

Bureau International des Poids et Mesures

**Director's Report on the
Activity and Management
of the International Bureau
of Weights and Measures**

(1 July 2007 – 30 June 2008)

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 these 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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**MEMBER STATES AND
ASSOCIATES OF THE GENERAL CONFERENCE**

as of 30 June 2008

Member States

Argentina	Korea (Dem. People's Rep. of)
Australia	Korea (Rep. of)
Austria	Malaysia
Belgium	Mexico
Brazil	Netherlands
Bulgaria	New Zealand
Cameroon	Norway
Canada	Pakistan
Chile	Poland
China	Portugal
Czech Republic	Romania
Denmark	Russian Federation
Dominican Republic	Serbia
Egypt	Singapore
Finland	Slovakia
France	South Africa
Germany	Spain
Greece	Sweden
Hungary	Switzerland
India	Thailand
Indonesia	Turkey
Iran (Islamic Rep. of)	United Kingdom
Ireland	United States
Israel	Uruguay
Italy	Venezuela (Bolivarian Rep. of)
Japan	

Associates of the General Conference

Albania	Kenya
Belarus	Latvia
Bolivia	Lithuania
CARICOM	Macedonia (the FYR of)
Chinese Taipei	Malta
Costa Rica	Moldova (Rep. of)
Croatia	Panama
Cuba	Philippines
Ecuador	Slovenia
Estonia	Sri Lanka
Georgia	Tunisia
Hong Kong, China	Ukraine
Jamaica	Viet Nam
Kazakhstan	

THE BIPM

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 m²) 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.

The task of the BIPM is to ensure worldwide unification of 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 direction and 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 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 of a different nationality: 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. 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 international comparisons of realizations of units, calibrations of standards and metrological research. 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 (CEEM), 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, charged particles), 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: Metrology in chemistry (CCQM), set up in 1993.
10. The Consultative Committee for Acoustics, Ultrasound and Vibration (CCAUV), set up in 1999.

The proceedings of the General Conference and the CIPM are published 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.*

The CIPM decided in 2003 that the reports of meetings of the Consultative Committees should no longer be printed, but would be placed on the BIPM website, in their original language.

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 BIPM.

**STAFF OF THE
INTERNATIONAL BUREAU OF WEIGHTS AND MEASURES**

on 30 June 2008

Director: Prof. A.J. Wallard

Mass: Dr R.S. Davis

Ms P. Barat, Dr H. Fang, Mrs C. Goyon-Taillade, Mr A. Kiss, Mr A. Picard

Time, frequency and gravimetry: Dr E.F. Arias

Mr R. Felder, Dr Z. Jiang, Mrs H. Konaté, Mr J. Labot,
Dr W. Lewandowski, Dr G. Panfilo, Dr G. Petit, Dr L. Robertsson,
Mr L. Tisserand, Dr L.F. Vitushkin

Electricity: Dr M. Stock

Mr R. Chayramy, Dr E. de Mirandés, Dr N. Fletcher, Mr R. Goebel,
Mr A. Jaouen, Mr S. Solve

Ionizing radiation: Dr P.J. Allisy-Roberts

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Mr M. Nonis, Dr S. Picard, Dr G. Ratel, Mr P. Roger

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Mr L. Le Mée, Dr J.R. Miles

BIPM key comparison database: Dr C. Thomas¹

Dr S. Maniguet

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Finance, administration and general services: Mrs B. Perent

Mr F. Ausset, Mr R. Cèbe, Mrs D. Etter, Mrs M.-J. Martin, Mrs D. Saillard¹

Caretakers: Mr and Mrs Dominguez², Mr and Mrs Neves²

Housekeepers: Mrs A. Da Ponte, Mrs M.-J. Fernandes

Gardeners: Mr C. Dias-Nunes, Mr A. Zongo

Workshop and site maintenance: Mr J. Sanjaime

Workshop: Mr F. Boyer, Mr M. de Carvalho, Mr S. Segura, Mr B. Vincent

Site maintenance: Mr P. Benoit, Mr P. Lemartrier

Emeritus directors: Prof. P. Giacomo, Dr T.J. Quinn

1 Also Publications.

2 Also site maintenance.

**Director's Report
on the Activity and Management
of the International Bureau
of Weights and Measures**

(1 July 2007 – 30 June 2008)

1 INTRODUCTION

1.1 General introduction and overview of the year

In a year during which there is a meeting of the General Conference on Weights and Measures (CGPM), much of the work of the BIPM is inevitably directed towards its preparation. The latter half of 2007 was no exception to this and, since the meeting of the CGPM in November we have been preoccupied with dealing with the consequences of its decisions, in particular of its budgetary ones.

As will be reported later, the overall financial outcome was disappointing in the light of the BIPM's needs to fulfil its mission, its scientific successes, its track record of increased international coordination and the fact that many Member States were willing to provide a higher level of financing for a significantly enlarged programme. As a consequence, it will become more difficult to implement the full programme of work proposed for the period 2009-2012, and priorities have to be set to match the financial income expected from Member States and other sources. Whilst the BIPM's core scientific work will continue, some projects will be delayed until resources allow and some current activities will be terminated. In consequence, it may not be possible to meet all the NMIs' needs, as expressed through their representatives at Consultative Committees such as the provision of new or enhanced international reference facilities or for the management of comparisons within the CIPM MRA. This situation causes concern to me, as Director, since the BIPM may not be able to pursue all the challenges which it faces so as to respond fully to the needs of NMIs or the international community. In particular the BIPM has had to slow down its effort devoted to work to extend the influence of the SI into new areas in which the fundamental concepts of traceability, uncertainty, and the SI itself, are greatly needed, and which would bring substantial scientific, commercial and societal benefits. This is happening at a time when the clearly articulated needs of communities such as those in climate change, food, laboratory medicine and forensic science, are becoming evident from the coordination and general internationally-based links the BIPM has created. It is therefore disappointing that the BIPM may not be able to respond fully.

Turning to the general interactions the BIPM has had, I am pleased to report on the study by the CIPM on measurement and traceability needs in materials science. This led to a decision to ask VAMAS to identify priority topics and

for a liaison to be created between VAMAS and the relevant Consultative Committees. With this in mind, a Memorandum of Understanding has been signed between the BIPM and VAMAS. Similarly, progress has been made with the WMO in moving towards agreement on the arrangements for their signature of the CIPM MRA. These arrangements were necessary since the WMO, unlike other intergovernmental organizations or international bodies which have become signatories, has no laboratories of its own.

1.2 The International System of Units (SI)

Several communities came together at the meeting of the Consultative Committee for Units (CCU) in June 2007 and reached the conclusion that a kilogram redefinition based on the Planck constant, h , was to be preferred to one based on the Avogadro constant, N_A . The CCU also agreed with the Consultative Committee for Electricity and Magnetism (CCEM) that a definition of the ampere should be based on a fixed value of the elementary charge, e . The thermometry community, represented by the Consultative Committee for Thermometry (CCT), reported to the CCU that they welcome a redefinition of the kelvin based on the value of the Boltzmann constant, k . In the next few years, new measurements of this constant are expected to allow an improved CODATA value.

At the time of writing, there is still not a satisfactory convergence of the results from watt balance experiments and from the International Avogadro Coordination project which would give confidence in the selection of a value for the Planck constant. However both approaches are expected to produce new results in the next year or so, and the CIPM will be in a position to consider whether the time is right for a redefinition to be proposed to the CGPM.

1.3 The CIPM Mutual Recognition Arrangement (CIPM MRA) and the JCRB

During the year, the number of signatories of the CIPM MRA rose to 74, from 45 Member States, 27 Associates of the CGPM and two international organizations, and it covers a further 120 Designated Institutes. Worldwide interest in the demonstrable equivalence between the realizations of the SI is increasing amongst accreditors, companies and other user communities. The BIPM continues to promote the concept of traceability to the SI through the

realizations made at NMIs and designated institutes, so as to emphasise the contribution of the CIPM MRA to the reduction of technical barriers to trade.

At the time of writing, the number of CMC entries in the KCDB has risen to over 20 000.

The *KCDB Newsletter* continues to be used for the promotion of the work of the BIPM and the successes of the CIPM MRA in helping reduce costs through the use of local NMIs as well as the scientific benefits of increased confidence in measurement capabilities.

A major development during the year was the acceptance by the CIPM and the International Laboratory Accreditation Cooperation (ILAC) of a common definition and understanding of the term Calibration and Measurement Capability (CMC). This term will gradually replace the term Best Measurement Capability (BMC) which has been in use in the accreditation community for many years. Both the CIPM and the ILAC hope that any confusion in the market place can now be avoided and that the NMI and the accredited laboratory community can work together to ensure robust traceability of measurement results from accredited laboratories to the SI through its realizations by the NMIs.

The Joint Committee of the BIPM and the Regional Metrology Organizations (JCRB) continues to oversee the operational aspects of the CIPM MRA. I am pleased to note the initiative to create AFRIMETS in the African continent as a result of which a number of States are expressing interest in either becoming a Member State of the BIPM or an Associate of the CGPM. Similar initiatives are afoot in the Gulf Region and the JCRB met with representatives of GULFMET.

1.4 Member States and Associates

The number of Member States of the BIPM remains static at 51. However, there has been a rise in the number of Associate States and Economies of the CGPM to 27, with the accession since last year of Albania, Bolivia, Georgia, Sri Lanka and Tunisia. The BIPM is in touch with a number of other States which have declared their intention to become Associates as well as with some current Associates which are considering becoming Member States.

1.5 NMI Directors' Meeting

Over 70 Directors from NMIs of Member States and from Associate States and Economies of the CGPM met at the BIPM during the meeting of the CGPM in November 2007. The main topics of discussion were: updates on the work of the BIPM and its work with intergovernmental organizations and international bodies; the 2008 BIPM Metrology Summer School and the planned meeting of NMIs and other bodies which either have, offer, or manage financial and technical aid programmes to NMIs in the process of development. Directors also heard an update on the CIPM's initiative to cover various aspects of materials metrology within the work of the existing Consultative Committees and a presentation by Dr Tanaka of the NMIJ on their work to develop "remote calibrations" through the use of the internet or satellite-based communication systems. Finally, during the Directors' Meeting, the CIPM MRA was signed by FYROM, the Republic of Moldova, Sri Lanka and Tunisia.

1.6 Meeting of the CIPM

The 96th meeting of the CIPM was held immediately before the CGPM in November 2007. Dr Attilio Sacconi of the INRiM has been elected to fill the vacancy left by the resignation of Professor Sigfrido Leschiutta after a distinguished career as a member of the CIPM and as President of the Consultative Committee for Time and Frequency.

The CIPM accepted the recommendations presented in Dr Bennett's report on materials metrology. As a result, the current Consultative Committees will pay more attention to traceability in a number of areas in which the SI can be applied in measurements of material properties.

As reported above, the CIPM accepted the proposed definition of CMC together with a number of notes which expand on the use of the term in various areas. The next step is for the BIPM and the ILAC to work on updating of various policy documents and to encourage greater synergy between the CIPM MRA and the ILAC Arrangement.

The CIPM also decided that the BIPM should link the statements of the uncertainties associated with its calibration capabilities more clearly to the CMCs of the NMIs listed in the KCDB.

The post of Director of the BIPM will be vacant in October 2010 at the occasion of my retirement. The CIPM nominated Professor Michael Kühne,

currently Deputy Director and a member of the Presidential Board of the PTB, Germany, Director Designate. Professor Kühne is expected to take up his duties at the BIPM in the early part of 2009.

After the CIPM meeting closed, three members offered their resignations: Dr M.S. Chung of the KRISS (Republic of Korea) who also served as President of the CCL, Professor Giorgio Moscati from INMETRO (Brazil), who was Vice-President of the CIPM and had also served as President of the CCRI and Dr Hratch Semerjian of the NIST (United States). I am grateful to these members of the CIPM for their support of the work of the BIPM and for their advice and guidance.

In June 2008, the CIPM elected three new members: Dr K.H. Chung of KRISS (Republic of Korea), Dr Willie E. May of the NIST (United States) and Dr Hector Nava-Jaimes of the CENAM (Mexico). I welcome these new members.

1.7 The General Conference on Weights and Measures

The 23rd meeting of the CGPM in November 2007, as always, resulted in several stimulating discussions and decisions on matters of importance to world metrology and to the BIPM. Major decisions were taken on: ways of encouraging Associate States to become Member States; the need for a new policy to assess applications from Economies as Associates of the CGPM; a process to deal with States which are in financial arrears; a limited outreach programme to undertake by the BIPM to encourage States in development and in transition to become a Member State or an Associate of the CGPM. The Resolutions of the CGPM may be found on the BIPM's website.

The CIPM had presented a strong case to the CGPM for an enhanced budget for the BIPM for the period 2009-2012. This was to reflect past financial under-funding of the BIPM's programmes of work and also included a realistic rate of inflation for the BIPM as a science based body. A significant number of Member States were prepared to fund the proposed programme of work in full and to meet the CIPM's request for a step increase of 11 % of the dotation for 2008 in 2009 together with an annual rate of inflation of 4 %, each of the year of the four-year period. Others were, however, opposed to this level of increase and the eventual compromise was a step increase of only 1.6 % in 2009 plus 2 % each year for inflation calculated on the dotation agreed by the 22nd CGPM for 2008 but excluding the additional discretionary contribution agreed by Member States in 2003. As a result of

the wish of some Member States to offer a higher level of financial and other support for the BIPM, an additional discretionary contribution of 4 % of the dotation voted for 2008 was agreed for 2009 plus 2 % each of the succeeding year of the four-year period for inflation. A number of Member States also offered to provide additional voluntary contributions in cash or kind for the programme of work. I am grateful to those who have so far offered additional support and encourage others to follow suit in line with the General Conference's invitation in the Resolution 3 of the CGPM.

The BIPM's programme of work proposed to the CGPM outlined a project to construct a linear accelerator for radiation dosimetry at the BIPM during the 2013-2016 programme of work. This would provide a shared-cost international facility which would enable the BIPM to operate a reference facility for the increasing number of NMIs that have to provide traceable dosimetry for their radiotherapy standards which are becoming more focused on clinical accelerators. The Member States asked the CIPM to bring a range of options to the next meeting of the CGPM for its consideration.

1.8 Joint Committee for Guides in Metrology (JCGM)

A major achievement of the year was the finalization of the 3rd edition of the VIM (*International Vocabulary of Metrology – Basic and General Concepts and Associated Terms*). This edition changes the treatment of measurement uncertainty from an Error Approach (sometimes called Traditional Approach or True Value Approach) to an Uncertainty Approach and therefore necessitated reconsideration of some of the related concepts appearing in the 2nd edition of the VIM. It also took the opportunity of including more terms which were of value to the chemical community. The "VIM3" has been adopted by the BIPM and placed on it on its website for free access by the metrology community (www.bipm.org/en/publications/guides/) where it is known as JCGM 200:2008. The Working Group on the Expression of Uncertainty in Measurement, the GUM, also finalized its work on a first supplement to the GUM which deals with Monte Carlo methods. This supplement to the GUM has also been adopted by the BIPM and placed on the open website (www.bipm.org/en/publications/guides/) where it is known as JCGM 101:2008.

1.9 Joint Committee for Traceability in Laboratory Medicine (JCTLM)

The first list of Reference Measurement Services offered by laboratories was published on the JCTLM website in June 2007.

In December 2007, the Executive Committee of the JCTLM agreed the timetables for the next round of nominations of Higher Order Reference Materials and Reference Measurement Procedures, and for nominations of Laboratory Reference Measurement Services.

One of the drivers for the creation of the JCTLM was the need for an objective way of demonstrating compliance with the requirements of the European Union's *In Vitro* Diagnostics Directive which called for measurements to be made against "standards of a higher order". The BIPM has been in discussion with the European Commission which has identified the written standards against which reference materials can be assessed. The JCTLM database incorporates data on materials which comply with these standards and so if a reference material is listed then it should conform to the EU's requirements.

The work of the Committee helps identify priorities for comparisons to be carried out within the broad remit of the CCQM and the JCTLM framework. It is increasingly seen as a model which could be used in collaborations with other intergovernmental organizations or international bodies, as the BIPM develops closer collaborations with them.

1.10 Liaison with intergovernmental organizations and international bodies

International coordination and liaison continues to consume a greater part of the BIPM resources. As was reported to the meeting of the CGPM, approximately 19 % of the time of BIPM staff is now spent on this activity compared with 11 % five years ago. In some cases such as the work of the Time group in relation to time transfer and time scales, the aims are to make sure that the interests and efforts of the relevant communities are coordinated and reinforce each other. In others such as in chemistry, the liaison deals with the scientific needs of the communities for comparisons and for the general acceptance and implementation of traceability to the SI and uncertainty into normal working practice. As will be seen from the report of each scientific section, the BIPM's influence and contribution is increasingly appreciated and its representation on committees or its technical leadership is requested in a growing number of subject areas.

Work with the OIML brings the BIPM closer on a number of matters and the joint metrology portal (www.metrologyinfo.org) was launched during 2007.

During last year, the continuing close relationship with the ILAC has resulted in a number of important decisions and developments. In particular, and after several years of discussion, the BIPM and ILAC agreed on a common definition and interpretation of the term “Calibration and Measurement Capabilities”. This will replace the term “Best Measurement Capability”, which was common practice in the accreditation community and so will help to reduce confusion for users. As a result, the BIPM is now working, with ILAC, on a number of consequential changes and revisions of policy documents connected with traceability and with the use of the KCDB by assessors to validate uncertainty and traceability claims in accredited laboratories. The BIPM is also trying to make better use of the resources deployed in the review of NMI Quality Systems, either through the CIPM MRA framework, or through third party certification.

1.11 BIPM Metrology Summer School

I am delighted to report a very successful Second BIPM Metrology Summer School in July 2008. Ninety students from some thirty countries spent two weeks at the BIPM during which there were 45 lectures and workshops. Speakers were largely drawn from NMIs but also included three Nobel Prize winners and other special guest speakers. The feedback has been excellent, with a high level of satisfaction among students as well as the lecturers, several of whom spent several days at the BIPM. Although the organization of a Summer School like this consumes considerable staff and financial resources, I believe it is a valued service for the NMIs of Member States and Associates, and is a unique opportunity for young metrologists to gain a wide perspective of the current state of the art.

1.12 World Metrology Day (WMD)

The 2008 theme was “No games without measurements” – capitalising on the Beijing Olympic Games. The success of, and enthusiasm for, this event has surpassed all the BIPM expectations. The BIPM is working with a greater number of NMIs and other partners; the BIPM Director's message was translated into 28 different languages and there were 84 different language versions of the posters which were produced. I received many reports of national events which were built around WMD and look forward for the

BIPM to expand its impact and the collaborators in 2009 when the central theme will be the impact of nearly 10 years of the CIPM MRA.

1.13 BIPM's measurement services and Quality System

The BIPM continues to provide a limited number of measurement services for NMIs from Member States and in the period of this report, some 66 Certificates and 1 Study Note were issued. All BIPM external, as well as a number of BIPM internal services meet the requirements of the BIPM's self-declared ISO/IEC 17025 Quality System. The BIPM's intention is to present its Quality System to RMO experts at a meeting in 2009.

1.14 Health and safety

The Health and Safety Committee created in 2007 with trained experts in key areas related to safety meets regularly. In addition, the BIPM commissioned an external review of safety procedures which came to the general conclusion that the current working practices and procedures had identified, and dealt with, the significant health and safety risks which are inherent in a scientific research laboratory. The BIPM procedures are based on a risk assessment process and thorough training of those responsible for maintaining the BIPM's procedures up to date.

1.15 Promotion of the work of the BIPM

In addition to regular announcements on the BIPM's extensive website and the *KCDB Newsletter*, the long-standing version of the BIPM Brochure was revised and published in time for the meeting of the General Conference.

The scientific staff of the BIPM continue to publish widely in peer reviewed journals, to present their work at scientific conferences and also in more general fora. The full list of the publications is to be found elsewhere in this report. Inevitably, there is significant media interest in the potential redefinition of the SI units, in particular of the kilogram.

1.16 BIPM staff commissions

In May 2008, a new set of Staff Regulations and Rules came into force after approval by the CIPM in February 2008. The new Regulations, which were the subject of extensive and thorough consultation with the relevant staff

commissions, brought the previous Statute up to date and clarified a number of areas. Further modifications may be made in due course.

These new Staff Regulations include new regulations on staff representation, which are based on recommendations made to me in 2007 by an internal BIPM working group. The Statute Commission, Salaries Commission and Information and Safety Commission were merged and new rules applicable to meetings between the Staff Commissions and the Direction were adopted. As a result it improved the effectiveness with which the commissions perform their role of giving advice to the Director on conditions of employment.

A major feature of the new terms and conditions of employment apply to provisions for staff disputes in accordance with the Amendment to the Headquarters Agreement to be ratified shortly by the French Parliament, which provides the recognition of the jurisdiction of an international administrative tribunal for staff disputes. In the case of the BIPM, as with many other intergovernmental organizations, the BIPM recognizes the jurisdiction of the Administrative Tribunal of the International Labour Organization (ILOAT).

As Director, I am acutely aware of the increased workload which has fallen on all staff as a result of the demand for our work – whether this be for the piloting and management of comparisons, the need to involve the BIPM in international metrological activities or the holding and operation of the ever-increasing number of meetings held at the BIPM. I am proud of the commitment and achievements of each and every one of the BIPM's staff and wish to thank them warmly for their commitment and their loyalty.

1.17 Science at the BIPM

Mass: Much of our work may be viewed as preparation for a possible redefinition of the kilogram, which may occur as early as 2011. We continue to lead the tasks involving mass metrology within the framework of the International Avogadro Coordination (IAC) project. This work has recently been complemented by our participation in the iMERA-Plus project of EURAMET. Experience gained in the Avogadro work is directly relevant to the development of the *mise en pratique* for a new kilogram definition. Our future work in this area will be in close coordination with a new Task Groups of the CCM Working Group on Mass Standards. Both Task Groups held their first organizational meetings in April 2008. Other pertinent work this

year includes provision of sorption artefacts to interested laboratories working on watt balances and the IAC, and installation of a glove box that will form part of a system to transfer mass standards maintained under an inert atmosphere.

We have continued to perform calibrations of 1 kg prototypes and other mass standards. However, routine quality checks of these measurements revealed unexpected changes to our working standards. The issuing of certificates has therefore been suspended until the recent history of our working standards was re-established.

At the request of the NPL, we have compared the so-called "BIPM method" for cleaning/washing 1 kg prototypes with a method developed by the NPL based on ultra-violet light and ozone. The NPL cleaning apparatus was transported to the BIPM for this study. The results are still being evaluated, but should provide useful information for the Task Groups mentioned above.

An automated weight exchanger has been installed for our 100 g balance and is being instrumented. When completed, the new facility will increase our efficiency in providing internal calibrations in the range 100 g to 5 g, for ourselves and other scientific sections.

Two notable publications this year have been the new CIPM-2007 formula for the density of moist air and the report of a supplementary comparison with the LNE to validate our internal pressure calibrations.

Three of our staff of five persons have devoted between 60 % and 100 % of their time to the watt balance experiment.

Time, frequency and gravimetry: The international time scales TAI and UTC are computed each month, and the results are published in *Circular T*, which serves as the monthly update of key comparison CCTF-K001.UTC (new name given for CCTF-K2001.UTC). The stability of TAI, expressed in terms of an Allan deviation, is estimated to be at, or below, 0.4×10^{-15} for averaging times of one month. Twelve primary frequency standards contributed during the period of this report to improving the accuracy of TAI, including eight caesium fountains (IT CSF1, LNE-SYRTE FO1, LNE-SYRTE FO2, LNE-SYRTE FOM, NICT CSF1, NIST-F1, NMIJ F1 and NPL CSF1). A total correction of -3.6×10^{-15} has been applied throughout the year to $[f(EAL) - f(TAI)]$. Since July 2007, the scale unit of TAI has been estimated to match the SI second to about 1×10^{-15} .

