NMIs). If the course is oversubscribed, students will have to be selected on the basis of their curricula vitae.

Prof. Kovalevsky noted that participation in the school would be restricted to staff from NMIs, with priority given to the NMIs of Member States, and was thus quite different from the Varenna School. Prof. Leschiutta explained that the Varenna School was instigated primarily for young researchers in the Italian metrology laboratories, and typically 75 students would be selected from about 115 applications. He added that the next Varenna School on Fundamental Constants would take place in 2006.

Dr Lusztyk and Dr Inglis asked about Associates of the CGPM, suggesting that their students should also be eligible to attend, on the basis of merit. However, it was agreed that applications from NMIs in Associate States would only be accepted if there was sufficient space. Also, Dr Quinn noted that this School is not intended to be for developing countries.

Dr Valdés commented that the *Proceedings of the Varenna School* was a very interesting and useful book, and asked if it would not be possible to produce a similar publication. Dr Quinn said that he wanted to avoid imposing extra work on the lecturers and therefore no formal proceedings would be published for the BIPM School. However, he would ask the lecturers to make their lecture notes available, and of course a CD of all notes in electronic form could be distributed.

19.2 National Conference of Standard Laboratories International

Prof. Wallard informed the Committee that he has been asked to join the board of the National Conference of Standard Laboratories International (NCSLI). He had checked with the direction of the NIST that this would not raise any problems, and told the Committee that he considered it a very useful link. With such a role he will be able to keep the NCSLI board broadly in touch with the activities of the BIPM.

Dr Lusztyk agreed that the NCSLI was an excellent forum for presenting metrology and Dr Inglis congratulated Dr Wallard on the appointment.

Dr Hengstberger said that he would welcome any progress Prof. Wallard can make in enlightening the NCSLI with regard to developing countries. He said that previously some opinions expressed by delegates had been very biased, and that South Africa no longer participated in NCSLI activities. Dr Brown noted that in fact this unfortunate situation had arisen due to one particular individual, not NCSLI opinion, and she has talked to the President of the NCSLI about it.

Finally, Dr Bennett told the Committee that EUROMET now has official representation at NCSLI, and suggested that other RMOs may like to do the same.

19.3 Metrology in Italy

Prof. Leschiutta informed the Committee that the Italian Government is considering creating a national authority on metrology within the Italian Ministry of Education and Research. This would imply a reorganization of the IMGC, IEN and ENEA. The new authority will not include legal metrology.

19.4 Recommendations adopted by the CIPM

The CIPM adopted three recommendations:

- Recommendation 1 (CI-2002) on the revision of the practical realization of the definition of the metre;
- Recommendation (CI-2002) on dose equivalent;
- Recommendation 3 (CI-2002) on the Avogadro constant.

20 DATE OF NEXT MEETING

Prof. Kovalevsky thanked the Committee for their cooperative spirit, and closed the meeting saying it had been long but highly productive. He reminded members that the CIPM would next meet on 9 and 10 October 2003, in the week before the 22nd General Conference, and on the afternoon of 17 October, after the close of the General Conference.

RECOMMENDATIONS
ADOPTED BY THE
INTERNATIONAL COMMITTEE
FOR WEIGHTS AND MEASURES

RECOMMENDATION 1 (CI-2002): Revision of the practical realization of the definition of the metre

The International Committee for Weights and Measures,

recalling

- that in 1983 the 17th General Conference (CGPM) adopted a new definition of the metre;
- that in the same year the CGPM invited the International Committee (CIPM)
  - to draw up instructions for the practical realization of the metre,
  - to choose radiations which can be recommended as standards of wavelength for the interferometric measurement of length and draw up instructions for their use,
  - to pursue studies undertaken to improve these standards and in due course to extend or revise these instructions;
- that in response to this invitation the CIPM adopted Recommendation 1 (CI-1983) (*mise en pratique* of the definition of the metre) to the effect
  - that the metre should be realized by one of the following methods:

  (a) by means of the length l of the path travelled in vacuum by a plane electromagnetic wave in a time t; this length is obtained from the measured time t, using the relation $l = c_0 \cdot t$ and the value of the speed of light in vacuum c_0 = 299 792 458 m/s,

  (b) by means of the wavelength in vacuum λ of a plane electromagnetic wave of frequency f; this wavelength is obtained from the measured frequency f using the relation $\lambda = c_0 / f$ and the value of the speed of light in vacuum c_0 = 299 792 458 m/s,