Studies on the use of phase measurements along with the code measurements of geodetic-type GPS receivers have concluded, and solutions based on this method (TAI PPP) have been computed in the Section since October 2007 to complete the analysis. In April 2008, a pilot experiment started with the participation of 25 laboratories for studying the introduction of PPP links in TAI. Extensive comparisons of the different techniques and methods for clock comparisons are computed regularly and published on the internet.

Calibration programmes of different types of GPS receivers have been organized and run by the Section. The implementation of a method for the calibration of GLONASS equipment in cooperation with a national laboratory has been concluded, and routine calibrations are under preparation for the second half of 2008.

Support has been provided to the Joint CCL/CCTF Frequency Standards Working Group, in which some members of the staff have responsibilities.

Research work in the Section is dedicated to space-time reference systems. The cooperation with the USNO (United States) for the provision of the Conventions Product Centre of the International Earth Rotation and Reference Systems Service (IERS) is continuing; a workshop on the IERS Conventions took place at the BIPM in September 2007.

Based on the new protocol elaborated by staff of the Section, the key comparison of stabilized lasers renamed CCL-K11 took place in the MIKES (Finland) with the BEV (Austria) acting as pilot laboratory. A member of staff attended the first run of this comparison to provide expertise. The Section has also provided calibration and measurement service of lasers for both internal and external users.

An important number of requests of iodine cells have been satisfied in the year covered by this report. Many of the demands concern specially designed cells with particular geometries.

The work on the gravimeter FG5-108 being made in cooperation with the VNIIM (Russian Fed.) is progressing. In particular, the system for delivering the laser light to the interferometer is under development, and the dropping chamber has been repaired and tested.

Members of the staff participate in activities linked to the special projects at the BIPM. Preliminary studies on the gravimetric equipment and environmental effects on gravity for the watt balance have begun. Work on

the construction of the interferometer for the length measurement in the calculable capacitor has progressed during the period of this report.

The Section's staff remained very active in the field of international coordination needed to accomplish the tasks conferred by the Member States. As part of this activity, the physicists of the Section have been widely invited to give lectures at conferences and invited to visit national laboratories. A significant number of articles have been written within the period of this report, and 19 have recently been published with another nine in press at the moment of writing of this report.

Special attention has been provided to training activities for physicists and technicians with the aim of broadening their capacities for the work for which they are responsible.

Electricity: During the period of this report, the Electricity section carried out two on-site Josephson comparisons, three comparisons with Zener voltage transfer standards, three comparisons with resistance transfer standards and two comparisons with capacitance transfer standards. The resistance comparison with the NIST will allow us to link the results of the SIM.EM-K1 comparison, with six participants, to the ongoing BIPM key comparison BIPM.EM-K13.a. The capacitance comparison with the NIST had been initiated by the BIPM to verify our measurement uncertainties after the recent changes of staff and the modifications of the measurement systems.

The key comparison of the conventional Josephson arrays of the BIPM and the LNE was followed by a "scientific" comparison of our 10 V programmable SINIS array, offered by the PTB, with the conventional array of the LNE. Both arrays were found to be in excellent agreement within an exceptionally small uncertainty. This is only the second time that agreement between the voltages realized with the traditional arrays and the new type of programmable SINIS arrays has been demonstrated at the level of 10 V.

In the field of impedance metrology, new ac-dc transfer resistors with improved stability have been introduced in the work with the quadrature bridge. This reduces the main uncertainty component in the traceability chain from the quantum Hall resistance standard to capacitance. Statistical techniques, which were developed recently in the section to treat correlated time series, were applied to measurements made with our impedance bridges and led to a better understanding of their statistical uncertainties. A good agreement was obtained between the predictions of these techniques on the

influence of a low pass filter, and experiment. These studies allow reliable determinations of Type A uncertainties of our bridge measurements in the presence of time correlations.

The preparations for the start of measurements with the calculable capacitor are now finished and we are waiting for the instrument to arrive. Work has started on the fabrication of a Josephson voltage standard for the watt balance experiment, based on an SNS array, offered by the NIST.

During the year 2007 the Electricity section has provided 49 calibrations certificates and three study notes for 15 NMIs of Member States. Calibrations are carried out for voltage (1.018 V and 10 V), resistance (1 Ω , 100 Ω and 10 k Ω) and capacitance (1 pF, 10 pF and 100 pF) and are offered mainly to smaller NMIs that do not yet possess their own primary standards.

Calculable capacitor: In collaboration with the NMIA of Australia, the BIPM is building two calculable capacitors of an improved design to measure the von Klitzing constant with an uncertainty of, the order of, 1 part in 10^8 to contribute to the next CODATA fundamental constants adjustment.

In September 2007 we received the two frequency doubled Nd:YVO₄ lasers needed to measure, by interferometry, the electrode spacing in the two instruments. The characteristics of the laser beams have been studied with a wave front sensor to determine the optical system needed to couple the laser beam into a fibre delivering the light to the interferometer. A test bench for studying the properties of the interferometer has been set up and first measurements of the interference fringes were made. The electrical measurement systems, which will link the quantized Hall resistance with the calculable capacitance, have been improved to reduce the related uncertainty, which is expected to dominate the uncertainty of this experiment. The workshop of the BIPM has continued to fabricate a large number of parts.

Watt balance: During the period of this report, the staffing situation has improved with the arrival of an assistant, who works nearly full-time on the project, a research fellow on a two year contract and a secondment from the NMIJ who worked at the BIPM for seven months. We have continued the development of the room temperature experiment, which will be followed at a later stage by a cryogenic experiment, to test the feasibility of simultaneous force and velocity measurements.

The main objective of the year 2007 was to carry out the first measurements of the voltage-velocity ratio, which has been achieved with a relative standard deviation between different measurements of, the order of, 1 part in

10^4 . The coil suspension has been improved to reduce the undesired coil movement in the five degrees of freedom resulting from a non perfect vertical movement. Further work on the current source has allowed us to reduce its long-term drift to about 1 part in 10^9 per minute, and to achieve a satisfactory short-term stability. A technique needed to separate the voltage induced in the coil from the voltage drop due to the current flow, based on the used of a second, non-inductive coil, has been tested and is being integrating into the apparatus.

Work has started on the geometrical and magnetic characterization of a large precision solenoid which will become the reference for the magnetic field alignment.

The collaboration with the Machine Tools Department of the Technical University of Aachen (RWTH/WZL) on the fabrication of the magnet is continuing. During the year 2008, detailed mechanical drawings for the fabrication of the magnetic circuit and the assembly devices will be provided. Preparations have been made for the installation of a vibration isolation base in the future watt balance laboratory.

Ionizing radiation: The new value for air kerma in ^{60}Co gamma fields for radiotherapy was adopted on 1 November 2007 following the publication of the re-evaluation of the BIPM standard in *Metrologia*. This was in accordance with the recommendation of the CCRI. In parallel, the higher activity (CIS-Bio) ^{60}Co source was adopted as the reference field. A new series of BIPM graphite cavity primary standards is under construction and the first chambers agree with the variable-volume chamber at the level of 2 parts in 10^4 .

The results of a study of low pressure (60 kPa) effects on graphite cavity standards, which was carried out in conjunction with some calibrations for the ININ (Mexico), have implications for all graphite-walled standards at the level of several parts in 10^3 , and further work is planned.

The results of a significant study of aperture effects (transmission, scatter and fluorescence) were presented to the KCWG(I) and have been prepared for publication prior to proposing a change of up to 7 parts in 10^3 to the medium-energy air-kerma standard at the CCRI in 2009.

The prototype graphite calorimeter for absorbed dose to water is now constructed and the first trials show that the novel design works well in practice in terms of absorbed dose to graphite. The CCRI Accelerator Dosimetry Working Group has recommended recently that the BIPM

calorimeter be used in a series of bilateral comparisons at the eight NMIs that have accelerators. The calorimeter will be tested in a trial comparison at the LNE-LNHB (France) later this year before this series of on-going comparisons is launched.

The primary standard free air chamber for mammography dosimetry does not appear to be as stable as the existing low-energy free air standard and this is under investigation. The mammography comparison facility will then be completed.

Three new dosimetry comparisons have been made and three other comparison reports have been published. We have just now succeeded in obtaining a guest scientist, from the ININ (Mexico), for the project on the CCRI brachytherapy comparisons, so progress should now be made. Twenty-eight national secondary standards have been calibrated and the Quality System for calibrations successfully underwent its internal audit. Support for the IAEA continues with regular irradiations of their dosimeters for the IAEA/WHO measurement service.

Last year, only five laboratories submitted eleven ampoules to eight of the BIPM ongoing activity comparisons using the International Reference System (SIR). The implication is that the NMIs are finding it more difficult to comply with the transport regulations and may now be relying more on the "Measurement methods grouping criteria for radionuclides", to support their CMCs. However, as 24 old comparison results will disappear from the KCDB this year there may be a resurgence of submissions next year. Impurity activity levels were measured using the BIPM Ge(Li) gamma spectrometer for four radionuclides submitted for comparisons and a guest worker from Albania is presently calibrating the replacement HpGe spectrometer. The BIPM is grateful to the NPL (UK) for their generous donation of over 5000 glass ampoules which will assure the SIR's continuation. An internal audit of the SIR was successful and the new SIR measurement system has been adopted with the final verification due at the end of 2008.

Studies of ^{85}Kr measurements in the SIR are continuing and the SIR Transfer Instrument has been tested for the short-lived $^{99\text{m}}\text{Tc}$ radionuclide at the NPL prior to making comparisons at more distant NMIs. We have devoted much effort to the extension of the SIR for pure beta emitters and the system should be in place by the end of the present programme. The BIPM is presently piloting two CCRI key comparisons and completing the reports for some earlier radionuclide activity comparisons.

Chemistry: The Chemistry section has consolidated its programme in gas metrology in support of the international comparability of gas standards for air quality and greenhouse gas monitoring, and in primary calibrator comparisons for organic analytes in support of clinical, food analysis and forensic applications. The Section is running or has completed six international comparisons in support of these areas during the time period covered by the report. The BIPM Chemistry section actively supports the Consultative Committee for Amount of Substance (CCQM), participating in its yearly meetings and biannual meetings of its working groups.

The first two year cycle of the on-going key comparison BIPM.QM-K1 – Ozone at ambient level – was launched in January 2007, and since July 2007, eight laboratories have brought their ozone standards to the BIPM, and two others have participated in linking RMO comparisons. Two national ozone reference standards have had upgrade kits fitted to them in order to correct for systematic biases identified by the BIPM and the NIST.

The programme to develop a candidate primary ozone photometer based on a laser light source has continued, with a strong focus on reducing the noise level of the system. The frequency doubling crystal included in the argon laser head has been replaced by one at the shorter wavelength of 244 nm, and measured ozone mole fractions are within 5 % of the values obtained using the Hg lamp-based standard reference photometer (SRP).

A third validation study of the NO₂ facility in support of the BIPM coordinated pilot study (CCQM-P110 – Nitrogen dioxide 10 µmol/mol) has been completed. It includes the comparison of five NO₂ primary gas standards with dynamic gas mixtures produced by the NO₂ facility, and on-line measurements using the FTIR facility, which has been improved.

The final report of the BIPM coordinated study, CCQM-P73 on nitrogen monoxide standards, performed over the period August 2006 – October 2007, was published in the *Metrologia Technical Supplement*.

The Organic Analysis Programme within the Chemistry section coordinates CCQM comparisons of the purity assessment of organic compounds, for use as primary calibrators. The analytical capabilities within the Programme were enhanced in 2007-2008 by the acquisition of a photo-ionisation source for use with the existing QTrap LC-MS/MS system, a stand-alone Agilent Rapid Resolution LC-UV system and a dynamic vapour sorption balance.

Development and validation of analytical methods required for use in the characterization and production of the cardiac glycoside CCQM-P20.f pilot

study material have been completed, and validation activities broadened to incorporate the planned CCQM-K55.a key comparison on pure steroid hormones.

In the second half of 2007, the homogeneity and stability assessments of the digoxin candidate materials for CCQM-P20.f, the second CCQM comparison coordinated by BIPM, were completed, and the material distributed to NMIs. A significant level of residual organic solvent was also present in the material, but detected only by a small number of laboratories. The Draft B report is currently in preparation.

The first round of the organic purity assignment key comparison, CCQM-K55.a, will be coordinated by the BIPM. The steroid 17 β -estradiol will be the principal component of the study material. The candidate material has been prepared by and supplied to the BIPM by collaborators from the Organic Analytical Chemistry division at the NMIJ (Japan), and is currently undergoing characterization at the BIPM.

As part of their planning for future key comparisons, the CCQM Organic Analysis Working Group (OAWG) identified purity assessment as being a core technical capability. The OAWG has recommended that participation in CCQM-K55 be compulsory for all NMIs which have activities or make CMC claims in the area of organic analysis.

As part of the activities in support of the JCTLM, a symposium on 'Activities and Challenges for Traceability and Standardization in Laboratory Medicine' was organized in Beijing in October 2007, in collaboration with colleagues from the NIM and the NIST. Procedures for the operation of the JCTLM Secretariat were presented to the JCTLM Executive for their approval, during their sixth meeting. The JCTLM Database website available at <http://www.bipm.org/jctlm/> was modified to include the reference measurement laboratory services as a searchable category to the database. The total number of external connections to the JCTLM Database website has increased from July 2007 to May 2008. This corresponds to about 1300 visits each month as of May 2008.

A workshop on 'Method Performance and Measurement Uncertainty' was organized by the BIPM Chemistry section in collaboration with other international organizations for Government delegates to the Codex Alimentarius Commission's Committee on Methods of Analysis and Sampling in April 2008.

1.18 Publications, lectures and travel of the Director

1.18.1 External publications

1. Wallard A.J., News from the BIPM – 2007, *Metrologia*, 2008, **45**, 119-126.
2. Wallard A.J., Letters to the editor: Traceability to the SI, *Measure*, 2008, **3(2)**, 4-5.

1.18.2 Travel (conferences, lectures and presentations, visits)

A.J. Wallard to:

- London (United Kingdom), 18 July 2007, for a meeting of the Measurement Board of the Department of Innovation, Universities, and Skills;
- Minneapolis, St Paul (United States), 28 July to 7 August 2007, for the National Conference of Standards Laboratories International (NCSLI), and for a meeting of the NCSLI Board;
- St Petersburg (Russian Fed.), 19-21 August 2007, for a meeting on gravimetry;
- Ottawa (Canada), 23-30 September 2007, for the SIM General Assembly, the INMS Advisory Board and the JCRB;
- Turin (Italy), 18 October 2007, to speak at the memorial seminar for Professor Anthos Bray;
- San Juan (Puerto Rico), 4-11 January 2008, for a meeting of the Board of NCSLI and to speak at local meetings;
- Bled (Slovenia), 11-13 February 2008, to attend a EURAMET meeting;
- Turin (Italy), 10 April 2008, for a meeting of the INRiM Science Council;
- Coventry (United Kingdom), 22-23 April 2008, for a meeting of the Measurement Board of the Department for Innovation, Universities, and Skills;
- Wellington (New Zealand), 26 April to 4 May 2008, for a meeting of the JCRB and to speak at local events;
- Teddington (United Kingdom), 19-22 May 2008, for the opening of the NPL's new laboratories and for a meeting of the Pathfinder Programme Management Group of the Department of Innovation, Universities, and Skills;

- Marseille (France), 3-4 June 2008, for the EURAMET General Assembly;
- Boulder Co (United States), 7-13 June 2008, for a meeting of the bureau of the CIPM and the CPEM 2008.

1.19 Activities of the Director related to external organizations

The Director is a member of the Scientific Council of the INRiM, Turin; a member of IUPAC's Interdivisional Committee on Terminology, Nomenclature and Symbols; and a member of IUPAP-C.2 Commission on symbols, units, nomenclature, atomic masses and fundamental constants (SUNAMCO). He is a Visiting Professor in the Institute of Mathematics and Physical Sciences of the University of Wales at Aberystwyth; a member of the Board of the National Conference of Standards Laboratories International (NCSLI); a member of the Scientific Academy of Turin; a member of UK's Pathfinder Programme Working Group and the National Measurement System Board of the Department for Universities, Innovation and Skills; a member of the Advisory Board of INMS-NRC, Canada, and Chairman of the JCRB and the JCGM.

2 MASS (R.S. DAVIS)

2.1 Calibrations

2.1.1 Certificates (P. Barat and R.S. Davis)

During the past year, certificates were issued for the following 1 kg prototypes in platinum-iridium: No. 83 (Singapore) and No. 16 (Hungary). Calibrations of prototypes for Germany and Brazil are underway.

Certificates were issued for three 1 kg standards in stainless-steel belonging to KIM-LIPI (Indonesia). The following 1 kg standards in stainless steel were also calibrated: four for the NMi (Netherlands); one for Enterprise Ireland; one for LATU (Uruguay); one for A*Star (Singapore) and one for the NPSL (Pakistan). Unfortunately, in the course of these calibrations we discovered a large shift in the masses of our working standards. An extensive

recalibration was carried out, traceable to prototypes Nos. 25 and 73 reserved for special use. This has resulted in several months' delay.

The calibration of a 1 kg standard in stainless steel belonging to INMETRO (Brazil) is underway.

Two 1 kg standards in stainless steel, to be used in an upcoming key comparison, were shipped to the NIST (United States), where the difference in their mass was measured. The standards are currently in transit back to the BIPM. The goal of this experiment is to establish whether the mass difference remains constant during shipment. If so, shipping will be offered as an alternative to hand-carrying as a means of transport between participating laboratories. This study has been undertaken because of the rough security inspections of standards in transit at many international airports.

Calibrations were made for KIM-LIPI of the magnetic susceptibilities of two metal blocks used with a BIPM-type magnetic susceptometer. A BIPM susceptometer was also provided to this NMI.

2.1.2 UVOx cleaning study (P. Barat, J. Berry* and R.S. Davis)

A technique for cleaning Pt-Ir prototypes based on ultraviolet light and ozone (UVOx) has been developed by the NPL. The apparatus was temporarily transferred to the BIPM, as were a number of Pt-Ir prototypes and other standards in Pt-Ir. The goal of this work was to compare the efficiency of the traditional BIPM method for cleaning and washing of prototypes with the UVOx method. This work will form a part of the NPL and BIPM contributions to CCM-WGM/TG1 and will be reported when the data have been analyzed.

2.2 **Balances to support development programmes** (P. Barat, H. Fang and A. Picard)

Last year we mentioned that the commissioning was carried out on our new Sartorius CCL1007 balance, but that some results had been obtained with large associated uncertainties. This year, the goal was to reduce the uncertainties of the measurements of some position errors as well as to confirm the linearity of the scale. This work is in preparation for the mass

* NPL (United Kingdom).

measurements of the two ^{28}Si spheres, planned for the second half of this year. Unfortunately, much of this year was devoted to improving the reliability of the balance. Several engineering interventions from Sartorius were scheduled to fix various functioning problems. The weighing cell, the lifter and the electronics were changed this year. These successive changes slowed down the progress of our preparation for our IAC work as some previously made investigations had to be carried out again after the engineering interventions. In particular, investigations of the scale linearity were made on three occasions, and the position errors were investigated on two occasions. So far, only the errors due to the position of the carousel have been re-estimated under vacuum and they are, for all eight carousel positions, within $0.5\ \mu\text{g}$, with an associated uncertainty within $0.1\ \mu\text{g}$. The re-estimation of the position error in air is ongoing. The linearity with previous electronics had been carried out but needs to be re-confirmed with the new electronics. Nevertheless, during this time we have been able to reduce the horizontal and vertical thermal gradients inside the balance case. A thick, plexiglass cover has been placed over the balance enclosure, and the window of the cabin in front of the balance has been covered by a thermally insulating sheet. If the illumination in the cabin remains permanently 'ON', the horizontal and vertical thermal gradients are for both within $10\ \text{mK}$. After these modifications, the magnitude of the horizontal and vertical thermal gradients was reduced by a factor of 3 and 6, respectively. In addition, the vertical thermal gradient is now positive, which is very important for the balance stability in air, to minimize any convection effects.

Since room 105 was completely renovated in late 2006, to accommodate the new Sartorius CCL 1007 mass comparator, we have observed some new discrepancies in the determination of air density. By measuring the air density by means of air buoyancy artefacts (gravimetric method) and by using the CIPM-2007 formula for air density determination, we are able to track the air density difference between the two methods. In March 2007 the relative difference was 2.5×10^{-4} . We suppose that the explanation is some contaminant in the air. However, an analysis by the NPL of VOCs in the room was conducted but no critical contaminant was detected and no obvious explanation was proposed. The difference of the air density determined between the two methods is decreasing with time and at present it is half that observed in March 2007. After having evacuated the enclosure, measurement of this difference has been carried out by injecting fresh air from outside the cabin. The air density difference obtained between the two methods was

$3.1(7) \times 10^{-5}$ in relative value. The density of air within the laboratory remains a concern.

Last year we have mentioned that specific software was written to compute the weighing results. This year we improved the software by incorporating a better uncertainty calculation as well as by simplifying the mass calculation routine.

2.3 100 g balance to support calibration programme (R.S. Davis and C. Goyon-Taillade)

The purpose of this balance is to shorten calibration time and improve accuracy for mass standards ranging from 100 g to 5 g, thus bridging a gap between our 1 kg mass comparators and our 5 g ultra-microbalance. In November 2007, the new automatic mass exchanger for our AX106 Mettler-Toledo mass comparator was installed by IPA Elektronika (Slovakia). The electronic parts which control the motion of the motors was provided by the installer. The mechanical pieces were made at the BIPM workshop with plans initially provided by R. Spurný (SMU, Slovakia), with some modifications of the workshop. In April 2008, tests were performed using software provided by I. Van Anandel of the NMi VSL (Netherlands). The first tests were encouraging, the standard deviation being considerably below what had been achieved with manual operation. A hygrometer and three thermistors were acquired and tested. These instruments and a manometer are necessary to calculate the air density by means of the CIPM-2007 formula. They will be installed in the balance in near future and code will be added in the software to acquire their readings. We then foresee full commissioning of the system followed by its introduction into our Quality Management System.

2.4 International Avogadro Coordination project (A. Picard)

The BIPM is still an active participant in the CCM Working Group on the Avogadro Constant and it performs the function of coordinator for the mass determination of silicon spheres in the framework of the International Avogadro Coordination (IAC) project. The two ^{28}Si spheres were machined and handed over from the CSIRO's Australian Centre for Precision Optics (ACPO) to the IAC in April 2008. The measurement procedure for the two spheres had been decided and a schedule of work covering more than two years was agreed by the IAC coordinators. The spheres, AVO28#5 and

AVO28#8, should arrive at the BIPM for mass determination in the second half of 2008. In the meantime, because the BIPM is the pilot laboratory, we have prepared a protocol for an international mass comparison between the BIPM, the NMIJ/AIST, the PTB and the NMIA. This second international mass comparison, under vacuum, will be carried out on the two ^{28}Si spheres. The protocol is based on the experience gained from the previous comparison mentioned in last year's Report, and we expect that it will be completed in spring 2009.

Complementary to this work, in February 2008 the BIPM began participation in the iMERA-Plus project to determine the molar Planck constant, $N_A h$.

2.5 Pt-Ir 1 kg sorption artefacts (A. Picard)

Last year we mentioned that to assist the NMIs involved in the watt balance experiment or in the Avogadro project we had planned to manufacture four sets of two 1 kg Pt-Ir sorption artefacts. Three sets are delivered, the last set of sorption artefacts is already machined and adjusted, but additional mass stability observation is required before the delivery of this set. A fifth set has been machined and sent to an NMI, which plans to polish and adjust the mass of the pair of artefacts. Concerning our BIPM sorption artefacts, the variation over a period of one year of the water vapor adsorption coefficient can be tracked with an uncertainty of about $3 \text{ ng} \cdot \text{cm}^{-2}$. From a fit as a function of time of the adsorption coefficients obtained (about $40 \text{ ng} \cdot \text{cm}^{-2}$) the value of the water adsorbed on the platinum surface can be deduced. For a classical 1 kg Pt-Ir mass standard (forming one of the pair of artefacts) the water sorption correction between air and vacuum is about $3 \mu\text{g}$, with an uncertainty of $0.2 \mu\text{g}$. This result demonstrates that by using such pair of artefacts, it is possible to accurately make the link between national prototypes, which are maintained in air and the test masses employed in the watt balance experiments or the silicon spheres used in the Avogadro project, which are all weighed under vacuum.

2.6 Glove box (A. Picard)

This year we have received the glove box, which is a key component of our vacuum-air transfer system. Use of the glove box will permit the transfer of a mass under vacuum or inert gas to the Sartorius CCL 1007 comparator, avoiding any contact with ambient air. The glove box is coupled to a vacuum oven in order to bake the silicon spheres used in the Avogadro project,

thereby eliminating water that is physisorbed on the sphere's surface. The glove box alone is not sufficient to carry out the transfer of mass. It is also necessary to have a Vacuum Transfer System (VTS) in order to load the mass into the balance, automatically and under vacuum. We should receive this VTS at the middle of this year and whole facility will then be tested.

2.7 Hydrostatic weighing apparatus (R.S. Davis and C. Goyon-Taillade)

This year, there was an unusual increase in the need for density calibrations. Densities were determined for four mass standards in stainless steel, one belonging to the LATU (Uruguay) and the remaining three to the KIM-LIPI (Indonesia). One new 1 kg prototype was manufactured by the BIPM for the United States and two 500 g standards in Pt-Ir for the LNE (France). The manufacture of three new 1 kg prototypes is in progress. Determinations of their densities have already been performed. Their masses are now at 0.7 g above 1 kg. After final adjustment, they will be well within the official tolerance of $1 \text{ kg} \pm 1 \text{ mg}$. In addition, acceptance tests were performed on four samples of Pt-Ir ingot under the terms of our protocol with our supplier, Johnson Matthey.

The density calibrations were performed with doubly distilled water as the density standard. We recall that last year preliminary, successful tests were carried out in a water bath using two 500 g cylinders of single-crystal silicon, whose densities had been previously determined at the NMIJ/AIST. The final goal is to substitute a fluorocarbon liquid for water, relying on the silicon cylinders to standardize the density of the fluorocarbon. The measurement procedure will be different from that presently used. We have already foreseen that a modification to the lower mass exchanger will be necessary. Before continuing, it is planned to upgrade the computer used to control the measurements, replace the mass exchanger controller by one with improved performance and update the software used to interrogate the various instruments. This work is progressing in steps according to the availability of the upgraded instruments and software.

2.8 Pressure (R.S. Davis and C. Goyon-Taillade)

Calibrations of BIPM manometers with respect to the pressure balance maintained in the Mass section have been carried out four times this year. Twenty-two internal certificates were issued.

We recall that a study was performed last year on the influences on a manometer of the ambient temperature and the length of connecting tube. A temperature dependence was found for one manometer used for this study. It was not possible to pursue this investigation with other manometers this year due to other work of higher priority. However, as a precaution it was decided to move all manometers under calibration to the pressure laboratory. The difference in ambient temperature between the pressure laboratory and other laboratories of the Mass section is less than 1 °C.

A bilateral comparison piloted by the LNE (France) was performed in January 2006 in order to commission our pressure balance before his implementation in our Quality Management System. The final report was issued this year, after review and acceptance by EURAMET. The report is now published in the *Metrologia Technical Supplement* (see publications list below).

2.9 G, Torsion balance experiment (R.S. Davis, T.J. Quinn* and C.C. Speake)**

The experiment was terminated in May 2008. Much of the apparatus will be transferred to the University of Birmingham (United Kingdom) under a pre-existing agreement. Results of the experiment are still being evaluated.

2.10 Publications, lectures, travel: Mass section

2.10.1 External publications

1. Picard A., Davis R.S., Gläser M., Fujii K., Revised formula for the density of moist air (CIPM-2007), *Metrologia*, 2008, **45**(2), 149-155.
2. Perkin M., Picard A., Lecollinet M., Fen K., Sardi M., Miiller A., Agarwal A., Jescheck M., Wüthrich C., Final report on CCM key comparison CCM.P-K2: Pressure (10 kPa to 120 kPa) absolute mode, *Metrologia*, 2008, **45**, *Tech. Suppl.*, 07002.
3. Otal P., Legras J.-C., Goyon C., Barat P., Davis R.S., Final report on supplementary comparison EUROMET.M.P-S3 of absolute pressure standards in the barometric range from 80 kPa to 110 kPa, *Metrologia*, 2008, **45**, *Tech. Suppl.*, 07004.

* Director Emeritus of BIPM.

** University of Birmingham (United Kingdom).

2.10.2 Travel (conferences, lectures and presentations, visits, training)

R.S. Davis to:

- LNE-INM/CNAM (France), 2 July 2007, for survey of technical work related to CCT activities;
- VNIIM (Russian Fed.), 24 August 2007, for a joint meeting of the CCM Working Group on Gravimetry;
- DFM (Denmark), 1 October 2007, to participate in a surveillance visit of the mass activities;
- 20th IMEKO Conference TC3, TC16, TC22, Merida (Mexico), 28-30 November 2007, to present a plenary talk "On the redefinition of the kilogram: Recent advances";
- CENAM (Mexico), 3-4 December 2007, to attend a meeting of the CCM WG Force;
- EURAMET TC-Mass, 5-7 March 2008, INM, Bucharest (Romania), accompanied by A. Picard;
- EURAMET TC-Therm, 31 March – 2 April 2008, NMi (Netherlands);
- NMi (Netherlands), 3 April 2008, to consult with I. van Andel on automation software;
- Boltzmann Workshop, LNE (France), 7 April 2008;
- Laboratoire de Physique Nucléaire et de Hautes Énergies (LPNHE, France), 10 April 2008, to present a seminar on a possible redefinition of the kilogram;
- Orléans School on the Science of the Universe OSSU08, Theme: Mass (origin, movement, measurement), to present an invited talk, "Mass metrology and the International System of Units", 23 June 2008.

A. Picard to:

- PTB, Braunschweig (Germany), 4 July 2007, for delivery of a silicon sphere related to the IAC project and for related discussions with personnel of Sartorius AG, accompanied by H. Fang;
- 20th IMEKO TC3, keynote talk entitled "Progress on the BIPM watt balance", 28-30 November 2007, Merida (Mexico);
- PTB, Braunschweig (Germany), 12-13 March 2008, to attend the IAC committee;
- NMIA, Sydney (Australia), 31 March – 9 April 2008, to attend the IAC committee.

- ENS, Cachan (France), 23-25 June 2008, to attend the Conference on Advanced Mathematical and Computational Tools in Metrology and Testing (AMCTM), accompanied by C. Goyon.

H. Fang to:

- 20th IMEKO TC3, talk entitled "Progress on mass determination of 1 kg silicon spheres for the Avogadro project", 28-30 November 2007, Merida (Mexico);
- LNE, Paris (France), 23 April 2008, to visit the mass laboratory, accompanied by A. Kiss;
- NIST (United States), 5 June 2008, to visit the mass laboratory.

2.11 Activities related to the work of Consultative Committees

R.S. Davis is Executive Secretary of both the Consultative Committee for Mass and Related Quantities (CCM) and the Consultative Committee for Thermometry (CCT).

The CCM and ten of its thirteen working groups and two task groups met at the BIPM in April 2008. The CCT, all nine of its working groups and its task group met at the BIPM in May 2008.

A. Picard is coordinator for mass measurements in the International Avogadro Coordination project/CCM Working Group on the Avogadro Constant (see Section 2.3). He is a member of the steering committee of CCM/WGM-TG1, which is charged with developing a *mise en pratique* for a future redefinition of the kilogram.

Three members of the Mass section devote a substantial percentage of their time to the watt balance, which is one of two special projects of the BIPM:

- A. Picard, 80 %;
- H. Fang, 70 %;
- A. Kiss, 100 % (since joining the Mass section in November 2007).

Note: progress on the BIPM watt balance is reported in Section 7.2.

2.12 Visitors to the Mass section

- Dr H. Imai (advisor to NMIJ/AIST) and Prof. T. Ono (Okayama Science University, Japan), 4 September 2007, to visit the watt balance laboratory.

- Mr A. Leistner (consultant CSIRO), 24 September 2007, to visit the Avogadro and watt balance laboratories.
- Dr P. Pinot (LNE-INM/CNAM) and Dr P.-A. Maury (LNE), 3 October 2007, to inspect to 500 g Pt-Ir mass standards manufactured for the LNE by the BIPM.
- Messrs L.F. Eason (Director North Carolina Standards Laboratory, United States) and K. Fraley (State metrologist, Oklahoma Bureau of Standards, United States), 18 October 2007, to discuss issues related to robotic weighing.
- Dr T. Froehlich and Dr D. Heydenbluth (Sartorius AG), 5-9 November 2007, for modifications and adjustments to CCL 1007 mass comparator.
- Dr R. Spurný and Mr I. Paduch (IPA Elektronika), 5-10 November 2007, for installation of automatic weight changer for 100 g balance.
- Mr M. Firlus (PTB), 6 November 2007, for discussions and collection of surface artefacts.
- Prof. J. Faller (University of Colorado, United States), 11 December 2007, to discuss precision mechanical measurements.
- Prof. R. Crease (Stony Brook University, United States), 26 December 2007, to discuss the role of the kilogram in the SI.
- Dr S. Davidson and Mr J. Berry (United Kingdom), 28 January 2008, to organize a collaborative study on ultra-violet/ozone cleaning of Pt-Ir prototypes.
- Mr J. Zuda (CMI), 11-14 February 2008, for advice on vacuum weighing.
- Dr P. Juncar and Dr M. Plimmer (LNE-INM/CNAM), 14 February 2008, to discuss possible applications of the BIPM refractometer.
- Mr J. Berry (NPL), 9-15 April 2008, for phase I of a three-phase collaborative study on ultraviolet/ozone cleaning of Pt-Ir prototypes; 13-16 May for phase II; 9-13 June for phase III.
- Mr Y. Yoshimoto (Chief Paris Representative of the New Energy and Industrial Technology Development Organization, NEDO), 18 April 2008, accompanied by Dr M. Tanaka, member of the CIPM.
- Mr T. Madec and Dr P.-A. Meury (LNE), 16 April 2008, to see the CCL 1007 mass comparator.
- Mr Y. Fujita (NMIJ/AIST), 23 April 2008.

- Mrs I. van Andel (NMI VSL), 23 April 2008, to perform tests on the BIPM 100 g automated balance using software developed by the NMI VSL.

3 TIME, FREQUENCY AND GRAVIMETRY (E.F. ARIAS)

3.1 International Atomic Time (TAI) and Coordinated Universal Time (UTC) (E.F. Arias, Z. Jiang, H. Konaté, W. Lewandowski, G. Panfilo*, G. Petit and L. Tisserand)

The reference time scales, International Atomic Time (TAI) and Coordinated Universal Time (UTC), are computed from data reported regularly to the BIPM by the various timing centres that maintain a local UTC; monthly results are published in *Circular T. The BIPM Annual Report on Time Activities for 2007*, volume 2, complemented by computer-readable files on the BIPM website (<http://www.bipm.org>), provides the definitive results for 2007.

3.2 Algorithms for time scales (Z. Jiang, W. Lewandowski, G. Panfilo* and G. Petit)

The algorithm used for the calculation of time scales is an iterative process that starts by producing a free atomic scale (*Échelle atomique libre* or EAL) from which TAI and UTC are derived. Research into time scale algorithms is conducted in the Section with the aim of improving the long-term stability of EAL and the accuracy of TAI. A new physicist was recruited in August 2007 to cover activities on time scale algorithms, which had been delayed in the last few years.

The Vth International Symposium on Time Scale Algorithms was organized jointly by the BIPM, the ROA, the INRiM and the USNO, and took place in San Fernando (Spain) on 28-30 April 2007, with the participation of about 70 metrologists.

* Physicist since 1 August 2007.

3.2.1 EAL stability

Some 86 % of the clocks used in the calculation of time scales are either commercial caesium clocks of the Symmetricom/HP/Agilent 5071A type or active, auto-tuned hydrogen masers. To improve the stability of EAL, a weighting procedure is applied to clocks where the maximum relative weight each month depends on the number of participating clocks. About 16 % of the participating clocks have, on average, been at the maximum weight, during 2007. This procedure generates a time scale which relies upon the best clocks.

Since 2003, it is estimated that the stability of EAL, expressed in terms of an Allan deviation, has been at or below 0.4×10^{-15} for averaging times of one month. Slowly varying, long-term drifts limit the stability to around 2×10^{-15} for averaging times of six months.

3.2.2 TAI accuracy

To characterize the accuracy of TAI, estimates are made of the relative departure, and its uncertainty, of the duration of the TAI scale interval from the SI second, as produced on the rotating geoid, by primary frequency standards. Since July 2007, individual measurements of the TAI frequency have been provided by twelve primary frequency standards, including eight caesium fountains (IT CSF1, LNE-SYRTE FO1, LNE-SYRTE FO2, LNE-SYRTE FOM, NICT CSF1, NIST F1, NMIJ F1 and NPL CSF1). Reports on the operation of the primary frequency standards are regularly published in the *BIPM Annual Report on Time Activities* and on the BIPM website.

Starting in July 2004, a monthly steering correction of a maximum of 0.7×10^{-15} is applied as deemed necessary. Since July 2007, the global treatment of individual measurements has led to a relative departure of the duration of the TAI scale unit from the SI second on the geoid ranging from $+2.3 \times 10^{-15}$ to $+4.9 \times 10^{-15}$, with a standard uncertainty of less than 1×10^{-15} . Over the year, twelve steering corrections have been applied for a total correction of $[f(EAL) - f(TAI)]$ of -3.6×10^{-15} .

To improve the performances of TAI, in term of accuracy, a study of the influence of different atomic clocks (caesium clocks, hydrogen masers, etc.) on the time scale algorithm has been initiated.

3.2.3 Independent atomic time scales

TT(BIPM)

Because TAI is computed in “real-time” and has operational constraints, it does not provide an optimal realization of Terrestrial Time (TT), the time coordinate of the geocentric reference system. The BIPM therefore computes an additional realization TT(BIPM) in post-processing, which is based on a weighted average of the evaluation of the TAI frequency by the primary frequency standards. We have provided an updated computation of TT(BIPM), named TT(BIPM07), valid until December 2007, which has an estimated accuracy of order 0.5×10^{-15} . Studies aiming at improving the computation of TT(BIPM) have been undertaken, in order to keep it in line with improvements in primary frequency standards.

3.3 Primary frequency standards and secondary representations of the second (E.F. Arias, G. Petit, R. Felder and L. Robertsson)

Members of the BIPM Time, Frequency and Gravimetry section are actively participating in the work of the CCL/CCTF Frequency Standards Working Group, seeking to encourage knowledge sharing between laboratories, the creation of better documentation, comparisons, and the use of high accuracy PFS (Cs fountains) for TAI.

Other microwave and optical atomic transitions are being proposed as secondary representations of the second by the CCL/CCTF Frequency Standards Working Group. The list containing frequency values and uncertainties for transitions in Rb, Hg⁺, Yb⁺, Sr⁺ and Sr, recommended by the Consultative Committee for Time and Frequency (CCTF): Recommendation CCTF 2 (2006) and by the CIPM: Recommendation 1 (CI-2006), remains valid as there was no meeting of the CCTF in 2007. BIPM staff continue to participate in the rapidly evolving field of optical frequency standards, addressing, for example, the issue of their comparison at the 10^{-17} uncertainty level or below.

3.4 Time links (E.F. Arias, Z. Jiang, H. Konaté, W. Lewandowski, G. Panfilo, G. Petit, and L. Tisserand)

As recommended by the CCTF at its meeting in October 2006, GPS time links used for clock comparison in TAI are calculated with the so-called method “GPS all in view”. The introduction of this method decreased

particularly the link noise for long distance links, and avoided the use of intermediate links for comparing clocks at very distant laboratories. Clock comparisons can presently be made by three independent techniques: GPS all in view based on C/A code measurements from GPS single frequency receivers; GPS all in view obtained with dual-frequency, multi-channel GPS geodetic type receivers (P3); and two-way satellite time and frequency transfer through geostationary telecommunications satellites (TWSTFT). Significant improvement is being made with the growing number of time links with P3 receivers (thirteen official links in May 2007, and several more computed as additional links), and with a regular schedule of twelve daily TWSTFT observations. The classical GPS single-channel, single-frequency receivers today represent only 14 % of the time transfer equipment and are in the process of being replaced by multi-channel, single or dual frequency receivers. As a result, there has been an improvement in the accuracy of time transfer, and the whole system of time links has become more reliable.

Testing continues on other time and frequency comparison methods and techniques.

3.4.1 Global Positioning System (GPS) and Global Navigation Satellite System (GLONASS) code measurements

All GPS links are corrected for satellite positions using IGS (International GNSS Service) post-processed, precise satellite ephemerides, and those links made with single-frequency receivers are corrected for ionospheric delays using IGS maps.

3.4.2 Phase and code measurements from geodetic-type receivers

GPS and GLONASS time and frequency transfer may also be carried out using dual-frequency, carrier-phase measurements in addition to code measurements. This technique, already in common use in the geodetic community, can be adapted to the needs of time and frequency transfer. These studies are conducted in the framework of the IGS Working Group on Clock Products, of which a physicist of the Section is a member.

The method developed to perform the absolute calibration of the Ashtech Z12-T hardware delays allows us to use this receiver for differential calibrations of similar receivers worldwide. Calibration trips began in January 2001. Since 2006, calibration results have also been issued for the

new type of receiver Septentrio PolaRx2, and other types of receivers are being investigated in collaboration with laboratories equipped with such receivers. A new receiver recently developed and commercialized (GTR50) has been purchased and is included in the calibration procedures since 2008. In all cases, at least two receivers remain at the BIPM to serve as a local reference with which the travelling receiver is compared between calibration trips.

Data from geodetic-type receivers worldwide are collected for TAI computation, using procedures and software developed in collaboration with the Observatoire Royal de Belgique (ORB). Such P3 time links are now routinely computed and compared to other available techniques, notably for two-way time transfer. Geodetic-type receivers also provide raw phase measurements which may be used, along with the code measurements, to compute time links. This is routinely done by the IGS for some time laboratories which are also part of the IGS network. The BIPM has computed its own solutions for such time links since October 2007, using Precise Point Positioning (PPP) software, developed in collaboration with geodetic institutes. Comparisons between PPP, IGS, P3 and two-way links have led to insightful results on the stability of each technique. Since April 2008, a pilot experiment (TAIPPP) has been started with the participation of some 25 TAI laboratories, to study the introduction of such PPP time links for TAI computation.

3.4.3 Two-way time transfer

Two meetings of the TWSTFT participating stations have been held since July 2007; the CCTF WG on TWSTFT met in METAS in September 2007. The BIPM collects two-way data from 17 operational stations and undertakes treatment of some two-way links. About ten TWSTFT links are routinely used in the computation of TAI; some other links are in preparation for their introduction into the computation of TAI. The BIPM is also involved in the calibration of two-way time-transfer links by comparison with GPS. A major event occurred in February 2008 with a satellite change that required hardware modification in the Earth TW stations, which provoked a loose of the equipment's calibration. The BIPM played a key role in maintaining the continuity of the links by keeping the calibrations through the GPS PPP links that are calculated in the scope of the pilot project.

3.4.4 Uncertainties of TAI time links

The values of the type A and type B uncertainties of TAI time links are published in the *Circular T*, together with the information on the time links used in each monthly calculation. The values of u_A are updated when deemed necessary, depending on the noise level present in the links.

3.4.5 Calibration of TAI time links

The BIPM continues to organize and run calibration campaigns of GPS time equipment in time laboratories which contribute to TAI. From July 2007 to June 2008, GPS time equipment for single and dual frequency reception have been calibrated. The BIPM is also taking part in the organization of TWSTFT calibration trips; these trips are supported with a GPS receiver from our time laboratory.

Progress has been possible on the calibration of GLONASS equipment thanks to the cooperation with the Space Research Centre in Warsaw (Poland). As a result of this cooperation, we plan to initiate in the last semester of 2008 the calibration of GLONASS frequencies on GPS/GLONASS receivers operated in TAI participating laboratories.

3.5 Key comparisons

(E.F. Arias, W. Lewandowski, G. Panfilo and L. Tisserand)

Monthly updates of key comparison in time CCTF-K001.UTC are published after the publication of *Circular T*. Timing centres in laboratories who are participants to the CIPM MRA from Member States and Associates of the CGPM, take part in this key comparison.

As recommended by the CCTF at its meeting in October 2006, a study on the frequency uncertainty for the key comparison in frequency CCTF-K002.FREQ has been started in the Section. The first results have been obtained and further studies are in progress.

3.6 Pulsars (G. Petit)

Collaboration continues with the Observatoire Midi-Pyrénées (OMP), Toulouse (France), and other radio-astronomy groups observing pulsars and analyzing pulsar data to study the potential capability of using millisecond pulsars as a means of sensing the very long-term stability of atomic time. The

Time, Frequency and Gravimetry section provides these groups with its post-processed realization of Terrestrial Time.

3.7 Space-time references (E.F. Arias and G. Petit)

A web and ftp site for the *IERS Conventions* has been established at the BIPM (<http://tai.bipm.org/iers/>) and a user discussion forum has been created (<http://tai.bipm.org/iers/forum/>) for users to offer comments related to the future updates of the *IERS Conventions*. Updates to the *Conventions* (2003) have been posted on the website (<http://tai.bipm.org/iers/convupdt>). These updates consider several new models for effects that affect the positions of Earth's points at the mm level, which are now significant. These modifications are studied with the help of the Advisory Board for the *IERS Conventions* updates, including representatives of all groups involved in the IERS. A Workshop on the IERS Conventions was organized at the BIPM on 20-21 September 2007 for a discussion of the improvement of already published models and on the implementation of new ones. About 65 scientists from 15 countries attended the workshop. The presentations are available on the BIPM website (http://www.bipm.org/en/events/iers/iers_documents.html).

Activities related to the realization of reference frames for astronomy and geodesy are developing in cooperation with the IERS. In these domains, improvements in accuracy will enhance the need for a full relativistic treatment and it is essential to continue participating in international working groups on these matters; e.g. through the new IAU Commission "Relativity in Fundamental Astronomy". Cooperation continues for the maintenance of the international celestial reference system, and work has progressed in the framework of the IAU, IVS and IERS for the construction of a new conventional reference frame to be submitted to the IAU in August 2009.

3.8 Comb activities (R. Felder and L. Robertsson)

As the result of the reorganization of activities in the Section, the comb activities are limited to the comb maintenance for BIPM internal applications.

3.9 BIPM key comparison BIPM.L-K11 and CCL-K11 (R. Felder and L. Robertsson)

In 2003, at its 22nd meeting, the General Conference endorsed the proposal of the CIPM to close the BIPM Length section during 2006. Consequently, the BIPM could no longer pilot the BIPM.L-K11 key comparison.

Besides providing direct traceability for these standards, the measurements made as part of this key comparison constitute a high-level traceability network from which the reduced uncertainty in the realization of the metre implementation can extend to smaller NMIs. Furthermore, the accumulated information from these measurements provides better values for the recommended radiations that are to be included in the *Mise en pratique*, yielding an improvement which was not available for the different frequency comparisons made in BIPM.L-K10.