  (c) by means of one of the radiations from the list below, whose stated wavelength in vacuum or whose stated frequency can be used with the uncertainty shown, provided that the given specifications and accepted good practice are followed;

- that in all cases any necessary corrections be applied to take account of actual conditions such as diffraction, gravitation or imperfection in the vacuum;
- that in the context of general relativity, the metre is considered a unit of proper length. Its definition, therefore, applies only within a spatial extent sufficiently small that the effects of the non-uniformity of the gravitational field can be ignored (note that, at the surface of the Earth, this effect in the vertical direction is about 1 part in 10^{16} per metre). In this case, the effects to be taken into account are those of special relativity only. The local methods for the realization of the metre recommended in (b) and (c) provide the proper metre but not necessarily that given in (a). Method (a) should therefore be restricted to lengths l which are sufficiently short for the effects predicted by general relativity to be negligible with respect to the uncertainties of realization. For advice on the interpretation of measurements in which this is not the case, see the report of the Consultative Committee for Time and Frequency (CCTF) Working Group on the Application of General Relativity to Metrology (Application of general relativity to metrology, *Metrologia*, 1997, **34**, 261-290);

- that the CIPM had already recommended a list of radiations for this purpose;

recalling also that in 1992 and in 1997 the CIPM revised the practical realization of the definition of the metre;

considering

- that science and technology continue to demand improved accuracy in the realization of the metre;
- that since 1997 work in national laboratories, in the BIPM and elsewhere has identified new radiations and methods for their realization which lead to lower uncertainties;
- that there is an increasing move towards optical frequencies for time-related activities, and that there continues to be a general widening of the scope of application of the recommended radiations of the *mise en pratique* to cover not only dimensional metrology and the realization of the metre, but also high-resolution spectroscopy, atomic and molecular physics, fundamental constants and telecommunication;
- that a number of new frequency values with reduced uncertainties for radiations of high-stability cold atom and ion standards already listed in the recommended radiations list are now available, that the frequencies of

radiations of several new cold atom and ion species have also recently been measured, and that new improved values with substantially reduced uncertainties for a number of optical frequency standards based on gas cells have been determined, including the wavelength region of interest to optical telecommunications;

- that new femtosecond comb techniques have clear significance for relating the frequency of high-stability optical frequency standards to that of the frequency standard realizing the SI second, that these techniques represent a convenient measurement technique for providing traceability to the International System of Units (SI) and that comb technology also can provide frequency sources as well as a measurement technique;

recognizes comb techniques as timely and appropriate, and recommends further research to fully investigate the capability of the techniques;

welcomes validations now being made of comb techniques by comparison with other frequency chain techniques;

urges national metrology institutes and other laboratories to pursue the comb technique to the highest level of accuracy achievable and also to seek simplicity so as to encourage widespread application;

recommends

- that the list of recommended radiations given by the CIPM in 1997 (Recommendation 1 (CI-1997)) be replaced by the list of radiations given below, including
  - updated frequency values for cold Ca atom, H atom and the trapped Sr^+ ion,
  - frequency values for new cold ion species including trapped Hg^+ ion, trapped In^+ ion and trapped Yb^+ ion,
  - updated frequency values for Rb-stabilized lasers, I_2-stabilized Nd:YAG and He-Ne lasers, CH_4-stabilized He-Ne lasers and OsO_4-stabilized CO_2 lasers at 10 μm,
  - frequency values for standards relevant to the optical communications bands, including Rb- and C_2H_2-stabilized lasers.

CIPM list of approved radiations for the practical realization of the metre, 2002: frequencies and vacuum wavelengths

This list replaces those published in *BIPM Proc.-Verb. Com. Int. Poids et Mesures*, 1983, **51**, 25-28, 1992, **60**, 141-144, 1997, **65**, 243-252 and *Metrologia*, 1984, **19**, 165-166, 1993/94, **30,** 523-525, 1999, **36**, 211-215.

In this list, the values of the frequency f and of the vacuum wavelength λ should be related exactly by the relation $\lambda \cdot f = c_0$, with c_0 = 299 792 458 m/s but the values of λ are rounded.

The data and analysis used for the compilation of this list are set out in the associated Appendix L 2 of the Consultative Committee for Length (CCL): Source data for the list of recommended radiations, 2001.

It should be noted that for several of the listed radiations, few independent values are available, so the estimated uncertainties may not reflect all sources of variability.