After the introduction of comb technology into some smaller NMIs, participation in BIPM.L-K11 has been seen as a way to provide comb validation to a level relevant to support their claimed measurement capability.

To meet the requests of the CCL and the needs of NMIs for such comparisons, a questionnaire was prepared and distributed to the Member States. The responses indicated that there is a real need for this type of measurement and a distributed structure for the continuation of the measurements covered by the BIPM.L-K11 has therefore been proposed. In this proposal, the BEV (Austria) applied to become the pilot laboratory in replacement of the BIPM and four national metrology institutes (MIKES, NMIJ, NPL and NRC), located in different RMOs, have proposed to participate as node laboratories. Final details concerning the new operation of the key comparison were discussed during the 13th meeting of the CCL in September 2007, when this new organization was approved and it was decided therefore to stop the key comparison BIPM.L-K11 and open the corresponding CCL-K11. A modified technical protocol has been prepared and the effective coordination is now transferred to BEV. The first measurements in CCL-K11 were made at the MIKES institute in December 2007, with the technical support of Dr L. Robertsson.

3.10 Calibration and measurement service
(R. Felder, J. Labot and L. Robertsson)

The section has provided calibration and measurement service for combs and reference lasers for internal needs only. This includes the periodic absolute frequency determination of our reference lasers, both at 633 nm and 532 nm, used for iodine cell quality testing lasers, for the calculable capacitor project and the gravimeter instrumentation at the BIPM.

3.11 Iodine cells (R. Felder, J. Labot and L. Robertsson)

We have received a continuous demand of iodine cells from NMIs and laboratories for use in stabilized lasers and in spectroscopy. Sixteen iodine cells have been sold during the period of this report (nine have already been delivered and seven under calibration as of June 2008). Advanced contacts have been established with several laboratories for the design and filling of cells in the last half of 2008. It is important to note that these demands concern, to a great extent, specially designed cells with specific geometrical features.

The standard iodine cells we produce are tested by a frequency comparison with our reference laser BIW 167. For this, the iodine cells are placed in the cavity of an auxiliary laser, BIPM7, in which we have replaced the gain tube. Consequently, a series of measurements were necessary on this auxiliary laser to determine the new power and pressure coefficients to be used for the calculation of the absolute frequency of the iodine cell under test.

In order to estimate the frequency reliability of an iodine cell before delivery to a client, we carry out, over a period of time, a series of measurements to determine the fluorescence behaviour of the cell under test by means of a semi-automated experiment. This experiment will be reinstalled in the laser building and we will take this opportunity to modify the mechanical device in order to facilitate the characterization of cells of specific design.

As mentioned in the previous Director's Report, a new vacuum system has been purchased. It has been satisfactorily tested, and the design and the construction of a new glass pipe-network for the iodine cells process is well underway.

3.12 Gravimeter FG5-108 (L. Vitushkin and O. Orlov*)

The system for the delivery of the light of the compact Nd:YVO₄/KTP/I₂ laser at a wavelength of 532 nm to the interferometer of FG5-108 using an optical fibre is under development. Several optical layouts were tested and analyzed.

The dropping chamber of the FG5-108 was tested after the repair and maintenance by the producer "Micro-g LaCoste, Inc."

3.13 The 7th International Comparison of Absolute Gravimeters, ICAG-2005 (Z. Jiang and L. Vitushkin)

The work on the evaluation of the uncertainty budgets for the absolute gravimeters, which participated in the ICAG-2005, was completed in cooperation with the participants and the CCM Working Group on Gravimetry discussion group on technical protocol and budget of uncertainties.

Several versions of the adjustment and evaluation of the absolute and relative data obtained during ICAG-2005 have been investigated. The results are under discussion and will provide the basis for the development of recommendations for the technical protocol of the ICAG-2009.

3.14 Preliminary study on the BIPM watt balance project in view of gravimetry (Z. Jiang)

The watt balance requires an uncertainty of 10^{-8} in the absolute gravity value. Preliminary studies have been carried out on the equipment and the influence of local and global environment for accurate gravity measurements.

3.15 Publications, lecture, travel: Time, Frequency and Gravimetry section

3.15.1 External publications

1. Arias E.F, A successful example of international coordination for metrology: the international time scales, *Proc. Int. Symposium, Terrestrial Gravimetry, Static and Mobile Measurements TGSM-2007*, State Research Centre of Russia Electropribor St Petersburg, 2008, 7-14.

* Guest scientist from VNIIM.

2. D'Agostino G., Germak A., Vitushkin L.F., International Comparison of Absolute Gravimeters, Technical Protocol and Estimate of the Reference Value and its Uncertainty, *Proc. Int. Symposium Terrestrial Gravimetry: Static and Mobile Measurements TGSMM-2007*, State Research Centre of Russia Electropribor, St Petersburg, 2008, 117-122.
3. Jiang Z., Vitushkin L., Becker M., Francis O., Jousset P., Ferry M., Dupont F., Deroussi S., Métivier L., Pajot G., Lee C., Tsai C., Falk R., Wilmes H., Kopaev A., Ruess D., Ullrich C., Meurers B., Mrlina J., Palinkas V., Kostelecky J., Pereir F., van Ruymbeke M., Naslin S., Relative campaign during the International Comparison of Absolute Gravimeters ICAG-2005 and the strategy of data treatment combined with the absolute results, *Proc. 1st Int. Gravity Field Service Symposium, Istanbul*, 2007, 371-376.
4. Jiang Z., Petit G., Defraigne P., Combination of GPS carrier phase solution with a calibrated time transfer link, *Proc. 21st EFTF*, 2007, 1182-1187.
5. Jiang Z., Becker M., Vitushkin L., The local gravity field at BIPM, *Proc. Int. Symposium Terrestrial Gravimetry: Static and Mobile Measurements TGSMM-2007*, State Research Centre of Russia Electropribor, St Petersburg, 2008, 152-157.
6. Krivtsov E., Yankovsky A., Vitushkin L., Francis O., Investigations of Characteristics of Gravimetric Sites Intended for High-Accuracy Measurements, *Proc. Int. Symposium Terrestrial Gravimetry: Static and Mobile Measurements TGSMM-2007*, State Research Centre of Russia Electropribor, St Petersburg, 2008, 158-166.
7. Lewandowski W., Matsakis D., Panfilo G., Tavella P., Analysis of Correlations, and Link and Equipment Noise in the Uncertainties of $[UTC - UTC(k)]$, *UFFC*, April 2008, **4**, 750-760.
8. Petit G., The long-term stability of EAL and TAI (revisited), *Proc. EFTF-FCS'07 meeting*, 2007, 391-394.
9. Petit G., Jiang Z., GPS All in view time transfer for TAI computation, *Metrologia*, 2008, **45**(1), 35-45.
10. Petit G., Jiang Z., Precise point positioning for TAI computation, *Proc. EFTF-FCS'07 meeting*, 2007, 395-398.
11. Petit G., Jiang Z., Precise point positioning for TAI computation, *IJNO* Article ID 562878, doi:10.1155/2008/562878, 2008.

12. Robertsson L., Felder R., Bertinetto F., Cordiale P., Wallerand J.-P., Suh H., Hussein H., Hamid R., Sahin E., Results from the CII-2006 campaign at the BIPM of the BIPM.L-K11 ongoing key comparison, *Metrologia*, 2007, **44**, *Tech. Suppl.*, 04003.
13. Robertsson L., Zucco M., Felder R., Ma L.-S., Quin J., Liu X., Liu Z., Inaba H., Ishikawa J., Hamid R., Results from additional measurements carried out within the BIPM.L-K11 ongoing key comparison. *Metrologia*, 2007, **44**, *Tech. Suppl.*, 04004.
14. Robertsson L., Zucco M., Felder R., Ma L.-S., Dahlan A.M., Prieto E., Perez M., Saraiva F., Sharma R., Results from the CII-2005 and CI-2006 campaigns at the BIPM of the BIPM.L-K11 ongoing key comparison, *Metrologia*, 2007, **44**, *Tech. Suppl.*, 04002.
15. Vitushkin L., Wolf P., Vitushkin A., Measurement of the Gravitational Constant Using the Attraction Between Two Freely Falling Discs: A Proposal, *Int. J. Modern Physics D*, 2007, **16**(12A), 2287-2295.
16. Vitushkin L., Measurement standards in gravimetry, *Proc. Int. Symposium Terrestrial Gravimetry: Static and Mobile Measurements TGSMM-2007*, State Research Centre of Russia Electropribor, St Petersburg, 2008, 98-105.
17. Vitushkin L., Orlov O., Nalivaev V., Test Measurements of Free-Fall Acceleration Using the FG5-108 Gravimeter With a Compact Diode-Pumped Solid-State Nd:YVO₄/KTP/I₂ Laser at a Wavelength of 532 nm, *Proc. Int. Symposium Terrestrial Gravimetry: Static and Mobile Measurements TGSMM-2007*, State Research Centre of Russia Electropribor, St Petersburg, 2008, 143-146.
18. Vitushkin L., Wolf P., Vitushkin A., A Proposal for the Measurement of the Gravitational Constant Using the Attraction Between Two Freely Moving Discs, *Proc. Int. Symposium Terrestrial Gravimetry: Static and Mobile Measurements TGSMM-2007*, State Research Centre of Russia Electropribor, St Petersburg, 2008, 259-263.
19. Wallerand J.-P., Robertsson L., Ma L.-S., Zucco M., Absolute frequency measurement of molecular iodine lines at 514.7 nm, interrogated by a frequency-doubled Yb-doped fibre laser, *Metrologia*, 2006, **43**(3), 294-298.

3.15.2 BIPM publications

20. *BIPM Annual Report on Time Activities for 2007, 2008*, **2**, 97 pp.

21. *Circular T* (monthly), 7 pp.

3.15.3 Travel (conferences, lectures and presentations, visits)

E.F. Arias to:

- St Petersburg (Russian Federation), 20-23 August 2007, for the Symposium “Terrestrial Gravimetry: Static and Mobile Measurements. TG-SMM-2007”, with an invited lecture;
- New Dehli (India), 29-31 August 2007, invited for a visit to NPLI and for giving a lecture on timing activities at the BIPM;
- Bangalore (India), 5-7 September 2007, for the Second Meeting of the International Committee for GNSS, with a lecture, and for ICG Working Group meetings;
- Sèvres (France), 20-21 September 2007, for the IERS Conventions Workshop;
- Toulouse (France), 1-4 October 2007, for the 1st Colloquium on Scientific and Fundamental Aspects of Galileo Programme, with a lecture and chairmanship of a session;
- Vienna (Austria), 18-19 February 2008 and 10 June 2008, for preparatory meetings of the International Committee on GNSS;
- Geneva (Switzerland), 11-14 September 2007, and 31 March – 4 April 2008 for meetings of the Working Party 7A of the International Communications Union, Radiocommunications Sector (ITU-R), as delegate from the BIPM;
- Douai (France), 11 April 2008, for the OIML Training Seminar, with a lecture;
- Toulouse (France), 23-25 April 2008, to attend the European Forum on Time and Frequency (EFTF 08) and for the meetings of the TWSTFT participating stations, of the CCTF Working Groups on Primary Frequency Standards and on the CIPM MRA;
- San Fernando (Spain), 28-30 April 2008, for the Vth International Symposium on Time Scale Algorithms, with a lecture in the tutorials session.

R. Felder to

- Noizay (France), 31 July – 1 August 2007, to receive 3 long iodine cells constructed by Ets. Dumas;
- Paris (France), 25 February 2008, Laboratoire “*AstroParticule et Cosmologie*” of University Paris 7 (APC), to visit the laboratories and to deliver 2 iodine cells;
- Paris (France), 25-28 March 2008, to the Société Française du Vide, for a training course on vacuum technology;
- Paris (France), 7 April and 14-15 May 2008, for the workshop on the Boltzmann constant at LNE-INM/CNAM;
- Toulouse (France), 22-25 April 2008, to attend the EFTF 08, and for the meeting of the CCTF Working Group on Primary Frequency Standards.

Z. Jiang to:

- St Petersburg (Russian Federation), 20-23 August 2007, for the Symposium “Terrestrial Gravimetry: Static and Mobile Measurements. TG-SMM-2007”;
- Beijing (China), 3-7 September 2007, for the ICMM 2007.

Z. Jiang and W. Lewandowski to:

- Long Beach, California (USA), 26-29 November 2007, for the 39th Precise Time and Time Interval Meeting;
- Toulouse (France), 23-25 April 2008, for the EFTF 08 meeting and for the meetings of the TWSTFT participating stations and of the CCTF Working Group on Primary Frequency Standards;
- San Fernando (Spain), 28-30 April 2008, for the Vth International Symposium on Time Scale Algorithms.

W. Lewandowski to:

- Bern (Switzerland), to the METAS, 17-19 September 2007, for the 15th meeting of the CCTF Working Group on TWSTFT;
- Warsaw (Poland), 10-14 December 2007, for meetings of the Polish Working Group on Metrology, and for activities at the Space Research Centre.

W. Lewandowski and G. Panfilo to Toulouse (France), 1-4 October 2007, for the 1st Colloquium on Scientific and Fundamental Aspects of Galileo Programme, with a lecture.

G. Panfilo to:

- Toulouse (France), 23-25 April 2008, for the EFTF 08, with a lecture and for meetings of the TWSTFT participating stations and of the CCTF working groups on primary frequency standards and on the CIPM MRA;
- San Fernando (Spain), 28–30 April 2008, for the Vth International Symposium on Time Scale Algorithms, with a lecture;
- Orsay (France), 13-15 May and 17-19 June 2008, to training courses on Fortran at the CNRS;
- Oxford (United Kingdom), 29 May 2008, to a training course on NAG Toolbox for Matlab;
- Paris (France), 23-25 June 2008, for the meeting on Advanced Mathematical and Computational Tools in Metrology and Testing (AMCTM), with a poster presentation.

G. Petit to:

- Paris-Meudon Observatory (France), 17-19 September 2007, for the Journées Systèmes de Référence Spatio-temporels;
- Sèvres (France), 20-21 September 2007, for the IERS Conventions Workshop, convenor of the meeting, chair of the organizing committee, two lectures;
- Toulouse (France), 1-4 October 2007, for the 1st Colloquium on Scientific and Fundamental Aspects of Galileo Programme;
- San Francisco (United States), 9-12 December 2007, for the meetings of the Governing Board of the IGS and of the Directing Board of the IERS, and of the AGU;
- Besançon (France), 4 April 2008, for a meeting on the “Programme Pluri-formations Systèmes de Référence”;
- Vienna (Austria), 12-15 April 2008, for the meeting of the Directing Board of the IERS, and of the EGU, with a lecture;
- Toulouse (France), 23-25 April 2008, for the EFTF 08, session chair and one invited lecture, and for the meeting of the CCTF Working Group on Primary Frequency Standards;
- San Fernando (Spain), 28-30 April 2008, for the Vth International Symposium on Time Scale Algorithms, with a lecture;
- Paris (France), 26 May 2008, for a meeting of the Fundamental Physics Group of the CNES.

G. Petit and L. Vitushkin to Perugia (Italy), 2-8 July 2007, for the General Assembly of the IUGG'2007.

L. Robertsson to:

- St Petersburg (Russian Fed.), 20-23 August 2007, for the Symposium "Terrestrial Gravimetry: Static and Mobile Measurements. TG-SMM-2007"; 24 August 2007 for the Third Joint Meeting of CCM WGG and IAG Study Group on Comparisons of Absolute Gravimeters at the VNIIM;
- Frascati (Italy), 10-12 October 2007, for the 2nd ESA International Workshop on Optical Atomic Clocks;
- Helsinki (Finland), 10-14 December 2007, for the key comparison CCL-K11 at MIKES;
- Paris (France), 6 February 2008, for a meeting of experts on laser frequency stabilization associated to LISA mission, AstroParticule et Cosmologie;
- Toulouse (France), 23-25 April 2008, for the EFTF 08, and for the meeting of the CCTF Working Group on Primary Frequency Standards.

L. Vitushkin to:

- St Petersburg (Russian Fed.), 24 August 2007, for the Third Joint Meeting of CCM WGG and IAG Study Group on Comparisons of Absolute Gravimeters at the VNIIM;
- Turin (Italy), 13-14 December 2007, for the meeting on the evaluation of the results of ICAG-2005;
- St Petersburg (Russian Fed.), 1-12 February 2008, for a cooperation on gravimetry with VNIIM;
- Kiev (Ukraine), 4-5 April 2008, for a meeting on microstructure cells, and the presentation on the applications of the diode-pumped solid-state lasers in absolute gravimeters invited by the Institute of Physics NAS Ukraine;
- Frankfurt (Germany), 6 April 2008, for a coordination meeting of the IAG Working Group on Absolute Gravimetry and CCM Working Group on Gravimetry, BKG;
- St Petersburg (Russian Fed.), 20-29 May 2008, for invited talks at the International Academy of Navigation and at the Seminar on Gravimetry at VNIIM, and for supervising the work on the absolute gravimeter;

- Turin (Italy), 17 June 2008, for the meeting at INRiM of CCM WGG discussion group on technical protocol and budget of uncertainties;
- Chania (Greece), 23-28 June 2008, for the IAG international symposium Gravity, Geoid and Earth Observation (GGEO-2008).

H. Konaté to Malakoff (France) for training courses on Descriptive Statistics I and II, 4-5, 14-15 June and 17-18, 27-28 September 2007.

J. Labot to:

- Orsay (France), 15-19 October and 3-7 December 2007, for training courses of vacuum technology;
- Noizay (France), 19-23 May 2008, for a training course on glass blowring.

L. Tisserand to:

- Orsay (France), 13-15 May and 17-19 June 2008, for training courses on Fortran at the CNRS;
- Paris (France), 26-30 May 2008, for a training course on Labview.

3.16 Activities related to external organizations

E.F. Arias is a member of the IAU, participating in two of its working groups: on nutation and on the International Celestial Reference System. She is an associate member of the IERS, a member of the International Celestial Reference System Product Centre, and of the Conventions Product Centre of the IERS. She is a member of the International VLBI Service (IVS), and of its Analysis Working Group on the International Celestial Reference Frame. She is the BIPM representative at the Governing Board of the IGS. She is the BIPM representative to the International Committee for GNSS. She is a member of the Argentine Council of Research (CONICET) and an associated astronomer at the SYRTE, Paris Observatory. She is the corresponding member of the Bureau des Longitudes. She is the BIPM representative to the Working Party 7A of the Study Group 7 of the ITU-R.

W. Lewandowski is the BIPM representative to the Civil GPS Service Interface Committee and chairman of its Timing Sub-committee. He is a member of the Scientific Council of Space Research Centre of the Polish Academy of Sciences. He also chairs a working group on scientific metrology at Polish Ministry of Economy. Together with E.F. Arias, he is the BIPM representative to the Working Party 7A of the Study Group 7 of the ITU-R.

G. Petit is co-director of the Conventions Centre of the IERS. He is vice-president of the IAU Commission 52 "Relativity in fundamental astronomy", member of the IAU Working Group on Numerical Standards in Fundamental Astronomy, of the IGS Working Group on Clock Products and of the Fundamental Physics Group of the CNES.

L. Vitushkin is President of IAG sub-commission 1 "Gravimetry and Gravity Networks" and Chairman of the Study Group 2.1.1 on Comparison of Absolute Gravimeters of the IAG Commission 2 "Gravity field". He is member of the International Scientific Committee of the IAG international symposium "Gravity, Geoid and Earth Observation GGEO-2008" that took place on 23-28 June 2008 in Chania (Greece).

3.17 Activities related to the work of Consultative Committees

E.F. Arias is Executive Secretary of the CCTF. She shares with R. Felder the Secretariat of the CCL/CCTF Working Group on Frequency Standards. She is a member of the CCTF Working Groups on Two-Way Satellite Time and Frequency Transfer, on Primary Frequency Standards and on TAI.

R. Felder is the Executive Secretary of the CCL and Joint Secretary to the CCL/CCTF Working Group on Frequency Standards.

Z. Jiang is a member of the CCTF Working Group on TWSTFT.

W. Lewandowski is Secretary of the CCTF Working Group on TWSTFT and Secretary of the CCTF Working Group on Global Navigation Satellite Systems Time-transfer Standards (CGGTTS).

G. Panfilo is a member of the CCTF working groups on algorithms and on primary frequency standards.

G. Petit is a member of the CCTF working groups on TAI, on algorithms, on primary frequency standards, and on the CGGTTS.

L. Vitushkin is the Chairman of the CCM Working Group on Gravimetry.

The 13th meeting of the CCL was held at BIPM, 13-14 September 2007. It was preceded by its subsequent working groups (WGDM and CCL/CCTF Joint Working Group on Frequency Standards). Responses to the questionnaires were analysed and a summary was prepared for presentation and discussion.

An important time was devoted to the preparation of the documents reporting on the CCL and CCTF activities during the period 2003-2007 and presented at the CGPM.

In the framework of the transfer of key comparison CCL-K11, L. Robertsson participated to the comparison hosted by MIKES and piloted by BEV on 10-14 December 2007.

3.18 Visitors to the Time, Frequency and Gravimetry section

- Dr E. Boyarskiy and Dr L. Afanasyeva (O. Yu. Schmidt Institute of Earth Physics, St Petersburg), 7-22 September 2007, for cooperation on software for gravimetry.
- Drs E. Plagnol, G. Auger, O. Jeannin and 2 colleagues (APC), 18 September 2007.
- Ings M. Orain (ONERA, Palaiseau) and M.-C. Mérienne (ONERA, Meudon), 19 September and 20 November 2007.
- Dr F. Cordara (INRiM), 19 September 2007, for a cooperation in the implementation of key comparison CCTF-K002.FREQ.
- Dr O. Jeannin and Mr O. Turazza (APC), 24 October 2007.
- Dr O. Acef (LNE-SYRTE) and Mr O. Turazza (APC), 28 November 2007.
- Mr P. Plombin (Ets. Dumas, Noizay, France), 6 December 2007 and 25 February 2008.
- Mr Borelly (Tilt Import, Bazainville, France), 12 December 2007.
- Prof. Dr M. Kühne (PTB), 21 January 2008.
- Dr A. Bauch (PTB), 14 February 2008.
- Dr C. Daussy (LPL), 20 February 2008.
- Dr J. Burger (NMISA), 17 April 2008.
- Prof. M. Gubin (Lebedev Institute, Moscow, Russian Fed.), 28 April 2008.
- Ms C. Adam (Imagine Optics, Orsay, France), 19 May 2008.
- Mr Calais (BOC-Edwards, France), 5-6 June 2008.
- Dr H. Belaidi (INMETRO), 13 June 2008.
- Dr P. Nogas (AOS), 16-20 June 2008.

3.19 Guest workers

- Dr O. Orlov (VNIIM), 8-25 September 2007, for the delivery of lasers for the calculable capacitor and for the cooperation in gravimetry; 1 October – 5 November 2007 for a cooperation in gravimetry.

4 ELECTRICITY (M. STOCK)

4.1 Electrical potential: Josephson effect (R. Chayramy, S. Solve)

The 10 V programmable SINIS Josephson array offered to the BIPM by the PTB in 2006 has been compared with a conventional Josephson array of LNE, following the BIPM.EM-K10.b comparison at LNE in December 2007. Care was taken to reduce systematic uncertainty contributions as well as the statistical uncertainty as much as possible. The relative voltage difference and uncertainty are exceptionally small, both are below 1 part in 10^{10} . This demonstrates that the performance of the SINIS array is neither limited by eventual resistive Josephson junctions nor by leakage currents through the current bias source. The results of this work were presented at the CPEM.

A large scale renovation programme of the voltage laboratory was begun in October 2007. The primary and secondary voltage standards together with the measurement facilities have been temporarily transferred to another laboratory to allow the continuation of the comparison and calibration work during the refurbishment. This has delayed the final testing of the new automatic Zener calibration system.

The uncertainty budget for the calibration of Zener voltage standards with the Josephson effect at BIPM has been reviewed in detail, and many experiments have been carried out to quantify the uncertainty components. The final version of the document is still under review before its official adoption in the framework of our Quality System. An internal audit was passed successfully in September 2007.

We have started to work on the design and the electronics of the dc current bias source for the programmable 1 V Josephson SNS array, offered by NIST, that will in the future serve as the voltage reference of the watt balance. The electronics of the source will be operated by a set a chargeable

batteries and will be able to bias 13 different and independent Josephson junctions segments.

Recently, it has become difficult to purchase high quality Josephson arrays which are essential for our on-site comparisons. With our Josephson equipment, S. Solve visited one of the few companies (Hypres Inc.) producing conventional arrays to select an array of sufficient quality from those available.

4.2 Electrical resistance and impedance

4.2.1 DC resistance and quantum Hall effect (N. Fletcher, R. Goebel, A. Jaouen)

Last year, the whole BIPM resistance scaling system based on our quantum Hall resistance (QHR) reference was checked with an accuracy of a few parts in 10^9 , including the one-hertz bridge (used to link the QHR and the first-order working standards) and the ratio of our Hamon resistor (used to link the QHR and the reference of capacitance). This year, confidence in this check was given at the 10^{-8} level through bilateral comparisons of travelling standards with the NIST (see Section 4.3).

During the last calibration campaign, a small leak was detected in the cryostat of the QHR reference (an Oxford Instruments cryostat), which does not impede the calibration process but greatly reduces the liquid helium hold time. As the leak cannot be fixed without dismantling the whole system, it was decided to reconfigure the second cryostat available in the Electricity section (a Cryogenic Ltd system), used several years ago for experiments on the ac QHR. A He^4 insert was mounted, and a probe equipped with a thermometer and electrical connections for a quantum Hall sample used in dc mode. The calibrations of the BIPM $100\ \Omega$ reference obtained from both systems agree within the repeatability of the measurements; that is, to within a few parts in 10^9 . A redundant system is now in place, which will allow the first one to be replaced without interruption to measurements.

In order to ease the periodic checks and calibrations of digital voltmeters at the 10^{-5} and 10^{-6} level, a commercial high-quality calibrator was installed to meet the internal needs of the Electricity section.

The refurbishment of the laboratories is continuing, and part of the air-conditioning system was renewed, which is essential for the stability of the measurements.

4.2.2 Maintenance of a reference of capacitance (R. Chayramy, N. Fletcher, R. Goebel)

After the move, last year, of the capacitance activities to a new laboratory, an improved traceability route making direct use of the quantum Hall system has been successfully established. The measurements in the new laboratory have now also been validated by a successful bilateral comparison with the NIST (see Section 4.3). Partly in support of the calibration services, and partly in preparation for the calculable capacitor experiment, continued studies and improvements have been undertaken on the quadrature bridge (which introduces the largest uncertainty component in the traceability chain). Allan variance analysis proved very helpful in identifying the major causes of instability in the bridge. The biggest problem was from short term stability of resistors used as ac-dc transfer standards. New versions of these resistors have demonstrated the improved stability required to reduce this uncertainty by a factor of about four, whilst still maintaining an acceptable (calibrated) ac-dc difference. The results of this work were presented at the CPEM.

Studies of the bridge stability have continued some of the previous work of the Section on time series analysis. These techniques have proved invaluable in investigating the uncertainty contributions throughout the chain of impedance bridges. The first versions of new software for the control of the bridges and analysis of data incorporating some of these techniques have been written. In particular, an analysis of the correlation between readings produced by filters used in the bridge detectors has been developed. This enables reliable type A uncertainty assessments for all bridge balances in the new software.

Both resistance and capacitance metrology were internally audited in September 2007.

4.3 **Calculable capacitor** (R. Felder, N. Fletcher, R. Goebel, L. Robertsson, J. Sanjaime, M. Stock)

The objective of the calculable capacitor project, carried out jointly with the NMIA (Australia), is to build two calculable capacitors capable of realizing a capacitance of 0.4 pF with an uncertainty of, the order of, 1 part in 10^8 . This will allow us to measure the value of the von Klitzing constant, R_K , for the next CODATA fundamental constants adjustment, and will significantly shorten the traceability chain for our capacitance calibrations. Staff of the

Electricity section, the Time, Frequency and Gravimetry section and the workshop are contributing to this work.

In September 2007 we received the two frequency doubled Nd:YVO₄ lasers, which will be used as light sources for the interferometers needed to measure the electrode separation of the capacitors. These lasers have been built at the VNIIM based on earlier development work done at the BIPM. The lasers are stabilized on an I₂ absorption line and operate in single-frequency mode. The relative stability of the laser wavelength in the range from 1 s to 1000 s is, of the order of, 1 part in 10¹². The lasers have been successfully tested and a procedure to lock them reproducibly on a specific I₂ transition has been developed.

A wave front sensor has been used to make detailed measurements of the laser beam characteristics. This is necessary in order to make the mode matching calculations that determine the optical arrangement needed to efficiently couple the laser beam into the single mode fibre used for beam transportation.

A test bench has been set up to test the behaviour of the interferometer. In the first measurements, the finesse of the interferometer was found to be lower than expected, which is probably related to an imperfect alignment of the two mirrors or the mirror surface quality.

The workshop of the BIPM has continued to fabricate a large number of mechanical parts for both instruments.

As described in the section of this report on the work of the Electricity section, the bridges that will in the future link the quantized Hall resistance to the calculable capacitance have been improved to reduce the related uncertainty.

At the NMIA, the biggest challenge is still the polishing of the electrode bars to near-perfect cylindricity within 100 nm over a length of nearly 50 cm. The first bars are now within this specification, but the surface still shows a visible structure which our colleagues are trying to remove with a special polish. They are also seeking to improve the first turning and grinding steps, to reduce the time necessary for the final manual polishing.

4.4 BIPM ongoing key comparisons in electricity

(R. Chayramy, N. Fletcher, R. Goebel, A. Jaouen, S. Solve, M. Stock)

Two on-site comparisons of Josephson voltage standards have been successfully completed, with the LNE (December 2007) and the KRISS (February 2008). The results are not yet officially available but the agreement between the BIPM and both NMIs is excellent.

Three voltage comparisons using Zener voltage standards as transfer standards were carried out with the KRISS (Republic of Korea), the NML (Ireland), and the VNIIM (Russia). The comparison with the KRISS was carried out for two different nominal voltages (1.018 V and 10 V) and the results are still under discussion.

The relative voltage differences and associated relative standard uncertainty obtained at 10 V for the NML and the VNIIM are:

$$\text{at 10 V: } (U_{\text{NML}} - U_{\text{BIPM}}) = -0.55 \mu\text{V} \quad u = 1.40 \mu\text{V}$$

$$\text{at 10 V: } (U_{\text{VNIIM}} - U_{\text{BIPM}}) = -0.22 \mu\text{V} \quad u = 0.34 \mu\text{V}$$

In the ongoing BIPM key comparison programme for resistance, we organized bilateral comparisons with the NIST (United States) and the CMI (Czech Republic). In the framework of BIPM.EM-K13.a, based on the circulation of one-ohm travelling standards, the relative differences in calibrations and the associated relative standard uncertainty were:

$$(R_{\text{NIST}} - R_{\text{BIPM}})/1 \Omega = -0.014 \times 10^{-6} \quad u = 0.021 \times 10^{-6}$$

$$(R_{\text{CMI}} - R_{\text{BIPM}})/1 \Omega = +0.040 \times 10^{-6} \quad u = 0.031 \times 10^{-6}$$

In the framework of BIPM.EM-K13.b, concerning 10 k Ω standards:

$$(R_{\text{CMI}} - R_{\text{BIPM}})/10 \text{ k}\Omega = -0.028 \times 10^{-6} \quad u = 0.035 \times 10^{-6}$$

The comparison carried out with the NIST will allow us to link the results of the recent SIM resistance comparison SIM.EM-K1 to the results of the ongoing BIPM comparison.

In the ongoing BIPM key comparison programme for capacitance, we organized bilateral comparisons with the NIST (United States) and the NML (Ireland). In the framework of BIPM.EM-K14.a, based on the circulation of 10 pF travelling standards, the relative difference in calibrations and the associated relative standard uncertainty were:

$$(C_{\text{NIST}} - C_{\text{BIPM}})/10 \text{ pF} = -0.03 \times 10^{-6} \quad u = 0.11 \times 10^{-6}$$

In the framework of BIPM.EM-K14.b, concerning 100 pF standards:

$$(C_{\text{NML}} - C_{\text{BIPM}})/100 \text{ pF} = + 0.01 \times 10^{-6} \quad u = 0.39 \times 10^{-6}$$

The comparison with the NIST had been requested by BIPM to verify our estimated uncertainties after the recent staff changes and the improvements made to the measurement systems.

4.5 Calibrations

During the period from July 2007 to June 2008, the Electricity section calibrated the following standards:

- 1 Ω resistors for Brazil, Hungary, Malaysia, Portugal, South Africa and Uruguay; 100 Ω resistors for Belgium and the Czech Republic; 10 k Ω resistors for Belgium, Brazil, Denmark, Hungary, Portugal and Uruguay;
- 1 pF capacitors for Malaysia and South Africa; 10 pF capacitors for Argentina, Belgium, India, Malaysia, Poland, Portugal, Romania and South Africa; 100 pF capacitors for Argentina, Belgium, India, Malaysia, Poland, Romania, and South Africa;
- Zener diode voltage standards were calibrated at 1.018 V and 10 V for Belgium, Romania and for the BIPM Ionizing Radiation section.

During the year 2007, we have provided in total 49 calibration certificates and three study notes.

4.6 Publications, lectures, travel: Electricity section

4.6.1 External publications

1. Fischer J., Stock M. *et al.*, Preparative steps towards the new definition of the kelvin in terms of the Boltzmann constant, *Int. J. Thermophysics*, 2007, **28**(6), 1753-1765.
2. Goebel R., Chrobok P., Fletcher N., Stock M., Final report on the bilateral comparison of 1 Ω standards (ongoing BIPM key comparison BIPM.EM-K13.a) between the CMI (Czech Republic) and the BIPM, *Metrologia*, 2008, **45**, *Tech. Suppl.*, 01004.
3. Goebel R., Elmquist R., Fletcher N., Stock M., Final report on the bilateral comparison of 1 Ω standards (ongoing BIPM key comparison BIPM.EM-K13.a) between the NIST (USA) and the BIPM", *Metrologia*, 2008, **45**, *Tech. Suppl.*, 01001.

4. Power O., Fletcher N., Final report on the bilateral comparison of 100 pF capacitance standards (ongoing BIPM key comparison BIPM.EM-K14.b) between the NML, Ireland and the BIPM, June-October 2007, *Metrologia*, 2008, **45**, *Tech. Suppl.*, 01002.

4.6.2 BIPM reports

5. Solve S., Chayramy R., van den Brom H.E., Houtzager E., Comparison of the Josephson voltage standards of NMi VSL and the BIPM (part of the ongoing BIPM key comparison BIPM.EM-K10.b), *Rapport BIPM-2007/01*, 12 pp.
6. Power O., Solve S., Stock M., Witt T.J., Bilateral comparison of 10 V standards between the NML (Ireland) and the BIPM, March to April 2007 (part of the ongoing BIPM key comparison BIPM.EM-K11.b), *Rapport BIPM-2007/03*, 7 pp.
7. Katkov A.S., Solve S., Stock M., Bilateral comparison of 10 V standards between the VNIIM (Russia) and the BIPM, August to October 2007 (part of the ongoing BIPM key comparison BIPM.EM-K11.b), *Rapport BIPM-2007/07*, 10 pp.

4.6.3 Travel (conferences, lectures and presentations, visits)

M. Stock, R. Goebel, N. Fletcher, S. Solve and E. de Mirandés to the CPEM 2008 and satellite meetings, Boulder (United States), 9-13 June 2008:

- S. Solve presented an invited lecture “A survey of Josephson comparisons” and a poster “Direct Josephson voltage standard comparison between a programmable SINIS array and a conventional SIS array”;
- N. Fletcher presented a lecture “The properties of commercial thick film resistance elements as ac-dc transfer standards” and a poster “Some applications of times series analysis techniques”;
- M. Stock attended the meetings of the CCEM working groups: WGLF (low frequency), GT-RF (radiofrequency), WGRMO, WGSP (strategic planning) and WGkg (monitoring the kilogram);
- S. Solve and E. de Mirandés attended the WGkg meeting;
- M. Stock attended the meeting of the CPEM Executive Committee on 12 June 2008;

- S. Solve attended the workshop on Josephson voltage standards at NIST, Boulder, 16-18 June 2008.

M. Stock to:

- Belo Horizonte (Brazil), 12-14 September 2007, to present an invited lecture "Watt balance experiments: towards an improved SI";
- Belgrade (Serbia), 18-19 October 2007, to participate in the EURAMET TC-EM meeting;
- Sydney (Australia), on 29-30 October 2007, to participate at the APMP TC-EM meeting and to visit the NMIA, on 31 October, for discussions on the calculable capacitor collaboration;
- LNE, Trappes (France), on 7 December 2007, for an on-site Josephson comparison;
- LNE, St Denis (France), on 7 April 2008, to participate in the workshop on new determinations of the Boltzmann constant;
- NPL, Teddington (United Kingdom), on 17-18 April 2008, to participate in the EURAMET TC-PR meeting.

S. Solve to:

- LNE, Trappes (France), 6-12 December 2007, for an on-site Josephson comparison; 13-19 December 2007, to study the limits of operating a 10 V programmable SINIS Josephson array in the situation of an on-site Josephson comparison; 4-6 February 2008, to carry out experiments on Josephson RF source accuracy and frequency stability;
- KRIS, Daejeon (Rep. of Korea), 20 February – 3 March 2008, to carry out an on-site Josephson comparison;
- Hypres Inc, Elmsford (United States), 14-19 April 2008, to select on-site a new 10 V Josephson voltage standard (JVS) chip using the transportable BIPM JVS equipment.

N. Fletcher to Les Houches (France) 1-12 October 2007, to participate in an international school on "Quantum Metrology and Fundamental Constants", including a poster presentation on the BIPM calculable capacitor.

4.7 Activities related to external organizations

M. Stock is a member of the Executive Committee of the CPEM and was a member of the Scientific Committee of the VII Semetro conference in Belo Horizonte (Brazil).

N. Fletcher is a member of the Programme Committee of the CPEM.

4.8 Activities related to the work of Consultative Committees

M. Stock is Executive Secretary of the CCEM, Executive Secretary of the CCPR and an *ex-officio* member of all CCPR working groups.

R. Goebel organizes the review of comparison reports and protocols within the CCPR Key Comparison Working Group.

N. Fletcher acts temporarily as Secretary of the JCGM WG 1 on the GUM during the maternity leave of C. Michotte.

4.9 Visitors to the Electricity section

- Dr B. Kibble (NPL, PTB), 25 October 2007, to discuss ac impedance work.
- Prof. Dr M. Kühne (PTB), 22 January 2008.
- Dr Ch. Daussy (LPL), 20 February 2008.
- A delegation from AQSIQ (China), 4 March 2008.
- Dr S. Benz (NIST Boulder), 8 March 2008, to discuss future collaboration work on Josephson voltage standards.
- Dr S. Djordjevic (LNE), 10-14 March 2008, for discussion on a paper submission on the last collaboration work.
- A delegation from Peru, 18 April 2008.
- The participants of the IAS conference, 6 May 2008.
- Prof. J. Boháček (Tech. Univ. of Prague), 7 May 2008.
- Ing. M. Botello, Director IBMETRO (Bolivia), 16 May 2008.
- Mr R. Fertell (NCSLI), 23 May 2008.

5 IONIZING RADIATION (P.J. ALLISY-ROBERTS)

5.1 X- and γ -rays

(P.J. Allisy-Roberts, D.T. Burns, C. Kessler, S. Picard and P. Roger)

5.1.1 Dosimetry standards and equipment

Following a decision of the CCRI in May 2007, a new value for the air-kerma rate in the reference ^{60}Co gamma field was adopted on 1 November 2007. As well as including correction factors calculated using the Monte Carlo method (published last year) and the results of a cavity volume determination using a chamber of variable volume (published this year in *Physics in Medicine and Biology*), the new reference value also includes a re-evaluation of the ion recombination correction. This correction was measured by applying higher voltages to two of the BIPM reference standards as well as to three configurations of the variable-volume chamber. The re-evaluation of the BIPM standard was published in *Metrologia*. At the same time as adopting the new standard, the higher activity (CIS-Bio) ^{60}Co source was adopted as the reference field.

The first of a new series of cavity standards of similar design to the existing standard was constructed and used to determine the air-kerma rate in the ^{60}Co beam. The chamber volume was measured using a 3D co-ordinate measuring machine. After applying the measured correction factors (for ion recombination, stem scatter and orientation) and those calculated using Monte Carlo, the air-kerma rate determination is consistent with that obtained using the variable-volume chamber at the level of 2 parts in 10^4 .

The calibration in the BIPM ^{60}Co reference field of two secondary standards of the ININ (Mexico), whose laboratory is at an altitude of 3000 m, motivated a study of the effect of low ambient air pressure on the response of four ionization chamber types. The response of two chambers with air-equivalent walls, when normalized to standard air pressure, was observed to be independent of air pressure, whereas that of two graphite-walled chambers decreased when the air pressure was reduced progressively to 60 kPa, in one case by a total of 2 parts in 10^3 . The results of this study have implications for all graphite-walled standards and further work is planned.

The scatter component from the aperture support for the medium-energy x-ray standard was re-measured this year, confirming the original measurements, and the results discussed at a meeting of the CCRI(I)

Working Group on Key Comparisons. They recommended that the necessary change to the standard be adopted as soon as possible and set a timetable for publication of the aperture corrections (for transmission, scatter and fluorescence) before the CCRI meeting in May 2009. A draft paper has been prepared for submission to *Physics in Medicine and Biology*.

The construction of the graphite calorimeter is now complete. The first measurements were made in the ^{60}Co reference beam and demonstrated that the novel design to produce a homogenous temperature distribution works well in practice. The reference absorbed-dose rate of 0.5 Gy/min produces a temperature rise of 0.7 mK/min. No additional electrical noise was observed under irradiation in ^{60}Co . The signal-to-noise ratio indicates that a statistical uncertainty of one or two parts in 10^3 should be achievable. Possible improvements were identified, including a new mechanical support, aimed at reducing thermal losses. These modifications have now been made and the graphite absorbed-dose rate using the calorimeter will be re-measured shortly.

The transfer ionization chamber that forms the basis of the absorbed-dose conversion from graphite to water has been constructed and is currently under test. This parallel-plate chamber, very similar in design to the BIPM ionometric standards, inserts directly into the graphite calorimeter phantom, replacing the core, and also into a waterproof envelope for use in a water phantom. Detailed Monte Carlo models of these experimental arrangements are in preparation and calculations will begin shortly.

Work on the BIPM mammographic facility is progressing well. A molybdenum target x-ray tube was installed in the low-energy x-ray laboratory. Radiographic measurements were made of the field size and shape and a new tungsten collimator was designed and machined to achieve the desired field. Radiation protection measurements showed that it was necessary to add lead around the head of the x-ray tube to reduce radiation leakage to a negligible level. Further measurements with the new primary standard for mammography were made to identify the cause of the discrepancy with the existing low-energy standard. The effects of the air gap surrounding the collector plate, the materials used, the volume determination and electric field homogeneity were studied, but the discrepancy has not yet been resolved so this study continues.

Primary measurements and reference chamber calibrations have continued in all of the reference x- and γ -ray beams, including the mammographic radiation qualities. Comparisons and calibrations are underpinned by a

significant effort in equipment calibration and maintenance, which is also required by the BIPM Quality System.

5.1.2 Dosimetry comparisons

Three comparisons with the NPL (United Kingdom) were carried out in September 2007 in terms of air kerma, absorbed dose to water and ambient dose equivalent in the gamma-ray beams. The reports have been drafted.

Reports of previous x-rays comparisons were published as *Metrologia Technical Supplements* for the BEV (Austria), LNE-LNHB (France) and the NIM (China), and a draft x-ray report has been sent to the NMI (Netherlands). Reports of x-ray comparisons with the ARPANSA (Australia), NPL (UK) and the NRC (Canada) are in preparation.

A summary of the BIPM.RI(I)-K1 comparison for air kerma in ^{60}Co gamma radiation was also published as a *Metrologia Technical Supplement*. A number of related comparison reports for the BARC (India), GUM (Poland), ITN (Portugal) and the NIM (China) are still under discussion.

The four transfer chambers for the high-energy absorbed-dose CCRI key comparison continue to be measured periodically in the BIPM ^{60}Co beam. One of these chambers will be used, together with a well-type ionization chamber, for the upcoming CCRI comparison of brachytherapy dosimetry for ^{192}Ir sources to be piloted by the BIPM.

5.1.3 Calibration of national standards for dosimetry

A review of calibration procedures and an internal audit of the calibration services were completed in September 2007. No non-compliance was recorded. The report on the measuring conditions used for calibration of ionization chambers at the BIPM was updated and published in November 2007.

Six series of calibrations of national standards were made in medium-energy x-rays for the HIRCL (Greece), the LNMRI (Brazil), NMISA (South Africa), and the SSI (Sweden). Two series were made in low-energy x-rays for the SSI (Sweden).

Twenty calibrations of national standards were carried out in the BIPM gamma-ray beams in terms of air kerma and absorbed dose to water, as

requested by the HIRCL (Greece), the LNMRI (Brazil), NMISA (South Africa), ININ (Mexico), and the SSI (Sweden).

The IAEA/WHO dosimetry assurance programme continued to be supported with reference irradiations in the ^{60}Co beam.

5.2 Radionuclides (P.J. Allisy-Roberts, S. Courte, D. Kryeziu*, C. Michotte**, M. Nonis and G. Ratel)

5.2.1 International Reference System (SIR) for gamma-ray emitting radionuclides

During 2007, the BIPM received eleven ampoules filled with eight different radionuclides from five laboratories: i.e. two ampoules from the BEV (one containing ^{60}Co and one ^{131}I), six ampoules from the LNE-LNHB (one ampoule containing ^{57}Co , two $^{99}\text{Tc}^{\text{m}}$, two ^{124}Sb and one ^{222}Rn), one ampoule containing ^{60}Co from the NIST, one ampoule containing ^{22}Na from the NMISA and one ampoule containing ^{137}Cs from the VNIIM.

All the submissions had been made to generate equivalence values in the key comparisons. One radionuclide, $^{99}\text{Tc}^{\text{m}}$ had been standardized by two different methods by the same laboratory although only one method has been used to generate an equivalence value. With the newly registered measurements for 2007, the cumulative number of ampoules measured since the beginning of the SIR, in 1976, is now 905, corresponding to a total of 662 independent results for 63 different radionuclides.

The results for five recent submissions have been registered in the SIR master file, for four different radionuclides: ^{22}Na (NMISA), ^{60}Co (BEV and NIST), ^{131}I (BEV), ^{137}Cs (VNIIM). Update reports of three comparisons were published in 2007 for ^{134}Cs , ^{237}Np and ^{241}Am with links to the associated RMO key comparisons. A further five update reports have been published since the beginning of 2008.

Each result prior to 2006 has now been published in *Metrologia Technical Supplement*. Of those submitted since 2006, 27 % have been published, 46 % are in Draft A reports and we are still awaiting the NMI activity results for the remaining 27 % of the submissions. The SIR results that are more than 20 years old are coloured black in the KCDB (a total of 134 results) and in

* On secondment from Tirana University (Albania) since April 2008.