Each of the listed radiations can be replaced, without degrading the accuracy, by a radiation corresponding to another component of the same transition or by another radiation, when the frequency difference is known with sufficient accuracy. Such radiations are listed in Appendix L 3 of the CCL: Absolute frequency of the other transitions related to those adopted as recommended and frequency intervals between transitions and hyperfine components.

It should be also noted that to achieve the uncertainties given here it is not sufficient just to meet the specifications for the listed parameters. In addition, it is necessary to follow the best good practice concerning methods of stabilization as described in numerous scientific and technical publications. References to appropriate articles, illustrating accepted good practice for a particular radiation, may be obtained by application to a member laboratory of the CCL[(1)] or to the BIPM.

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(1) At its 1997 meeting, the CIPM changed the name of the Consultative Committee for the Definition of the Metre (CCDM) to that of Consultative Committee for Length (CCL).

1 Recommended radiations of stabilized lasers

1.1 Absorbing ion $^{115}In^{+}$, $5s^2\ ^1S_0 - 5s5p\ ^3P_0$ transition

The values $f = 1\ 267\ 402\ 452\ 899.92$ kHz

$\lambda = 236\ 540\ 853.549\ 75$ fm

are associated with a relative standard uncertainty of 3.6×10^{-13}.

1.2 Absorbing atom ^1H, 1S–2S two-photon transition

The values $f = 1\ 233\ 030\ 706\ 593.55$ kHz

$\lambda = 243\ 134\ 624.626\ 04$ fm

with a relative standard uncertainty of 2.0×10^{-13} apply to the laser frequency stabilized to the two-photon transition in a cold hydrogen beam, corrected to zero laser power, and for atoms which are effectively stationary, i.e. the values are corrected for second-order Doppler shift.

1.3 Absorbing ion $^{199}Hg^{+}$, $5d^{10}6s\ ^2S_{1/2}$ ($F = 0$) – $5d^9 6s^2\ ^2D_{5/2}$ ($F = 2$) $\Delta m_F = 0$ transition

The values $f = 1\ 064\ 721\ 609\ 899\ 143$ Hz

$\lambda = 281\ 568\ 867.591\ 969$ fm

with a relative standard uncertainty of 1.9×10^{-14} are corrected for the second-order Zeeman shift.

1.4 Absorbing ion $^{171}Yb^{+}$, $6s\ ^2S_{1/2}$ ($F = 0$, $m_F = 0$) – $5d\ ^2D_{3/2}$ ($F = 2$, $m_F = 0$) transition

The values $f = 688\ 358\ 979\ 309\ 312$ Hz

$\lambda = 435\ 517\ 610.739\ 69$ fm

are associated with a relative standard uncertainty of 2.9×10^{-14}.

1.5 Absorbing ion $^{171}Yb^{+}$, $^2S_{1/2}$ ($F = 0$, $m_F = 0$) – $^2F_{7/2}$ ($F = 3$, $m_F = 0$) transition

The values $f = 642\ 121\ 496\ 772.6$ kHz

$\lambda = 466\ 878\ 090.061$ fm

with a relative standard uncertainty of 4.0×10^{-12} are corrected for the AC Stark shift and second-order Zeeman shift.

1.6 Absorbing molecule $^{127}I_2$, a_{10} component, R(56) 32-0 transition[(2)]

The values f = 563 260 223 513 kHz

λ = 532 245 036.104 fm

with a relative standard uncertainty of 8.9×10^{-12} apply to the radiation of a frequency-doubled Nd:YAG laser, stabilized with an iodine cell external to the laser, having a cold-finger temperature of –15 °C.

1.7 Absorbing molecule $^{127}I_2$, a_{16}, or f, component, R(127) 11-5 transition

The values f = 473 612 353 604 kHz

λ = 632 991 212.58 fm

with a relative standard uncertainty of 2.1×10^{-11} apply to the radiation of a He-Ne laser with an internal iodine cell, stabilized using the third harmonic detection technique, subject to the conditions:

- cell-wall temperature (25 ± 5) °C [(3)];
- cold-finger temperature (15.0 ± 0.2) °C;
- frequency modulation width, peak-to-peak, (6.0 ± 0.3) MHz;
- one-way intracavity beam power (i.e. the output power divided by the transmittance of the output mirror) (10 ± 5) mW for an absolute value of the power shift coefficient ≤ 1.0 kHz/mW.

These conditions are by themselves insufficient to ensure that the stated standard uncertainty will be achieved. It is also necessary for the optical and electronic control systems to be operating with the appropriate technical performance. The iodine cell may also be operated under relaxed conditions, leading to the larger uncertainty specified in Appendix L 2 of the CCL.

1.8 Absorbing atom ^{40}Ca, $^1S_0 - {}^3P_1$; $\Delta m_J = 0$ transition

The values f = 455 986 240 494 150 Hz

λ = 657 459 439.291 67 fm

with a relative standard uncertainty of 1.1×10^{-13} apply to the radiation of a laser stabilized to Ca atoms. The values correspond to the mean frequency of

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(2) All transitions in I_2 refer to the $B^3\Pi\, 0_u^+ - X^1 \sum_g^+$ system from now on.

(3) For the specification of operating conditions, such as temperature, modulation width and laser power, the symbols ± refer to a tolerance, not an uncertainty.

the two recoil-split components for atoms which are effectively stationary, i.e. the values are corrected for the second-order Doppler shift.

1.9 Absorbing ion $^{88}Sr^{+}$, $5\ ^{2}S_{1/2} - 4\ ^{2}D_{5/2}$ transition

The values $f = 444\ 779\ 044\ 095.5$ kHz

$\lambda = 674\ 025\ 590.8631$ fm

with a relative standard uncertainty of 7.9×10^{-13} apply to the radiation of a laser stabilized to the transition observed with a trapped and cooled strontium ion. The values correspond to the centre of the Zeeman multiplet.

1.10 Absorbing atom ^{85}Rb, $5S_{1/2}$ ($F_g = 3$) – $5D_{5/2}$ ($F_e = 5$) two-photon transition

The values $f = 385\ 285\ 142\ 375$ kHz

$\lambda = 778\ 105\ 421.23$ fm

with a relative standard uncertainty of 1.3×10^{-11} apply to the radiation of a laser stabilized to the centre of the two-photon transition. The values apply to a rubidium cell at a temperature below 100 °C and are corrected to zero laser power.

1.11 Absorbing molecule $^{13}C_2H_2$, P(16) ($\nu_1+\nu_3$) transition

The values $f = 194\ 369\ 569.4$ MHz

$\lambda = 1\ 542\ 383\ 712$ fm

with a provisional relative standard uncertainty of 5.2×10^{-10} apply to the radiation of a laser stabilized with an external $^{13}C_2H_2$ cell at a pressure range from 1.3 Pa to 5.3 Pa.

1.12 Absorbing molecule CH_4, $F_2^{(2)}$ component, P(7) ν_3 transition

1.12.1 The values $f = 88\ 376\ 181\ 600.18$ kHz

$\lambda = 3\ 392\ 231\ 397.327$ fm

with a relative standard uncertainty of 3×10^{-12} apply to the radiation of a He-Ne laser stabilized to the central component, (7-6) transition, of the resolved hyperfine-structure triplet. The values correspond to the mean frequency of the two recoil-split components for molecules which are effectively stationary, i.e. the values are corrected for second-order Doppler shift.

1.12.2 The values f = 88 376 181 600.5 kHz

λ = 3 392 231 397.31 fm

with a relative standard uncertainty of 2.3×10^{-11} apply to the radiation of a He-Ne laser stabilized to the centre of the unresolved hyperfine-structure of a methane cell, within or external to the laser, held at room temperature and subject to the following conditions:

- methane pressure ≤ 3 Pa;
- mean one-way intracavity surface power density (i.e., the output power density divided by the transmittance of the output mirror) $\leq 10^4$ W m^{-2};
- radius of wavefront curvature ≥ 1 m;
- inequality of power between counter-propagating waves ≤ 5 %;
- servo-referenced to a detector placed at the output facing the laser tube.

1.13 Absorbing molecule OsO_4, transition in coincidence with the $^{12}C^{16}O_2$, R(10) $(00^01) - (10^00)$ laser line

The values f = 29 054 057 446 579 Hz

λ = 10 318 436 884.460 fm

with a relative standard uncertainty of 1.4×10^{-13} apply to the radiation of a CO_2 laser stabilized with an external OsO_4 cell at a pressure below 0.2 Pa. This laser line is selected due to its reduced sensitivity to pressure shifts and other effects, in comparison with the previously selected R(12) laser line.