** On maternity leave from March 2008.

accordance with the recommendation of the CCRI, twenty-four of these results that are now more than 30 years old are being deleted from the KCDB at the same time as the reports for these radionuclides are updated.

The project to identify gas pressure effects on the SIR with gas ampoules filled with ^{85}Kr prepared by the LNE-LNHB is pending the activity values. Once these are received, the BIPM will be able to produce a report on the effect on the SIR; it is hoped that this will be before the 2008 CCRI comparison of ^{85}Kr activity measurements is finished so that the information can be used in the final analysis.

A successful internal audit of the SIR within the BIPM Quality System was carried out towards the end of 2007. As good agreement at about 10^{-4} has been observed over the past two years between the new SIR data acquisition chain and the original one, measurements are now made using the new system while continuing to monitor the original chain. Once verification of the new system is complete, the Quality System will be updated accordingly.

The BIPM gratefully acknowledges the donation of 5000 ampoules from the NPL (UK). This will enable the SIR to be maintained for the foreseeable future.

5.2.2 Gamma spectrometry

No significant impurities were detected by the Ge(Li) spectrometer in any of the $^{99}\text{Tc}^{\text{m}}$, ^{56}Mn , ^{54}Mn and ^{99}Mo solutions submitted to the SIR in 2008. However, the final analysis is not yet complete.

Work is well in hand to calibrate the hyper-pure germanium spectrometer. The preliminary investigations with respect to the measurement chain have been completed. Monte Carlo calculations have identified the optimum design and material content for the 2-stage collimators and ampoule support that are presently under construction. The necessary calibration sources have been identified and are being procured.

5.2.3 Extension of the SIR to short-lived radionuclides

The travelling well-type NaI(Tl) transfer instrument was taken to the NPL (UK) by train to test its portability and to measure $^{99}\text{Tc}^{\text{m}}$ activity on site to provide a further link to the SIR for the more distant laboratories. The NIST also participated by supplying a ^{99}Mo ampoule so that the response of the

instrument to this known radionuclide impurity in $^{99}\text{Tc}^m$ solutions could be measured. The results are now awaiting the final activity measurements from these two NMIs to provide a robust linking factor and impurity corrections to include in the final protocol for the future comparisons.

5.2.4 Extension of the SIR to pure beta emitters

Some progress has been made towards the project to measure pure beta emitters as part of the SIR. The most suitable method for quenching the sample solutions is being investigated using the traditional CIEMAT/NIST method, a modified CIEMAT/NIST and some variants of the Triple-to-Double Ratio method (TDCR). In parallel, the CCRI(II) Working Group on this topic is actively involved in identifying a new scintillator with high efficiency and long-term stability to which aqueous radioactive solutions can be added. Although a specific chemical formula has been developed, it does not exhibit reproducible results when prepared at different NMIs. The CIEMAT kindly provided a guest scientist to supervise work at the BIPM in producing the same scintillator but although some improvements were made, the preparation is not yet optimal. The BIPM is working to resolve the discrepancies observed.

5.2.5 Improvements to the BIPM TDCR counting system

The BIPM TDCR counting system is being renovated to increase its detection efficiency, principally in the design of the containers for the photomultiplier bases. Commercial photomultiplier bases have been purchased to replace the original BIPM bases as these are more suited to a light-tight system. The three BIPM preamplifiers have been also replaced by commercial fast preamplifiers designed for the new photomultiplier bases. The quenching variation, necessary to determine the activity of the radioactive substance, obtained by varying the applied dynode voltage has not proved to be satisfactory. A different method using cylindrical grey filters of different absorption qualities placed around the glass vials will be tested.

In parallel, a new TDCR system using three small photomultipliers with integrated high voltage and a high gain and low noise is under construction. The sample chamber has been designed to eliminate noise due to parasitic light. The sample holder has also been redesigned to allow simpler sample

handling. The three photomultipliers are mounted on micrometric platforms that allow the quenching to be changed, additionally to the use of the transmission filters, by increasing the distance between source and detectors.

5.2.6 Measurements of ^{55}Fe

Investigations into the BIPM measurements of ^{55}Fe have been made to identify the cause of the significantly high activity values. New samples of quenched ^3H and of ^{55}Fe from the distributed solution have been prepared with a new batch of prepared scintillator. In addition, and to extend the robustness of the BIPM measurements, a new low-activity level commercial liquid-scintillation spectrometer has been purchased and tested. Results obtained for the same sets of ^3H and ^{55}Fe with this new facility will be compared with the results produced the original spectrometer used for the international comparison measurements.

5.2.7 CCRI activity comparisons

The BIPM has issued ampoules prepared by the LNE-LNHB to the nine participants for the ^{85}Kr gas activity comparison. Invitations have been distributed to potential participants for the ^3H (tritiated water) comparison for which the LNE-LNHB has also prepared the ampoules.

5.3 Publications, lectures, travel: Ionizing Radiation section

5.3.1 External publications

1. Allisy-Roberts P.J., Burns D.T., Kessler C., Summary of the BIPM.RI(I)-K1 comparison for air kerma in ^{60}Co gamma radiation, *Metrologia*, 2007, **44**, *Tech. Suppl.*, 06006.
2. Allisy-Roberts P.J., Williams J., *Farr's Physics for Medical Imaging*, Saunders/Elsevier, 2008, VIII-207 pp.
3. Burns D.T., Kessler C., Roger P., Air-kerma determination using a variable-volume cavity ionization chamber standard, *Phys. Med. Biol.*, 2007, **52**, 7125–7135.
4. Burns D.T., Allisy P.J., Kessler C., Re-evaluation of the BIPM international standard for air kerma in ^{60}Co gamma radiation, *Metrologia*, 2007, **44**, L53–L56.

5. Burns D.T., Kessler C., Denoziere M., Ksouri W., Key comparison BIPM.RI(I)-K3 of the air-kerma standards of the LNE-LNHB, France and the BIPM in medium-energy x-rays, *Metrologia*, 2008, **45**, *Tech. Suppl.*, 06004.
6. Burns D.T., Tiefenböck W., Witzani J., Key comparison BIPM.RI(I)-K3 of the air-kerma standards of the BEV, Austria and the BIPM in medium-energy x-rays, *Metrologia*, 2008, **45**, *Tech. Suppl.*, 06003.
7. Burns D.T., Tian Zhongqing, Lu Yazhu, Wan Guoqing, Fan Cheng, Key comparison BIPM.RI(I)-K3 of the air-kerma standards of the NIM and the BIPM in medium-energy x-rays, *Metrologia*, 2007, **44**, *Tech. Suppl.*, 06008.
8. Pearce A.K., Michotte C., Hino Y., Ionization chamber efficiency curves, *Metrologia*, 2007, **44**(4), S67-S70.
9. Picard S., Burns D.T., Roger P., Determination of the specific heat capacity of a graphite sample using absolute and differential methods, *Metrologia*, 2007, **44**, 294-302.
10. Ratel G., Obituary: Wolfgang Georg Wilhelm (known to his friends as Jörg) Müller, PhD, *Appl. Radiat. Isot.*, 2008, **66**, 680-682.
11. Ratel G., Analysis of the results of the international comparison of activity measurements of a solution of ^{55}Fe , *Appl. Radiat. Isot.*, 2008, **66**, 729-732.
12. Ratel G., The Système International de Référence and its application in key comparisons, *Metrologia*, 2007, **44**(4), S7-S16.
13. Ratel G., Uncertainty vade-mecum in radioactivity measurement, *Metrologia*, 2007, **44**(4), S102-S117.
14. Ratel G., Michotte C., Kryeziu D., Kossert K., Activity measurements of the radionuclide ^{186}Re for the PTB, Germany in the comparison BIPM.RI(II)-K1.Re-186, *Metrologia*, 2008, **45**, *Tech. Suppl.*, 06006.
15. Ratel G., Michotte C., Kryeziu D., Moune M., Keightley J., Johanson L., Szűcs L., Csete I., Activity measurements of the radionuclide ^{54}Mn for the LNE-LNHB, France, NPL, United Kingdom and the MKEH, Hungary, in the ongoing comparison BIPM.RI(II)-K1.Mn-54, *Metrologia*, 2008, **45**, *Tech. Suppl.*, 06009.
16. Ratel G., Michotte C., Leena J., Igllicki A., Sahagia M., Hino Y., Update of the BIPM comparison BIPM.RI(II)-K1.Cs-134 of activity measurements of the radionuclide ^{134}Cs to include the 2005 results of the BARC (India) and the CNEA (Argentina), the 2006 result of the IFIN-

HH (Romania) and the link for the 2005 regional comparison APMP.RI(II)-K2.Cs-134 to include the VNIIM and the INER, *Metrologia*, 2007, **44**, *Tech. Suppl.*, 06004.

17. Ratel G., Michotte C., Moune M., Bobin C., Kossert K., Johansson L., Activity measurements of the radionuclide ^{201}Tl for the LNE-LNHB, France, PTB, Germany and the NPL, UK in the ongoing comparison BIPM.RI(II)-K1.Tl-201, *Metrologia*, 2008, **45**, *Tech. Suppl.*, 06008.
18. Ratel G., Michotte C., Sahagia M., Park T.S., Dryak P., Sochorová J., Maringer F.J., Kreuziger M., Results of the IFIN-HH (Romania), KRISS (Republic of Korea), CMI (Czech Republic) and the BEV (Austria) in the BIPM comparison BIPM.RI(II)-K1.I-131 of activity measurements of the radionuclide ^{131}I , *Metrologia*, 2008, **45**, *Tech. Suppl.*, 06007.
19. Ratel G., Michotte C., Sahagia M., Yunoki A., Update of the BIPM comparison BIPM.RI(II)-K1.Ba-133 of activity measurements of the radionuclide ^{133}Ba to include the results of the IFIN-HH (Romania) and the NMIJ (Japan), *Metrologia*, 2008, **45**, *Tech. Suppl.*, 06002.

5.3.2 BIPM reports

20. Allisy-Roberts P.J., Burns D.T., Kessler C., Measuring conditions used for the calibration of ionization chambers at the BIPM, *Rapport BIPM-2007/06*, 20 pp.
21. Cox M.G., Michotte C., Pearce A.K., Measurement modelling of the International Reference System (SIR) for gamma-emitting radionuclides, *Monographie BIPM-7*, 2007, 48 pp.

5.3.3 Travel (conferences, lectures and presentations, visits)

P.J. Allisy-Roberts to:

- London (United Kingdom), 5 July 2007, to chair a Decision Conference for the Ionizing Radiation and Acoustics programmes of the UK National Measurement System (NMS); 4 October 2007, for the editorial board of the *Journal of Radiological Protection*;
- NPL (United Kingdom), 1-2 November 2007, for a meeting of the Programme Working Group Chairmen at the Department for Innovation, Universities and Skills Measurement Board; 29 January to 1 February 2008, with M. Nonis, to conduct an on-site activity comparison for $^{99}\text{Tc}^{\text{m}}$ using the BIPM SIR transfer instrument; 26 February to chair the

Acoustics and Ionizing Radiation Working Group of the UK NMS; 20 May 2008, invited to attend the official opening of the NPL laboratory building;

- LNE (France), 21 November 2007 and 2 April 2008, to attend the *Comité Scientifique* for ionizing radiation;
- Vienna (Austria) 10-14 March 2008, to chair the 13th Scientific Committee of the IAEA/WHO Network of Secondary Standards Dosimetry Laboratories;
- Edinburgh (United Kingdom), 4-6 June 2008, to attend the L.H. Gray Conference;
- Manchester (United Kingdom), 19 June 2008, to present a seminar on the latest ICRP recommendations and participate at an RPA [Review of Public Administration] Update meeting.

D.T. Burns to:

- Florence (Italy), 10-16 October 2007, to attend the meetings of the Main Commission of the ICRU and of the Fundamental Quantities and Units Committee;
- Saclay (France), 4 April 2008, to visit the LNE-LNHB laboratories in preparation for a comparison of calorimeter standards;
- Washington DC (United States), 12-13 June 2008, to attend a meeting of the ICRU Report Committee on Key Data for Measurement Standards in the Dosimetry of Ionizing Radiation.

S. Picard to:

- Paris (France), 3-5 October 2007, to participate in a professional training on applications of the finite element software Comsol;
- PTB (Germany), 10-11 March 2008, to visit their facilities for dosimetry, and to discuss possibilities for collaborations and questions concerning calorimetry;
- LNE-LNHB (France), 4 April 2008, to prepare for a pilot study of absorbed dose using the BIPM calorimeter;
- SSI (Sweden), 13 May 2008, to visit their dosimetry facilities;
- METAS (Switzerland) 27 May 2008, to prepare for a comparison of absorbed dose using the BIPM calorimeter.

G. Ratel to:

- Paris (France), 11-12 December 2007, to attend les “Sixièmes rencontres des personnes compétentes en radioprotection (PCR)” to maintain his PCR certification;
- Bratislava (Slovakia), 9-12 May 2008, to attend the ICRM Executive Board;
- Paris (France), 22 May 2008, to attend a meeting on “Evaluation of Measurements Uncertainties”;
- Davos (Switzerland), 26-30 May 2008, to attend the LSC 2008 Advances in Liquid Scintillation Spectrometry Conference;
- Paris (France), 23-25 June 2008, to attend the “8^e Conférence internationale AMCTM”, Conference on advanced mathematical and computational tools in metrology and testing.

5.4 Activities related to external organizations

P.J. Allisy-Roberts is the Chairman of a joint Working Group for the UK National Measurement System programme for ionizing radiation and acoustics and the Chairman of the UK Ionising Radiation Health and Safety Forum. She is the BIPM representative on the IAEA SSDL Scientific Committee, a member of the *Comité scientifique rayonnements ionisants* (LNE, France), on the editorial board of the *Journal of Radiological Protection* and the Comité editorial of the *Revue Française de Métrologie*, and a referee for *Physics in Medicine and Biology*, *Medical Physics* and the *British Journal of Radiology*.

D.T. Burns is the BIPM representative at the ICRU, a member of the ICRU Committee on Fundamental Quantities and Units (currently preparing a revision of ICRU Report 60) and a member of the ICRU Report Committee on Key Data for Dosimetry. He is the BIPM contact person at the EURAMET for ionizing radiation and radioactivity and a consultant to the IAEA. He is a referee for *Physics in Medicine and Biology* and for *Medical Physics*.

G. Ratel is the BIPM representative at the International Committee for Radionuclide Metrology (ICRM) of which he is joint Vice-President. He is a jury member for an NMI colleague to obtain the “*habilitation à diriger des recherches*” at the University of Orsay (France). He is also a referee for

Metrologia, Applied Radiation and Isotopes and Nuclear Instruments and Methods.

5.5 Activities related to the work of Consultative Committees

P.J. Allisy-Roberts is Executive Secretary of the CCRI and its three Sections. She is also Executive Secretary of the CCAUV. She participated in the CCRI RMO WG, which met in November 2007. This last year has also seen the publication of a new *Monographie 7* in support of the CCRI(II).

P.J. Allisy-Roberts and D.T. Burns are members of the CCRI(I) working groups on key comparisons (KCWG), on accelerator dosimetry (ADWG) and on brachytherapy standards (BSWG). Both the KCWG and the ADWG met in April 2008. P.J. Allisy-Roberts and D.T. Burns contributed to the special issue of *Metrologia* for radiation dosimetry, as principal authors (papers on free-air chambers and international aspects), co-author (on cavity standards) and as referees.

C. Michotte is the coordinator of the CCRI(II) Working Group on the SIR Transfer Instrument. C. Michotte is the contact person at the BIPM and *rapporteur* for the JCGM/WG1 that met in November 2007, and in May 2008 at which she was replaced by N. Fletcher.

G. Ratel is a member of the CCRI(II) working groups on the extension of the SIR to beta emitters, on key comparisons attended with P.J. Allisy-Roberts and C. Michotte), on measurement uncertainties, and on the realization of the becquerel for which he is the *Rapporteur*. Three of these meetings took place at the BIPM in December 2007.

5.6 Visitors to the Ionizing Radiation section

- Dr P. Cassette (LNE-LNHB), 16 July 2007.
- Mr T. Cabral (LNMRI-IRD), 19-23 November 2007.
- Dr H. Schrader (PTB), 6 December 2007.
- Dr J.T. Alvarez (ININ), 4-8 February 2008.
- Mr C. Iacobaeus (SSI), 7 February 2008.
- Dr G. Stucki (METAS), 12 April 2008.

5.7 Guest workers

- Drs M. Kelly and J. Manning (NPL), 10-12 September 2007.
- Dr L. Rodriguez (CIEMAT), 8-19 October 2007.

6 CHEMISTRY (R.I. WIELGOSZ)

6.1 Gas metrology programme

(E. Flores, P. Moussay, J. Viallon and R.I. Wielgosz)

6.1.1 Ozone photometer comparison programme

(P. Moussay and J. Viallon)

The first two year cycle of the on-going key comparison BIPM.QM-K1 – Ozone at ambient level – was launched in January 2007 with a comparison with the NIST (United States). Since July 2007, six laboratories have brought their ozone national standard to the BIPM for a direct comparison with the BIPM-SRP27 reference standard: the CHMI (Czech Republic) and the INRiM (Italy) in September 2007; the FMI (Finland) and the KRISS (Republic of Korea) in October 2007; the LNE (France) in April 2008 and the NPL (United Kingdom) in May 2008. In addition, two laboratories sent a transfer standard to the BIPM: the GUM (Poland) in September 2007 and the VNIIM (Russian Federation) in November 2007.

All comparisons were successfully completed. The report of the comparison with the CHMI was published in *Metrologia Technical Supplement* in April 2008. The reports of the comparisons with the NIST and the VNIIM are in the last review stage. The reports of the comparisons with the LNE and the ISCIII (Spain), which was carried out in June 2007, are in Draft A stage.

Furthermore, the UBA (Germany) and the NIM (China) performed a comparison of their ozone national standards with the NIST standard in their laboratories in March 2007 and March 2008, respectively, and requested a link to the key comparison BIPM.QM-K1. The first drafts of these reports are in progress and will be discussed during the CCQM Gas Analysis Working Group meeting in November 2008.

During all bilateral comparisons performed at the BIPM in the framework of BIPM.QM-K1, at least one other SRP (BIPM-SRP28) – and when possible a third one (BIPM-SRP31) – was also compared with the reference BIPM-SRP27 to monitor its stability. In April 2008 a small change in the agreement between SRP28 and SRP27 was observed. Although the magnitude of this change was covered by the combined measurement uncertainties, corrective actions were undertaken. The UV filters within SRP27 were replaced with new ones. The agreement observed in November 2007 with SRP28 was recovered. The shift in value in SRP27 was attributed to a visible degradation of the UV filter, notably on the gas cell subjected to the higher UV light intensity, which in turn affected the reflectivity of the filters and the optical pathlength. This effect was corrected by the introduction of new UV filters within SRP27.

Upgrade of NIST Standard Reference Photometers (SRPs)

Since the installation of one “SRP upgrade kit” performed on BIPM-SRP32 in January 2007 by J. Norris (NIST) and P. Moussay, the BIPM has been able to install upgrade kits for those participants in the key comparison BIPM.QM-K1 maintaining a NIST SRP as a national standard and requesting this service. A kit was installed on the FMI instrument (SRP37) during their comparison in October 2007, as well as on the NPL instrument (SRP20) during their comparison in May 2008. The two upgrades were successful. The effect of the upgrade on the agreement between the key comparison reference standard BIPM-SRP27 and the laboratories national standards will be reported in the respective key comparison reports. A report summarizing all upgrades performed by the NIST and by the BIPM is also in preparation.

Development of a laser-based SRP

The programme to develop a candidate primary ozone photometer based on a laser light source has continued, with a strong focus on reducing the noise level of the system. After the progress made in February 2007 to reduce the variations of the temperature of the cooling water system of the argon laser, another source of instability in the laser intensity remained. A spectrum analysis of the signal detected by the photodiodes did not help to identify the cause of the instability. Recently, a strong correlation between the laser intensity variation and the laser input voltage variation was observed. Systems to stabilize the input voltage are currently under test.

In parallel, progress has been made with the replacement of the frequency doubling crystal included in the argon laser head to switch from the initial wavelength of 257.4 nm to the shorter wavelength of 244 nm in November 2007. As with 257.4 nm, the laser-based SRP operating at the shorter wavelength succeeded in measuring ozone mole fractions in dry air within 5 % from the lamp-based SRP. This result demonstrates the feasibility of the foreseen measurements at the three different wavelengths in the UV region with the argon laser.

6.1.2 Primary NO₂ gas standard facility

The NO₂ facility was upgraded with an electronic pressure controller immediately downstream from the permeation chamber to effectively avoid mass measurements perturbations induced by changes in the dilution flow. The nitrogen generation facility supplying the NO₂ facility has been improved by the addition of a methane reactor, and in addition to our FTIR analyzer, a new NO₂ analyzer based on UV absorption has been studied and the first results are promising. Further investigations of this measurement technique will be carried out during the second half of this year. Extensive leak testing of the system has been performed, and the validity of the calibration of the facility's flow measurement system has been extended by comparison with recently calibrated instruments of the same quality.

A gas dilution system is currently under development. It will allow the generation of low level concentration mixtures from stable high concentration NO₂ standards and give an independent alternative way of testing the NO₂ permeation facility.

A third validation study of the NO₂ facility has been completed. It includes the comparison of five NO₂ primary gas standards to dynamic gas mixtures produced by the NO₂ facility before and after the dismantlement and reassembly and the aforementioned upgrades of the facility.

In April 2008, the protocol of a BIPM coordinated pilot study (CCQM-P110 nitrogen dioxide 10 µmol/mol) was presented to the Gas Analysis Working Group meeting held at BIPM. The pilot study objectives are to compare the measurement capabilities of the NMIs determining NO₂ mass fractions by conventional techniques and the development of optical spectroscopic methods for these measurements.

Development of FTIR facilities

During the period 2007-2008, the programme to develop Fourier Transform Infrared (FTIR) spectroscopy as an accurate analytical method for gas metrology has continued. The data acquisition software IMACC installed in June 2007 is now routinely used to retrieve the real-time concentrations of molecules under study for quantification as well as purity analysis of gases. Data exchange with the main control programme of the NO₂ facility was made possible allowing on-line data acquisition of FTIR results.

Substantial progress was also made in the quantification of molecules detected by the FTIR. An entire synthetic spectra library was generated using MALT and E-Trans software. The synthetic spectra library is used to minimize nonlinearity effects produced by the FTIR detector. The background moisture concentration in the FTIR system was reduced by upgrading the FTIR enclosure box replacing the non metallic walls by stainless steel. At the beginning of this year, the temperature measurement system of the FTIR spectrometer gas cell was upgraded via the installation of a new temperature probe positioned directly into the cell.

6.1.3 NO gas standard comparison facility (R.I. Wielgosz and P. Moussay)

The final report of the BIPM coordinated study, CCQM-P73, performed over the period August 2006 – October 2007, was published in the *Metrologia Technical Supplement*. A new set of gravimetrically prepared NO standards in the range (30-70) $\mu\text{mol/mol}$ from 2 NMIs have been purchased, and measurements begun, in order to find an explanation for the variation between gas standards observed in CCQM-P73.

6.2 Organic analysis programme

(R.I. Wielgosz, S. Westwood, R. Josephs and A. Daireaux)

The organic analysis programme within the Chemistry section coordinates CCQM comparisons of the purity assessment of organic compounds, for use as primary calibrators. The facilities established at BIPM are used for the handling, preparation, characterization and storage of the CCQM study materials. The analytical capabilities within the Programme were enhanced in 2007/2008 by the acquisition of a photoionization source for use with the existing QTrap LC-MS/MS system, a stand-alone Agilent Rapid Resolution LC-UV system and a dynamic vapour sorption balance. Where appropriate

the programme at BIPM is supported by external collaborations and with secondments from NMIs and by the contracting of specialized analytical services such as elemental microanalysis, particle sizing and nuclear magnetic resonance (NMR) spectroscopy to suitable external service suppliers.