2 Recommended values for radiations of spectral lamps and other sources

2.1 ^{86}Kr spectral lamp radiation, $5d_5 - 2p_{10}$ transition

The value λ = 605 780 210.3 fm

with a relative expanded uncertainty $U = 3.9 \times 10^{-9}$, where $U = ku_c$ ($k = 3$), u_c being the combined standard uncertainty, applies to the radiation emitted by a discharge lamp. The radiation of ^{86}Kr is obtained by means of a hot-cathode discharge lamp containing ^{86}Kr, of a purity not less than 99 %, in sufficient quantity to assure the presence of solid krypton at a temperature of 64 K, this lamp having a capillary with an inner diameter from 2 mm to 4 mm and a wall thickness of about 1 mm.

It is estimated that the wavelength of the radiation emitted by the positive column is equal, to within 1 part in 10^8, to the wavelength corresponding to the transition between the unperturbed levels, when the following conditions are satisfied:

- the capillary is observed end-on from the side closest to the anode;
- the lower part of the lamp, including the capillary, is immersed in a cold bath maintained at a temperature within one degree of the triple point of nitrogen;
- the current density in the capillary is $(0.3 \pm 0.1)\ \mathrm{A \cdot cm^{-2}}$.

2.2 ^{86}Kr, ^{198}Hg and ^{114}Cd spectral lamp radiations

Vacuum wavelengths, λ, for ^{86}Kr, ^{198}Hg and ^{114}Cd transitions

Atom	Transition	λ / pm
^{86}Kr	$2p_9 - 5d'_4$	645 807.20
^{86}Kr	$2p_8 - 5d_4$	642 280.06
^{86}Kr	$1s_3 - 3p_{10}$	565 112.86
^{86}Kr	$1s_4 - 3p_8$	450 361.62
^{198}Hg	$6^1P_1 - 6^1D_2$	579 226.83
^{198}Hg	$6^1P_1 - 6^3D_2$	577 119.83
^{198}Hg	$6^3P_2 - 7^3S_1$	546 227.05
^{198}Hg	$6^3P_1 - 7^3S_1$	435 956.24
^{114}Cd	$5^1P_1 - 5^1D_2$	644 024.80
^{114}Cd	$5^3P_2 - 6^3S_1$	508 723.79
^{114}Cd	$5^3P_1 - 6^3S_1$	480 125.21
^{114}Cd	$5^3P_0 - 6^3S_1$	467 945.81

For ^{86}Kr, the above values with a relative expanded uncertainty $U = 2 \times 10^{-8}$, where $U = ku_c$ ($k = 3$), apply to radiations emitted by a lamp operated under conditions similar to those specified in Section 2.1.

For ^{198}Hg, the above values with a relative expanded uncertainty $U = 5 \times 10^{-8}$, where $U = ku_c$ ($k = 3$), apply to radiations emitted by a discharge lamp when the following conditions are met:

- the radiations are produced using a discharge lamp without electrodes containing ^{198}Hg, of a purity not less than 98 %, and argon at a pressure from 0.5 mm Hg to 1.0 mm Hg (66 Pa to 133 Pa);

- the internal diameter of the capillary of the lamp is about 5 mm, and the radiation is observed transversely;
- the lamp is excited by a high-frequency field at a moderate power and is maintained at a temperature less than 10 °C;
- it is preferred that the volume of the lamp be greater than 20 cm^3.

For ^{114}Cd, the above values with a relative expanded uncertainty $U = 7 \times 10^{-8}$, where $U = ku_c$ ($k = 3$), apply to radiations emitted by a discharge lamp under the following conditions:

- the radiations are generated using a discharge lamp without electrodes, containing ^{114}Cd of a purity not less than 95 %, and argon at a pressure of about 1 mm Hg (133 Pa) at ambient temperature;
- the internal diameter of the capillary of the lamp is about 5 mm, and the radiation is observed transversely;
- the lamp is excited by a high-frequency field at a moderate power and is maintained at a temperature such that the green line is not reversed.

2.3 Absorbing molecule $^{127}I_2$, a_3 component, P(13) 43-0 transition

The values f = 582 490 603.38 MHz

λ = 514 673 466.4 fm

with a relative standard uncertainty of 2.5×10^{-10} apply to the radiation of an Ar^+ laser stabilized with an iodine cell external to the laser, having a cold-finger temperature of (–5 ± 2) °C.