6.2.1 Method development

Development and validation of analytical methods required for use in the characterization and production of the cardiac glycoside CCQM-P20.f pilot study material have been completed. The main focus has been the identification and quantification of the major component digoxin and related structure cardiac glycoside impurities as well as their corresponding aglycones. The scope of the method development and validation activities was broadened to incorporate the planned CCQM-K55.a key comparison on pure steroid hormones. For CCQM-K55.a, methods for the determination of β -estradiol and a variety of related structure steroid hormones have been developed. Procedures developed in the last year include:

- LC-UV as key method for the identification and quantification by external calibration for the analysis of digoxin and related compounds in the CCQM-P20.f pilot study material. An equivalent approach is being developed for the determination of β -estradiol and related compounds to serve as well for homogeneity and stability testing of the CCQM-K55 candidate material.
- LC-MS/MS methods providing both qualitative identification and permitting the quantification of selected cardiac glycosides and steroid hormones for the characterization of both candidate materials and for the final comparisons.
The LC-MS/MS method has been compared with the LC-UV methods and has been selected for assessing the homogeneity of inherent impurities in the digoxin material.
- GC-MS method for determination of volatile organic impurities in CCQM-P20.f and CCQM-K55 materials.
- Karl Fischer titration using heated oven transfer for the determination of low level moisture content in the CCQM-P20.f and CCQM-K55 materials.

- Thermal techniques (DSC/TGA) as supporting methods for the estimation of the mole fraction content of high purity materials and total volatile impurities.
- Protocols for the preparation, stability testing and homogeneity assessment of selected cardiac glycoside and steroid hormone materials containing low levels of inherent related structure impurities.
- Dynamic vapour adsorption studies were also undertaken on materials to assess their potential to adsorb atmospheric moisture during transport and storage.

6.2.2 Coordination of CCQM-P20 and development of CCQM-K55

In the second half of 2007, the homogeneity and stability assessments of the digoxin candidate materials for CCQM-P20, the second CCQM comparison coordinated by BIPM, were completed. One unit of the study material, consisting of purified digoxin containing a minimum of 500 mg of material, was shipped under controlled conditions to each of the twelve participating laboratories. The BIPM was one of the participating laboratories. The participants were required to assign the mass fraction and corresponding uncertainties of the digoxin content in each material and, if possible, to provide mass fraction estimates of all major impurities. Initial results and a draft summary of the pilot study were circulated to the participants and were discussed at the CCQM Organic Analysis Working Group meeting in April 2008.

Given the complexity of the molecular structure of digoxin and the relatively large number of impurities it contained, there was a good level of agreement between participants in their estimates of the mass fractions of both related structure impurities and water content in the study samples. However there is strong evidence that a significant level of residual organic solvent is also present in the material. This resulted in a discrepancy in the overall results between the small number of participants (including the BIPM) who identified and quantified the levels of residual solvent and the larger number of participants who did not.

The first round of the organic purity assignment key comparison, CCQM-K55.a, will be coordinated by BIPM. The steroid 17 β -estradiol will be the principal component of the study material. The candidate material has been prepared by and supplied to the BIPM by colleagues from the Organic Analytical Chemistry Division at the NMIJ (Japan). Analytical method

development to characterize the material and assess its homogeneity and stability commenced at the BIPM in 2007, with measurements of the homogeneity and isochronous stability of the candidate material underway and scheduled for completion by the third quarter of 2008. Distribution of the study material to participant laboratories, in the form of a single vial containing 300 mg of 17β -estradiol, is proposed for late 2008, with the initial discussion of results scheduled for the April 2009 CCQM.

As part of their planning for future key comparisons, the CCQM Organic Analysis Working Group (OAWG) identified purity assessment as being a core technical capability. The OAWG has recommended that participation in CCQM-K55 be compulsory for all NMIs which have activities or make CMC claims in the area of organic analysis.

6.3 Activities related to the JCTLM (S. Maniguet and R.I. Wielgosz)

R.I. Wielgosz is Executive Secretary of the Joint Committee for Traceability in Laboratory Medicine (JCTLM), and a member of its review team on Quality Systems and Implementation, and S. Maniguet is coordinating the development of the JCTLM Database.

A symposium on 'Activities and Challenges for Traceability and Standardization in Laboratory Medicine' was organized by R.I. Wielgosz in Beijing in October 2007, in collaboration with colleagues from the NIM and the NIST, and was followed by meeting of the JCTLM working groups.

The sixth meeting of the Executive Committee of the JCTLM was held at the BIPM in December 2007, and the timetable for the approval of Cycle IV nominations of higher order reference materials and reference measurement services, and of Cycle II nominations of Laboratory Reference Measurement Procedures was agreed. The Executive meeting was preceded by a meeting of a JCTLM WG2 *Ad Hoc* Task Group on Laboratory Networks, Accreditation and Quality Systems.

Procedures for the operation of the JCTLM Secretariat, developed in collaboration with Dr C. Jackson (JCTLM WG1 Quality Manuals Review Team Leader), were presented to the JCTLM Executive for their approval.

The development for the extension of the system of back-office and front-office of the internet-based searchable database was completed in October 2007. The JCTLM Database website available at <http://www.bipm.org/jctlm/>

was modified to include the reference measurement laboratory services as a searchable category to the database.

The total number of external connections to the JCTLM Database website has increased from July 2007 to May 2008. This corresponds to about 1300 visits each month as on May 2008.

6.4 Activities related to the work of Consultative Committees

R.I. Wielgosz is the Executive Secretary of the CCQM.

J. Viallon is a member of the CCQM gas analysis and surface analysis Working Groups.

E. Flores is a member of the CCQM Working Group on Gas Analysis.

S. Westwood is a member of the CCQM Working Group on Organic Analysis and is a technical observer on the CCQM Key Comparison Working Group.

R. Josephs is a member of the CCQM bioanalysis and organic analysis working groups.

6.5 CCQM comparisons coordinated by the BIPM

The BIPM is the coordinating laboratory for following CCQM comparisons:

- BIPM.QM-K1 – Ozone, ambient level (on-going);
- CCQM-P73 – Nitrogen monoxide in nitrogen, preparative capabilities (completed);
- CCQM-P20.e – Theophylline, purity analysis series;
- CCQM-P20.f – Digoxin, purity analysis series;
- CCQM-K55.a – 17 β -estradiol, purity analysis;
- CCQM-P110 – NO₂ in air at 10 μ mol/mol.

6.6 Activities related to external organizations

R.I. Wielgosz is a BIPM representative to the Codex Alimentarius Commission, and ISO TC 212, Clinical laboratory testing and *in vitro* diagnostic test systems, Working Group 2 on Reference Systems, and ISO TC 146 on Air Quality, and is a member of the editorial board of *Accreditation and Quality Assurance*.

S. Westwood is the BIPM and CCQM representative at ISO REMCO, and the BIPM representative to the CIPM *Ad Hoc* Material Metrology Working Group.

R. Josephs is the BIPM representative to the Codex Committee on Methods of Analysis and Sampling (CCMAS) of the Codex Alimentarius Commission and member of the related electronic working group on measurement uncertainty.

6.7 Publications, lectures, travel: Chemistry section

6.7.1 External publications

1. Bremser W., Viallon J., Wielgosz R.I., Influence of correlation on the assessment of measurement result compatibility over a dynamic range, *Metrologia*, 2007, **44**, 495-504.
2. Wielgosz R.I., Esler M., Viallon J., Moussay P., Oh S.H., Kim B.M., Botha A., Tshilongo J., Mokgoro I.S., Maruyama M., Mace T., Sutour C., Stovčík V., Valková M., Musil S., Pérez Castorena A., Serrano Caballero V., Rangel Murillo F., Konopelko L.A., Kustikov Y.A., Pankratov V.V., Gromova E.V., Thorn W.J., Guenther F.R., Smeulders D., Baptista G., Dias F., Wessel R.M., Nieuwenkamp G., van der Veen A.M.H., Final report on CCQM-P73: International comparison of nitrogen monoxide in nitrogen gas standards (30-70) $\mu\text{mol/mol}$, *Metrologia*, 2008, **45**, *Tech. Suppl.*, 08002.
3. Viallon J., Moussay P., Wielgosz R., Novak J., Vokoun M., Final report of the on-going key comparison BIPM.QM-K1: Ozone at ambient level, comparison with CHMI, 2007, *Metrologia*, 2008, **45**, *Tech. Suppl.*, 08005.
4. Buttinger G., Josephs R.D., Harbeck S., Certification of the mass fraction of aflatoxin B1 in acetonitrile (ERM-AC057), aflatoxin B2 in acetonitrile (ERM-AC058), aflatoxin G1 in acetonitrile (ERM-AC059) and of aflatoxin G2 in acetonitrile (ERM-AC060), IRMM-Information, EUR-Report, Luxembourg (2007) EUR 22889 EN.
5. Linsinger T.P.J., Josephs R.D., Reply to Professor Michael Thompson's rebuttal, *Trends Anal. Chem.*, 2007, **26** (7), 662-663.
6. Krska R., Schubert-Ulrich P., Josephs R.D., Emteborg H., Buttinger G., Pettersson H., van Egmond H.P., Schothorst R.C., MacDonald S., Chan D., Determination of molar absorptivity coefficients for major type-B

trichothecenes and certification of calibrators for deoxynivalenol and nivalenol, *Anal. Bioanal. Chem.*, 2007, **388**, 1215-1226.

6.7.2 BIPM reports

7. Viallon J., Moussay P., Wielgosz R.I., Novak J., Vokoun M., Comparison of ozone reference standards of the CHMI and the BIPM, September 2007, *Rapport BIPM-2007/05*, 12 pp.

6.7.3 Travel (conferences, lectures and presentations, visits)

R.I. Wielgosz to:

- AFNOR, St Denis (France), 3-4 September 2007, to represent the BIPM at ISO TC 212 WG2 meetings on Reference Measurement Systems for Laboratory Medicine;
- NPL, Teddington (United Kingdom), 13 September 2007, for a pre-meeting of the CCQM KCRV Working Group;
- NIM, Beijing (China), 15-18 October 2007, for the JCTLM symposium and WG meetings;
- NMIJ, Tsukuba (Japan), 29 October – 2 November 2007, plenary session presentation and chairing of sessions at the 11th International Symposium on Biological and Environmental Reference Materials (BERM 11);
- LGC, Teddington (United Kingdom), 7-8 February 2008, to participate in the first meeting of the CCQM *Ad Hoc* Efficient and Effective Testing of CMC Claims Working Group (EETWG);
- Tubitak, Istanbul (Turkey), 13-15 February 2008, to attend a meeting of the EURAMET MetChem Gas Sub-committee and the plenary meeting;
- CCMAS, Inter-Agency Meeting (IAM) and Uncertainty Workshop, Budapest (Hungary), 7-12 April 2008, as co-organizer of the “Method Performance and Analytical Uncertainty Workshop” and to represent BIPM at the Inter-Agency and Codex meetings;
- PTB, Braunschweig (Germany), 24 April 2008, to attend meeting on Biologicals/virus measurement standardization and links to JCTLM.

R.I. Wielgosz and J. Viallon to Sydney (Australia), 23-27 October 2007, to attend a meeting of the CCQM GAWG.

J. Viallon to Tubitak, Istanbul (Turkey), 13 February 2008, to attend a meeting of the EURAMET MetChem Gas Sub-committee.

S. Westwood to:

- NMIA, Sydney (Australia), 24 August 2007, to speak on “BIPM and the Organic Analysis Work Programme”;
- Tampa Bay (United States), 25-27 September 2007, to attend the US Pharmacopeia Annual Scientific Meeting, and to speak to the US Pharmacopeia Resolution 3 (New Technology) Advisory Panel on the “BIPM Work Programme in Primary Calibrators for Organic Analysis”;
- PTB, Braunschweig (Germany), 8-12 October 2007, for the CCQM-OAWG meeting;
- Cracow (Poland), 4 March 2008, to speak on “National Measurement Institutes and the Role and Use of Key Comparison Studies” at a seminar of the ENFSI Quality and Competence Committee;
- Frankfurt (Germany), 4 April 2008, to speak on “International Metrology Activities in Chemical and Biological Measurement” at a USP European Stakeholder’s Forum;
- Rio de Janeiro (Brazil), 9-13 June 2008, to represent the BIPM and CCQM at the 31st annual ISO Reference Materials Committee (ISO REMCO) meeting.

R. Josephs to:

- PTB/BAM, Braunschweig/Berlin (Germany), 8-12 October 2007, to participate in the CCQM-OAWG meeting and visit PTB and BAM chemistry laboratories;
- London (United Kingdom), 2-3 October 2007, to attend the Annual Reference Standards Conference;
- CCMAS, IAM and Uncertainty Workshop, Budapest (Hungary), 7-12 April 2008, to present a lecture on “Guides to uncertainty in measurement” at the Method Performance and Analytical Uncertainty workshop and to represent BIPM at the Inter-Agency and Codex meetings.

E. Flores to:

- Borås (Sweden), 17-18 October 2007, to attend the EURAMET/iMERA Workshop on Metrology Needs and Measurement Priorities in the Environmental Sector;

- Newbury (United Kingdom), 12-16 May 2008, LabView Training course;
- Nijmegen (The Netherlands), 5-6 June 2008, Training course in molblox/molbloc DHI instruments.

6.8 Visitors to the Chemistry section

- Drs J. Novak and M. Vokoun (CHMI), 3-7 September 2007.
- Ms M. Sassi and Mr E. Malgeri (INRiM), 24-28 September 2007.
- Mr J. Walden (FMI), 1-5 October 2007.
- Drs Jin-Chun Woo and Byung Moon Kim (KRISS), 8-12 October 2007.
- Mr D. Selyukov (VNIIM), 26-30 November 2007.
- Drs C. Sutour, J. Couette and T. Macé (LNE), 14-18 April 2008.
- Dr B. Sweeney (NPL), 19-23 May 2008.
- Drs R. Wessel and G. Nieuwenkamp (NMi VSL), 28 May 2008.

6.9 Guest workers

- Mr J. Guardado (CENAM), 30 March – 31 July 2007.
- Dr C. Jackson (JCTLM WG1), 23-27 July 2007.

7 WATT BALANCE (M. STOCK)

7.1 Watt balance (H. Fang, A. Kiss, E. de Mirandés, A. Picard, J. Sanjaime, M. Stock, C. Urano*)

Since the beginning of the development work in spring 2005, considerable progress has been made on the BIPM watt balance. The progress of the room temperature experiment to test the feasibility of simultaneous force and velocity measurements continues. The staffing situation has improved during the reporting period with the arrival of an assistant, who works nearly full-

* On secondment from NMIJ from September 2007 to March 2008.

time on the project, a research fellow on a two year contract and a secondment from NMIJ who has been at the BIPM for seven months.

The suspension of the moving coil has been re-designed to correct some mechanical imperfections of the previous model and to incorporate additional elements needed for the coil alignment. The design of the flexure clamps has been modified to avoid jumps which led to discontinuities in the movement of the coil. The horizontal run-out during the vertical movement is now within 250 μm , which corresponds to a reduction of a factor of two, but needs to be reduced further. The level of reproducibility of the movements in each degree of freedom indicates that it should be possible to servo-control the coil position. The servo to stabilize the coil against a rotation around the vertical axis is already in place and the residual rotation is within 50 μrad . A mechanical system which will be used to control the horizontal inclination of the coil has been designed and will be fabricated soon. This system will also permit us to modify the function of the moving coil so that it can be used as a probe during the alignment procedure as well as a transmitter during the normal watt balance operation.

The collaboration with the Machine Tools Department of the Technical University of Aachen (RWTH/WZL) on the fabrication of the magnet is continuing. The first project phase included a study of the machining behaviour of the iron-nickel alloy to be used for the yoke and a feasibility study to determine if our mechanical specifications can be met. The greatest challenge is the required parallelism of the inner and outer pole faces. It was concluded that the fabrication is possible, but will be very difficult, requiring a large ultra-high precision lathe. Contacts have been established to a company having such machining capabilities. During the second project phase, which will be carried out during 2008, detailed mechanical drawings for the fabrication of the magnetic circuit and the assembly devices will be provided. The fabrication is foreseen for next year. A simplified magnetic circuit has been built for provisional use.

A moving coil has been made and inserted into the air gap of the magnet. The voltage induced, at a coil velocity of 0.2 mm/s, is 0.1 V. In the present room temperature experiment, the voltage is measured with a voltmeter which will be replaced later by a system based on a Josephson voltage standard. Particular care has been taken to obtain synchronization between the acquisition of the velocity, which is carried out every 0.001 s, and the integration time of the voltmeter (3-5 power line cycles), to ensure that the voltage and the velocity readings are integrated over the same period. This

allows us to reduce the effect of correlated noise when calculating the ratio of both quantities.

To test the repeatability of the voltage-velocity part of the experiment, 16 measurements each with 53 runs up and down were carried out. From each measurement, a value is deduced which characterizes the magnitude of the magnetic field at a given position. The relative standard deviation of the 16 results is 1.4 parts in 10^4 . No corrections were applied for temperature differences between runs and for the imperfect (not purely vertical) movement of the coil. To improve the repeatability and the reproducibility, we have started to develop software which will allow us to correct the raw data by taking into account the horizontal displacements and inclinations as well as the vertical rotation of the moving coil. Further significant improvement will require operation in vacuum and vibration isolation.

When the current of 1 mA is injected to the moving coil for the force measurement, the total voltage over the coil is composed of the induced voltage (0.1 V) and the voltage due to the current flow (0.6 V). A second, non-inductive coil, with very similar resistance, is mounted in series with the travelling coil. The role of this second coil is to compensate the change in resistance of the travelling coil due to temperature variations. The voltage difference of both coils should, to a first approximation, only give the induced voltage of the travelling coil. It was demonstrated that the use of the second coil allows a reduction of the influence of the temperature variations on the voltage measurement by a factor of several hundred.

The stabilized current source has been improved and now has a long term drift of, the order of, 1 part in 10^9 per minute, and a short term standard deviation of 4 parts in 10^8 .

Work has started on the geometrical and magnetic characterization of a large precision solenoid which will become the reference for the magnetic field alignment. We are at present measuring the uniformity of the winding diameter and the pitch, and will then calculate the corresponding imperfections of the magnetic field.

The seismic properties of the ground below the BIPM site have been determined to choose the optimal solution for the future vibration isolation of the watt balance. A concrete base will be installed later during this year.

A collaboration with the NIST has been started which should help us to anticipate the main challenges when at a later stage building a cryogenic watt balance.

7.2 Publications, lectures, travel

7.2.1 External publications

1. Stock M., Watt balance experiments: towards an improved SI system, *Proc. VII Semetro*, Belo Horizonte, 2007, 4 pp.
2. Picard A., Fang H., Stock M., The BIPM watt balance: Progress and principle, *Proc. 20th IMEKO TC3 Conference*, November 2007, 12 pp.

7.2.2 Travel (conferences, lectures and presentations, visits)

M. Stock, H. Fang, A. Picard and E. de Mirandés to CPEM 2008 and satellite meetings, Boulder (United States), 9-13 June 2008:

- M. Stock attended the meetings of the CCEM working groups: WGLF (low frequency), GT-RF (radiofrequency), WGRMO, WGSP (strategic planning) and WGkg (monitoring the kilogram);
- M. Stock gave a presentation at the CPEM on the BIPM watt balance;
- H. Fang, A. Picard, and E. de Mirandés attended the WGkg meeting and presented the progress of the BIPM watt balance.

H. Fang, E. de Mirandés, A. Picard, M. Stock and Ch. Urano visited the watt balance and the Electricity section of the LNE (Trappes), on 21 March 2008.

M. Stock to:

- Belo Horizonte (Brazil), 12-14 September 2007, to present an invited lecture "Watt balance experiments: towards an improved SI";
- Sydney (Australia), 29-30 October 2007, to participate at the APMP TC-EM meeting for a presentation of the BIPM watt balance. He visited the NMIA on 31 October 2007 for discussions on the calculable capacitor collaboration.

A. Picard to:

- PTB (Germany), 30 October 2007, to present a colloquium talk entitled "The BIPM watt balance";
- Merida (Mexico), 28-30 November 2007, for the 20th IMEKO TC3 conference, keynote talk entitled "Progress on the BIPM watt balance";
- Sydney (Australia), 31 March – 9 April 2008, to the NMIA International Symposium on the Avogadro Project and re-definition of the SI units, talk entitled "Progress on the BIPM watt balance".

7.3 Visitors

- Dr S. Cundiff (NIST), watt balance laboratory, 17 December 2007.
- Prof. Dr M. Kühne (PTB), watt balance and calculable capacitor, 22 January 2008.
- Dr Ch. Daussy (LPL), watt balance, 20 February 2008.
- A delegation from AQSIQ (China), watt balance, 4 March 2008.
- Mr F. Hoffmann (RWTH/WZL, Germany), discussion on the magnet fabrication, 11 March 2008.
- Dr M. Tanaka (NMIJ) and Mr Y. Yoshimoto (NEDO), watt balance, 18 April 2008.
- A delegation from Peru, 18 April 2008.
- Prof. J. Boháček (Techn. Univ. of Prague), watt balance and calculable capacitor, 7 May 2008.
- Ing. M. Botello, Director IBMETRO (Bolivia), watt balance, 16 May 2008.
- Mr R. Fertell (NCSLI), watt balance, 23 May 2008.

7.4 Guest worker

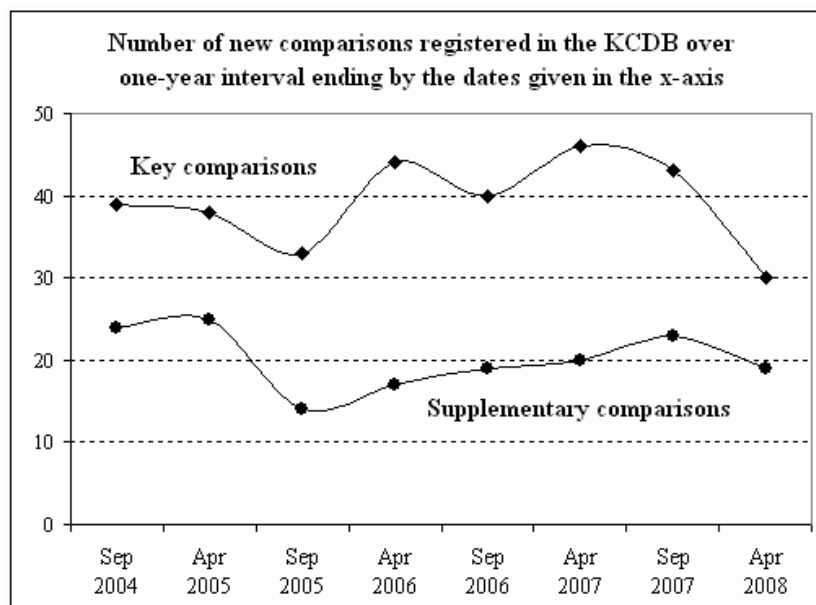
- Dr Ch. Urano (NMIJ) contributed to the watt balance during his secondment, September 2007 to March 2008.

8 THE BIPM KEY COMPARISON DATABASE, KCDB (C. THOMAS)

8.1 Content of the KCDB website (S. Maniguet and C. Thomas)

8.1.1 Key and supplementary comparisons

On 11 June 2008, the key and supplementary comparisons database covered 620 key comparisons (79 from the BIPM, 310 from the CCs, and 231 from RMOs) and 181 supplementary comparisons. The evolution of the number of key and supplementary comparisons registered in the KCDB over one-year intervals is show below.