2.4 Absorbing molecule $^{127}I_2$, a_9 component, R(12) 26-0 transition

The values f = 551 579 482.97 MHz

λ = 543 516 333.1 fm

with a relative standard uncertainty of 2.5×10^{-10} apply to the radiation of a frequency stabilized He-Ne laser with an external iodine cell having a cold-finger temperature of (0 ± 2) °C.

2.5 Absorbing molecule $^{127}I_2$, a_1 component, P(62) 17-1 transition

The values f = 520 206 808.4 MHz

λ = 576 294 760.4 fm

with a relative standard uncertainty of 4×10^{-10} apply to the radiation of a dye laser (or frequency-doubled He-Ne laser) stabilized with an iodine cell, within or external to the laser, having a cold-finger temperature of (6 ± 2) °C.

2.6 Absorbing molecule $^{127}I_2$, a_7 component, R(47) 9-2 transition

The values f = 489 880 354.9 MHz

λ = 611 970 770.0 fm

with a relative standard uncertainty of 3×10^{-10} apply to the radiation of a He-Ne laser stabilized with an iodine cell, within or external to the laser, having a cold-finger temperature of (–5 ± 2) °C.

2.7 Absorbing molecule $^{127}I_2$, a_9 component, P(10) 8-5 transition

The values f = 468 218 332.4 MHz

λ = 640 283 468.7 fm

with a relative standard uncertainty of 4.5×10^{-10} apply to the radiation of a He-Ne laser stabilized with an internal iodine cell having a cold-finger temperature of (16 ± 1) °C and a frequency modulation width, peak-to-peak, of (6 ± 1) MHz.

RECOMMENDATION 2 (CI-2002): Dose equivalent

The International Committee for Weights and Measures,

considering that

- the current definition of the SI unit of dose equivalent (sievert) includes a factor "*N*" (product of any other multiplying factors) stipulated by the International Commission on Radiological Protection (ICRP), and
- both the ICRP and the International Commission on Radiation Units and Measurements (ICRU) have decided to delete this factor *N* as it is no longer deemed to be necessary, and
- the current SI definition of *H* including the factor *N* is causing some confusion,

decides to change the explanation in the brochure "Le Système International d'Unités (SI)" to the following:

The quantity dose equivalent *H* is the product of the absorbed dose *D* of ionizing radiation and the dimensionless factor *Q* (quality factor) defined as a function of linear energy transfer by the ICRU:

$$H = Q \cdot D$$

Thus, for a given radiation, the numerical value of *H* in joules per kilogram may differ from that of *D* in joules per kilogram depending on the value of *Q*.

The Committee further **decides** to maintain the final sentence in the explanation as follows:

In order to avoid any risk of confusion between the absorbed dose *D* and the dose equivalent *H*, the special names for the respective units should be used, that is, the name gray should be used instead of joules per kilogram for the unit of absorbed dose *D* and the name sievert instead of joules per kilogram for the unit of dose equivalent *H*.

Background information for the CIPM

In 1986, a Joint Task Group of the ICRP and the ICRU published a report entitled "The quality factor in radiation protection" [1] in which it is recommended (page 11) that the additional factor N be eliminated from the equation for dose equivalent. "Since the factor N originally included in the definition of the dose equivalent has not found any practical application and no value different from unity has been given by the ICRP or is expected to be given, it is recommended that N no longer be part of the definition."

Subsequent publications of both the ICRU and the ICRP no longer use the factor N in the definition of dose equivalent. For example in ICRU Report 51 "Quantities and units in radiation protection dosimetry (1993)", dose equivalent is defined as $H = Q \cdot D$. Similarly in the "Glossary of terms and definitions of quantities", on page IX of ICRP Publication 74 "Conversion coefficients for use in radiological protection against external radiation (1996)", dose equivalent is defined as $H = Q \cdot D$.

[1] ICRU Report 40 "The quality factor in radiation protection (1986)", Bethesda, ICRU.

RECOMMENDATION 3 (CI-2002): On the Avogadro constant

The International Committee for Weights and Measures,

recognizes that the Avogadro project is an important initiative in fundamental metrology and an important example of a new approach to international collaboration in metrology between national metrology institutes (NMIs) and other scientific institutes, which goes beyond the capacity of individual NMIs or regional metrology organizations,

encourages all NMIs to participate and contribute to the project to the maximum extent possible,

also **encourages** the NMIs participating in the project to develop an effective mechanism for formalizing contributions, commitment and evaluation,

instructs the Consultative Committee for Mass and Related Quantities (CCM) to establish a special committee to oversee the implementation of effective mechanisms to coordinate the Avogadro collaboration and to keep the International Committee informed of progress through the provision of an annual report and evaluation assessment.

LIST OF ACRONYMS USED IN THE PRESENT VOLUME

1 Acronyms for laboratories, committees and conferences

AIST*	National Institute of Advanced Industrial Science and Technology, see NMIJ/AIST
APLAC	Asia Pacific Laboratory Accreditation Cooperation
APMP	Asia/Pacific Metrology Programme
BCR	Community Bureau of Reference of the Commission of the European Communities
BIPM	International Bureau of Weights and Measures/ Bureau International des Poids et Mesures
BNM	Bureau National de Métrologie, Paris (France)
BNM-INM	Bureau National de Métrologie, Institut National de Métrologie, Paris (France)
CC	Consultative Committee of the CIPM
CCAUV	Consultative Committee for Acoustics, Ultrasound and Vibration/Comité Consultatif de l'Acoustique, des Ultrasons et des Vibrations
CCDM*	Consultative Committee for the Definition of the Metre/ Comité Consultatif pour la Définition du Mètre, see CCL
CCDS*	Consultative Committee for the Definition of the Second/ Comité Consultatif pour la Définition de la Seconde, see CCTF
CCE*	Consultative Committee for Electricity/Comité Consultatif d'Électricité, see CCEM
CCEM	(formerly the CCE) Consultative Committee for Electricity and Magnetism/Comité Consultatif d'Électricité et Magnétisme
CCEMRI*	Consultative Committee for Standards of Ionizing Radiation/Comité Consultatif pour les Étalons de Mesure des Rayonnements Ionisants, see CCRI
CCL	(formerly the CCDM) Consultative Committee for Length/ Comité Consultatif des Longueurs

* Organizations marked with an asterisk either no longer exist or operate under a different acronym.

CCM	Consultative Committee for Mass and Related Quantities/ Comité Consultatif pour la Masse et les Grandeurs Apparentées
CCPR	Consultative Committee for Photometry and Radiometry/ Comité Consultatif de Photométrie et Radiométrie
CCQM	Consultative Committee for Amount of Substance: Metrology in Chemistry/Comité Consultatif pour la Quantité de Matière: Métrologie en Chimie
CCRI	(formerly the CCEMRI) Consultative Committee for Ionizing Radiation/Comité Consultatif des Rayonnements Ionisants
CCT	Consultative Committee for Thermometry/Comité Consultatif de Thermométrie
CCTF	(formerly the CCDS) Consultative Committee for Time and Frequency/Comité Consultatif du Temps et des Fréquences
CCU	Consultative Committee for Units/Comité Consultatif des Unités
CGPM	General Conference on Weights and Measures/ Conférence Générale des Poids et Mesures
CIPM	International Committee for Weights and Measures/ Comité International des Poids et Mesures
CODATA	Committee on Data for Science and Technology
COOMET	Cooperation in Metrology among the Central European Countries
CPEM	Conference on Precision Electromagnetic Measurements
CSIR-NML	Council for Scientific and Industrial Research, National Metrology Laboratory, Pretoria (South Africa)
CSIRO*	see NML CSIRO
DFM	Danish Institute of Fundamental Metrology, Lyngby (Denmark)
EFTF	European Frequency and Time Forum
ENEA	Ente per le Nuove Tecnologie, l'Energia e l'Ambiente - Istituto Nazionale di Metrologia delle Radiazioni Ionizzanti, Roma (Italy)
ETL*	Electrotechnical Laboratory, see NMIJ/AIST
EU	European Union
EUROMET	European Collaboration in Measurement Standards
GT-RF	CCEM Working Group on Radiofrequency Quantities/ Groupe de Travail du CCEM pour les Grandeurs aux Radiofréquences
IAF	International Accreditation Forum

ICRP	International Commission on Radiological Protection
ICRU	International Commission on Radiation Units and Measurements
IEC	International Electrotechnical Commission
IEN	Istituto Elettrotecnico Nazionale Galileo Ferraris, Turin (Italy)
IFCC	International Federation of Clinical Chemistry and Laboratory Medicine
ILAC	International Laboratory Accreditation Conference
IMEKO	International Measurement Confederation
IMGC	Istituto di Metrologia G. Colonnetti, Turin (Italy)
INM*	Institut National de Métrologie, see BNM-INM
INMETRO	Instituto Nacional de Metrologia, Normalizaçao e Qualidade Industrial, Rio de Janeiro (Brazil)
INTI	Instituto Nacional de Tecnología Industrial, Buenos Aires (Argentina)
IOP	Institute of Physics, London (United Kingdom)
IOPP	Institute of Physics Publishing, London (United Kingdom)
IRMM	Institute for Reference Materials and Measurements, European Commission
ISO CASCO	International Organization for Standardization, Conformity Assessment Committee
ISO REMCO	International Organization for Standardization, Committee on Reference Materials
ISO	International Organization for Standardization
ITU	International Telecomunication Union
JCDCMAS	Joint Committee on Coordination of Assistance to Developing Countries in Metrology, Accreditation and Standardization
JCGM	Joint Committee for Guides in Metrology
JCRB	Joint Committee of the Regional Metrology Organizations and the BIPM
JCTLM	Joint Committee on Traceability in Laboratory Medicine
METAS	(formerly the OFMET) Office Fédéral de Métrologie et d'Accréditation, Wabern (Switzerland)
MoU	Memorandum of Understanding (between the CIPM and ILAC)
MRA	Mutual Recognition Arrangement
NCSLI	National Conference of Standard Laboratories International
NIMC*	National Institute of Material and Chemical Research, see NMIJ/AIST

NIST	National Institute of Standards and Technology, Gaithersburg MD (United States)
NMI	National Metrology Institute
NMIJ/AIST	National Metrology Institute of Japan, National Institute of Advanced Industrial Science and Technology, Tsukuba (Japan)
NML-CSIRO	National Measurement Laboratory, CSIRO, Pretoria (Australia)
NPL	National Physical Laboratory, Teddington (United Kingdom)
NRC	National Research Council of Canada, Ottawa (Canada)
NRC-INMS	National Research Council of Canada, Institute for National Measurement Standards, Ottawa (Canada)
NRLM*	National Research Laboratory of Metrology, see NMIJ/AIST
OFMET*	Office Fédéral de Métrologie/Eidgenössisches Amt für Messwesen, see METAS
OIML	Organisation Internationale de Métrologie Légale
PITTCON	Pittsburgh Conference
PTB	Physikalisch-Technische Bundesanstalt, Braunschweig and Berlin (Germany)
RMO	Regional Metrology Organization
SADC	Southern African Development Community
SADCMET	Southern African Development Community Cooperation in Measurement Traceability
SIM	Sistema Interamericano de Metrología
SL	State Laboratory, Dublin (Ireland)
SMU	Slovenský Metrologický Ústav/Slovak Institute of Metrology, Bratislava (Slovakia)
SRPI	Swedish Radiation Protection Institute, Stockholm (Sweden)
UME	Ulusal Metroloji Enstitüsü/National Metrology Institute, Marmara Research Centre, Gebze-Kocaeli (Turkey)
UNIDO	United Nations Industrial Development Organization
USNO	U.S. Naval Observatory, Washington DC (United States)
VNIIMS	Russian Research Institute for Metrological Service of Gosstandart of Russia, Moscow (Russian Fed.)
WGLF	CCEM Working Group on Low-Frequency Quantities
WHO	World Health Organization
WMO	World Meteorological Organization
WTO	World Trade Organization

WTO-TBT	World Trade Organization, Committee for Technical Barriers to Trade

2 Acronyms for scientific terms

CMC	Calibration and measurement capabilities
COMAR	Database on certified reference materials (COde of Reference MAterials)
CRM	Certified reference material
DNA	Deoxyribonucleic acid
GLONASS	Global Navigation Satellite System
GPS	Global Positioning System
GUM	Guide to the Expression of Uncertainty in Measurement
INAA	Instrumental Neutron Activation Analysis
IVD	In Vitro Diagnostic
KCDB	BIPM key comparison database
KCRV	Key comparison reference value
MAS	Metrology, accreditation and standardization
NMR	Nuclear magnetic resonance
NTRM	NIST Traceable Reference Material
QHR	Quantum Hall resistance
SI	International System of Units
SIR	International Reference System for gamma-ray emitting radionuclides
SRP	Standard Reference Photometer
TAI	International Atomic Time
UTC	Coordinated Universal Time
VIM	International Vocabulary of Basic and General Terms in Metrology