One observes that the rate, over a mean period of one year, of new comparisons registered in the KCDB remains stable at a level of about 20 new supplementary comparisons, but has decreased from about 40 to 30 new key comparisons. This fluctuation comes from a delay in registering new key comparisons decided by the CCQM working groups. This problem is now being corrected thanks to close cooperation between the KCDB Office and the CCQM working group Chairs.

Among the 620 key comparisons that were registered:

- 88 corresponded to exercises prior to the implementation of the CIPM MRA, and will never have results published in the KCDB (they were “Approved for provisional equivalence”),
- 73 of the 79 on-going BIPM key comparisons had results published in the KCDB, which are regularly extended when new data becomes available (most of them serves also as “master” key comparisons to which other CC and RMO key comparisons are linked), and
- another 221 CC and RMO key comparisons had their final reports approved and posted in the KCDB website, and corresponding tables of numbers and graphs entered in the database.

All together, the KCDB currently displays a total of more than 1000 graphs of equivalence.

The results of 76 RMO key comparisons – 26 conducted by APMP, seven by COOMET, 40 by EURAMET, and three by the SIM – are published in the KCDB. Linkage has also been carried out for 14 bilateral key comparisons subsequent to full-scale CC key comparisons; their results are added on the appropriate graphs of equivalence. The most complete graph of equivalence available from the KCDB displays 66 degrees of equivalence, obtained from four different RMO key comparisons linked to CCM.M-K1 (1 kg stainless steel mass standards).

The final reports of 54 of the 181 supplementary comparisons registered in the KCDB are also posted in the KCDB.

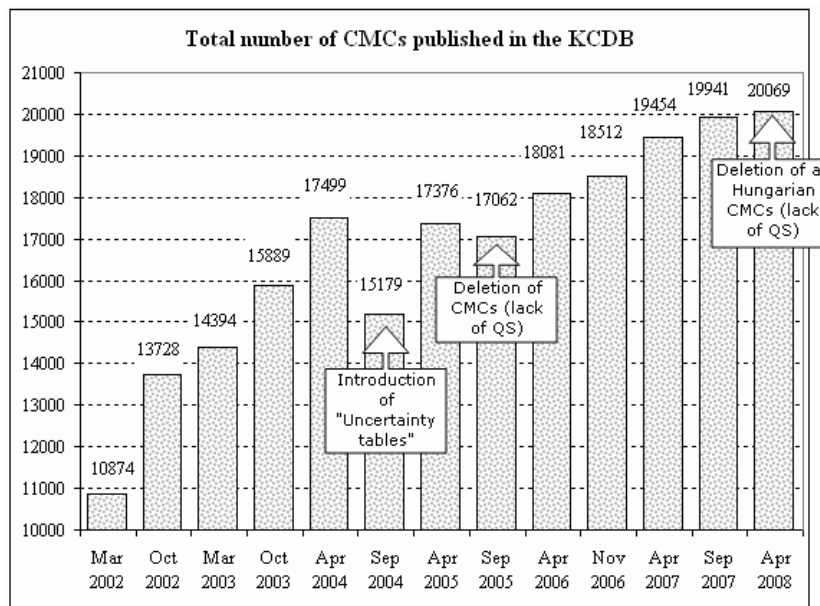
Note that final reports of key and supplementary comparisons posted in the KCDB are also generally published in the series of *Metrologia Technical Supplement*.

A number of key comparison results are also regularly updated. These mainly concern the ongoing BIPM key comparisons in electricity (voltage, resistance, and capacitance), in chemistry (ozone measurements), and on radionuclide activity conducted within the framework of the SIR. These updates correspond to new bilateral comparisons that are regularly carried out between the BIPM and various NMIs. In addition, new data concerning the computation of Coordinated Universal Time, UTC (key comparison CCTF-K001.UTC), are published every month.

Statistics on the participation in key and supplementary comparisons are regularly updated in the statistics page of the KCDB website at http://kcdb.bipm.org/kcdb_statistics.asp.

8.1.2 Calibration and Measurements Capabilities – CMCs

At the end of May 2008, more than 20 000 CMCs were published in the KCDB. This is an additional 600 CMCs compared to May 2007, but not many more than six months ago. Indeed, over the last six months, 15 newly approved sets of CMCs were published, among which the set identified as “EUROMET.EM.4.2007” (285 new CMCs and hundreds of revised CMCs from EURAMET in electricity and magnetism), but 364 CMCs from Hungary were deleted on 28 March 2008 due to a lack of an approved Quality System (QS).



Details on the number of CMCs currently published in the KCDB, per country and per metrology area, are available in real-time from the KCDB Statistics web page.

On 15 May 2008, 662 CMCs were still greyed-out from the KCDB due to the lack of an approved Quality System (QS). The main actions related to Quality Systems that took place over the last six-month period are as follows:

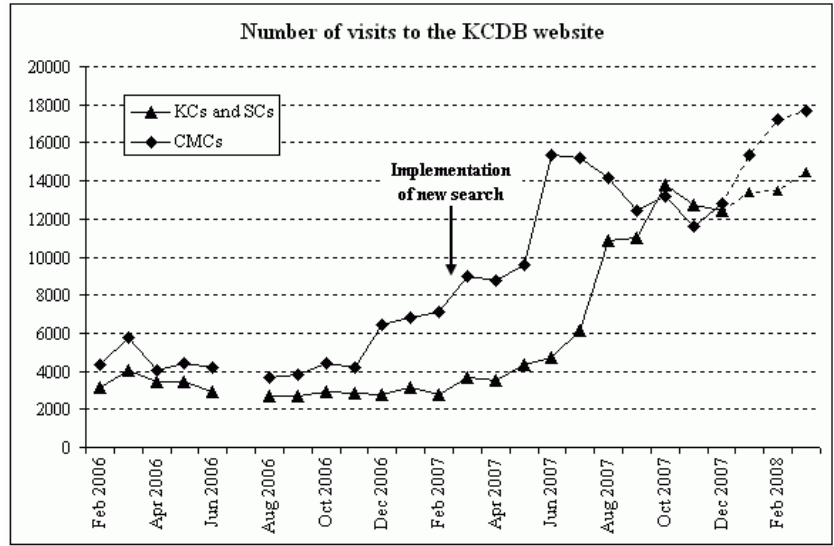
- All CMCs from LATU (Uruguay) that had been removed from the KCDB on 10 August 2007 were re-instated on 30 March 2008.
- The CMCs from NRC (Canada) in length – laser radiations – deleted from the KCDB in July 2005, were replaced by 10 newly approved CMCs on 25 March 2008.
- All CMCs from MKEH (Hungary), namely 364 CMCs covering all fields of metrology, were greyed-out on 28 March 2008.
- All CMCs from Cuba (mass and related quantities and ionizing radiation) were reinstated on 15 May 2008, following a decision of the 20th JCRB.

The KCDB Office notified the 20th JCRB that it may be the case that some of those CMCs that were greyed-out in July 2005, following the decision of the 15th JCRB, will never be re-published as they are out of date and no longer correspond to any services actually delivered by the laboratory. The KCDB Office therefore asked the JCRB to clarify the status of these CMCs,

should they be deleted definitively from the KCDB. This will probably be further considered by the RMOs.

8.2 Visits to the KCDB website (C. Thomas)

The total number of visits of monthly external connections to the KCDB website has increased from 10 300 to 27 200 between August 2006 and August 2007. Details on the number of visits are given for the two main parts of the website (key and supplementary comparisons and CMCs) in the Figure shown below, giving evidence of the impact of the new search facility implemented in March 2007.



The numbers displayed for the three first months of 2008 are only estimation. We observed a huge increase of the requests entered in the free-text search over that period (up to hundreds of thousands over one month), essentially the same requests repeated every 10 or 30 seconds over hours and days exploring all possible answers. We identified that these automatic searches were carried out by “robots”, which scrutinized the KCDB site.

These are not malicious attacks as it does not alter the content of the database or the way the information is displayed on the web. On the contrary, they index the content of the KCDB site and provide links to our site from search engines available on the Internet. No action was thus taken for the time being, except doubling the front server to be able to handle all requests.

It remains difficult to know the number or “real” visits, which is the reason why the curves are shown with dashed lines on the above Figure. We are currently implementing a new tool for analyzing the log-on files and hope to get more robust estimation in near future. It should also be pointed out that the “bump” observed in June and July 2007 on the curve for comparisons is probably also due to the same phenomenon.

One can, however, conclude that more and more users navigate on the KCDB website, and we receive regular feedback from National Metrology Institutes. We think that they constitute a part of the audience, but that our site attracts also other communities such as regulators, accreditors, and commercial and industrial companies.

8.3 Publicity and *KCDB Newsletters* (S. Maniguet and C. Thomas)

We try to publicize the KCDB as often as we can through, for example, the distribution of copies of the KCDB leaflet, and the presentation of the KCDB website at workshops and congresses. The KCDB website and new search engine was demonstrated on 1 August 2007 at the NCSLI Conference (Saint Paul, Minnesota, United States), kindly hosted by the NRC on their stand. In addition, issues 8 and 9 of the *KCDB Newsletter* were launched on 11 December 2007 and 13 June 2008, respectively.

8.4 Publication

1. Thomas C., Wallard A.J., “A User’s Guide to the Information in the BIPM Key Comparison Database”, *Measure*, Special Reports, **2(4)**, December 2007, 22-27.

8.5 Travel (conferences, lectures and presentations, visits): KCDB

C. Thomas to:

- Saint Paul, Minnesota (United States), 1-2 August 2007, for the NCSLI’2007 Conference;
- the Institut de France, Paris (France), 18 December 2007;
- Paris (France), 17 January 2008, 19 February 2008, 17 March 2008, and 24 June 2008, for the organization of the congress “Metrology’2009” at the LNE;

- Trappes (France), 13 March 2008, for preparing the LNE visit scheduled during the BIPM Metrology Summer School 2008;
- Paris (France), 21 March 2008, for preparing the OP visit scheduled during the BIPM Metrology Summer School 2008;
- Saint Denis (France), 7 April 2008, for the 3rd Workshop on Progress in Determining the Boltzmann Constant at the LNE-INM/CNAM;
- Wellington (New-Zealand), 30 April and 1-2 May 2008, for the 20th JCRB meeting;
- Tsukuba (Japan), 9 May 2008, for a visit to NMIJ where she made two oral presentations on the BIPM activities and the KCDB.

8.6 Activities related to external organizations

C. Thomas is a member of the “*Cabinet scientifique des Secrétaires perpétuels de l'Académie des sciences de Paris*”. In this context, she is a member and acts as the Scientific Secretary of the permanent committee of the Académie des Sciences “*Science et métrologie*”. C. Thomas is a member of the Organizing Committee and of the Scientific Committee of the International Congress of Metrology 2009, to be held in Paris from 22 to 25 June 2009 (“Metrology’2009”).

8.7 Activities related to the work of Consultative Committees

C. Thomas is the Executive Secretary of the CCU. She is a member of the CCEM working groups on proposed modifications of the SI (CCEM WGSi) and on coordination of the regional metrology organizations (CCEM RMO WG), a member of the CCM Working Group on the SI Kilogram (CCM WGSi kg), and a non-voting member of the CCT Working Group on Key Comparisons (WG 7).

C. Thomas attended the following meetings in part or full:

- 13th CCL and related meetings, 10-14 September 2007;
- 96th CIPM (in part), 7-9 November 2007;
- 23rd CGPM (in part), 12-16 November 2007;
- CCRI RMO Working Group, 29-30 November 2007;
- 4th RMOs/RCABs meeting, 10-11 March 2008;
- 14th CCQM, 3-4 April 2008;

- 11th CCM and related meetings, 21-24 April 2008;
- 24th CCT and related meetings, 21-23 May 2008.

C. Thomas is also responsible for the organization of seminars at the BIPM, and is the Scientific Secretary of the BIPM Metrology Summer School 2008.

She managed the update of the BIPM website from December 2007 to April 2008, together with C. Fellag Ariouet, D. Le Coz, and L. Le Mée, during the absence of the BIPM webmaster.

8.8 Visitors

- Mrs M. Chambon (LNE), 10 October 2007.
- Prof. Ch. Bordé (Académie des Sciences), 24 October 2007.
- Prof. Dr M. Kühne (PTB), 22 January 2008.
- Dr A. Steele, 20 May 2008.

9 THE JOINT COMMITTEE OF THE REGIONAL METROLOGY ORGANIZATIONS AND THE BIPM, JCRB (P. ESPINA AND L. MUSSIO)

9.1 JCRB Executive Secretary

Dr Pedro Espina from the NIST (United States) ended his three year term as JCRB Executive Secretary after the 20th meeting of the JCRB, May 2008. Prof. Luis Mussio from LATU (Uruguay) was selected to be the JCRB Executive Secretary for the next two year period.

9.2 CMC definition

For several years there have existed two complementary definitions, “Calibration and Measurement Capability, CMC” and “Best Measurement Capability, BMC”, in the metrology and accreditation communities, and an effort to produce a commonly acceptable definition of the term CMC has now proven successful. The new definition was accepted by the CIPM and the ILAC General Assembly, and it will serve as the basis for future work in

both the accreditation and metrology communities. The new CMC definition contains eight explanatory notes that are considered essential. The new definition can be found at: www.bipm.org/cc/CIPM/Allowed/96/CIPM11_OPEN_ACCESS_CMC_BMC_ACCEPTED.pdf

9.3 Rules of procedure for the JCRB

The JCRB felt the need to formalize the operation of its meetings and to that end, the JCRB has developed rules of procedure, defining the process for arriving at decisions, voting rights for members of the Joint Committee, and the quorum needed to hold meetings. The JCRB Rules of procedure can be found at: www.bipm.org/utis/common/CIPM_MRA/CIPM_MRA-D-01.pdf.

9.4 Monitoring CMC changes after the results of comparisons become available

The process for monitoring the impact of results from comparisons on published CMCs was discussed during the last two JCRB meetings. As a result from those discussions, the long standing comparisons flowcharts were modified (see www.bipm.org/utis/common/documents/jcrb/flowchart_comparisons_processes.pdf). The new step in the process has been introduced in the reporting of results, as outlined below.

1. The pilot laboratory will send a letter to the NMI alerting them to any potential problems in their results for the comparison. This letter will be copied to the NMI's RMO, the appropriate CC WG on CMCs (JCRB-11/6(2)) with jurisdiction over the CMC covered by the comparison, the JCRB and the President of the CC.
2. Within 90 days, the RMO is to send a letter to the CC WG on CMCs, the JCRB and the President of the CC (with copy to the NMI) stating the action plan for correcting any potential problems. A resolution statement, in the next RMO annual report on the status of Quality Systems, will follow stating the results of the corrective action. In those exceptional cases when such an action plan fails to resolve the problems within six months, the RMO will request from the JCRB the temporary removal of the CMCs from the KCDB.
3. The RMO shall request from the JCRB the reinstatement of temporarily removed CMCs once the corrective action has been implemented.

4. The President of the CC shall inform the CIPM of the incident as part of his/hers annual report.

9.5 Evaluation of NMIs' Quality Systems

The JCRB considered the implications of a change in the type of support used by an NMI for their QS; specifically, the change from accreditation to self-declaration. Among the aspects considered was the period that the CMCs from that NMI may remain in the KCDB during the transition, prior to a re-evaluation by the new method of support. The JCRB expressed itself as follows:

“NMIs wishing to change the method of evaluation of their Quality Systems [see CIPM MRA, section 7.3, p. 35] will have a 1-year grace period to make the change. The RMOs are to inform the Joint Committee of such changes in their annual report on the status of the Quality Systems of their NMIs. Changes requiring more than 1 year to implement will necessitate the temporary removal of the NMI's CMCs from the KCDB.”

9.6 Documents under consideration

The JCRB is developing a document aimed at defining the process by which a conglomerate of NMIs might formally be recognized as an RMO for the purposes of the CIPM MRA. The document is intended to assist in the formation of future RMOs such as AFRIMETS (a conglomerate of NMIs from African States) and possibly, GULFMET (a conglomerate of NMIs from the Gulf States).

The Joint Committee has come to realize the complexity and large number of documents which currently control the operation of the CIPM MRA. To aid users, the Joint Committee requested that the Executive Secretary consolidate the CIPM MRA documents into categories, and reformat their numbering following the system used in the BIPM QS.

9.7 RMOs – RCABs joint meeting

The annual meeting of the Regional Metrology Organizations and the Regional Coordination of Accreditation Bodies was held on 10-11 March 2008 at the BIPM. During the meeting, a Joint Task Group on the Review-

Assessment Process was created to work on the harmonization of the Quality System review processes used within the framework of the CIPM MRA and of the accreditation process. One of the expected outputs from this group's work will be the document on recommendations on the accreditation of NMIs.

During the meeting, the participants also discussed the treatment of the influence of the device under test in the uncertainty budgets, and possible changes to the KCDB service categories, to better accommodate those instrument categories considered in accreditation outside the scope of the CIPM MRA.

9.8 Workshop on Enhancing the Participation in the CIPM MRA

The first Workshop on Enhancing the Participation in the CIPM MRA was held in Muldersdrift (South Africa), on 2-3 May 2007. Representatives from six CIPM MRA signatory NMIs [LACOMET (Costa Rica), DZM (Croatia), NIS (Egypt), KazInMET (Kazakhstan), KEBS (Kenya), and VMI (Viet Nam)] joined representatives from the five Regional Metrology Organizations (RMOs) and the BIPM for two days of information exchange and strategic planning.

The workshop began with a presentation setting the expectations for the exercise. This was followed by presentations from each NMI in which they described the state of the national metrology infrastructure in their countries and the role of their NMIs in the national metrology structure. The NMI representatives highlighted: their participation in RMO and CIPM MRA activities (including their comparison activities), the metrology areas where they would like to make their first CMC submissions and enumerated some of the problems that they see ahead.

Representatives from the BIPM spoke about CMCs and their review process, the KCDB and the different types of comparisons used within the framework of the CIPM MRA, and the need for the effective implementation of quality management systems in accordance with ISO/IEC 17025 and ISO Guide 34 (where applicable). To conclude, the Director of CENAMEP (Panama), Mr H. Flórez, spoke about the experiences of his NMI in seeking to gain acceptance of their CMCs for publication in the KCDB.

Following the presentations, experts and NMI delegates divided into working groups to develop individual strategies for gaining acceptance of their CMCs for the KCDB. The main issues discussed were:

1. the need for comparisons to support the proposed CMCs, and
2. the need for recognition by their RMO for their Quality System (QS) which covered the CMCs.

The workshop was especially useful in showing how smaller Economies might have special requirements that place particular demands on their RMOs and the CIPM MRA infrastructure.

As of May 2008, the Laboratory for Process Measurement of the Croatian Faculty of Mechanical Engineering and Naval Architecture became the first NMI from this group of workshop participants to publish CMCs in the KCDB (six months ahead of schedule). Their 10 CMCs in pressure were published on 16 May 2008 as part of EURAMET.M.8.2007. Meanwhile, the remaining five NMIs continue to make progress in their 18-month plans, with the NIS already having gained approval of their QS from EURAMET and having sent their CMCs to the appropriate EURAMET TCs for intra-RMO review.

9.9 JCDCMAS

The two-year term of UNIDO as the secretariat of the Joint Committee on Coordination of Assistance to Developing Countries in Metrology, Accreditation and Standardization (JCDCMAS) concluded at the end of March 2008. During that term, Dr O. Loesener Díaz served as the Executive Secretary of the JCDCMAS.

The JCDCMAS held its 2008 annual meeting at the BIPM, Sèvres (France) on 7 March. On that occasion, the member organizations summarized their 2007-2008 activities aimed at aiding developing economies. At the end of the meeting, the participants unanimously supported the transfer of the JCDCMAS secretariat for the next two years to the BIPM, with M. Streak on secondment from the NMISA serving as Executive Secretary.

The major highlights achieved by the JCDCMAS during the preceding two years period were enhanced cooperation amongst JCDCMAS members and enhanced visibility, as well as knowledge sharing with developing countries, on the subject matter of Metrology, Accreditation and Standardization (MAS) through organization and participation in the following events:

- Expert Group Meeting on “How best to Assemble and Conduct Analysis of Non-Compliances affecting Market Access for Developing Economies” held in Vienna (Austria), on 26-27 September 2007.

- An international seminar on “D1 Elements for a law on metrology: when and how to legislate on metrology?” held in Shanghai (China), on 23 October 2007.
- Training on how to use the international document OIML D1 “Law on metrology” held in Maputo (Mexico), on 13 November 2007.
- Symposium on “Interactions between National Metrology Institutes and Accreditation Bodies for Laboratories and Inspection and Certification Bodies – with particular focus on issues for developing economies” held in Sydney (Australia), on 31 October 2007.
- ISO Workshop on Conformity Assessment for Sustainable Development and Trade held in Kiev (Ukraine), on 12-13 June 2008.

9.10 Publications, lectures, travel: JCRB

9.10.1 New CIPM MRA documents

Available at: www.bipm.org/en/committees/jc/jcrb/documents.html

1. Report of the 18th JCRB Meeting.
2. Report of the 19th JCRB Meeting.

9.10.2 Revised CIPM MRA documents

Available at: www.bipm.org/en/committees/jc/jcrb/documents.html

1. Flowcharts of the comparisons process.

9.10.3 Travel (conferences, lectures and presentations, visits)

P. Espina to:

- Pretoria (South Africa), 3-7 July 2007, to participate in the first AFRIMETS General Assembly;
- Braunschweig (Germany), 6-7 September 2007, 4-6 December 2007, and 27-28 May 2008, for meetings with staff of the PTB Presidential Board and PTB Technical Cooperation;
- Ottawa (Canada), 24-30 September 2007, to participate in the SIM General Assembly and the 19th Meeting of the JCRB;
- Minsk (Belarus), 1-4 October 2007, to participate in the COOMET TC 1.4 (flow) and 1.6 (mass) meetings;

- Gulf Region [Manama (Bahrain), Kuwait City (Kuwait), Riyadh (Saudi Arabia), Doha (Qatar), Dubai (United Arab Emirates), Muscat (Oman)], 20-29 October 2007, to visit the GSO and promote the benefits of the BIPM's programmes among the Gulf States;
- Giza (Egypt), 31 October 2007 – 7 November 2007, to visit the NIS and to participate in the Arab Metrology Conference;
- Teddington (United Kingdom), 4 January 2008, for meetings with NPL staff regarding the 2008 World Metrology Day project;
- Gaithersburg (United States), 25-31 January 2008, for meetings with NIST staff;
- Vienna (Austria), 18 February 2008, for meetings with UNIDO staff regarding the JCDCMAS and seeking support for AFRIMETS;
- Sofia (Bulgaria), 20-23 February 2008, to participate in the EURAMET TC-Quality meeting;
- Astana (Kazakhstan), 18-24 May 2008, to participate in the KazInMetr World Metrology Day event and to promote the benefits of BIPM Membership among Kazakhstani Government officials;
- Kiev (Ukraine), 11-14 June 2008, to participate in the ISO Workshop on Conformity Assessment for Sustainable Development and Trade (JCDCMAS event);
- Bogotá (Colombia), 22-25 June 2008, to participate in the event *Segunda Semana de la Calidad* and to promote the benefits of participation in the BIPM programmes among Colombian Government officials.

P. Espina and L. Mussio to Sydney (Australia) and Wellington (New Zealand), 25 April 2008 – 3 May 2008, to participate in the NMIA Metrology Symposium and for meetings with NMIA staff; to participate in the MSL-IRL Workshop *Measuring Our World: Metrology 2008* and for meetings with MSL-IRL staff; to participate in the 20th meeting of the JCRB.

L. Mussio to Braunschweig (Germany), 5-6 June 2008, for meetings with staff of the EURAMET Secretariat, PTB Technical Cooperation, and a delegation from CARICOM.

M. Streak to Geneva (Switzerland), 25-26 April 2008, to participate in ISO DEVCO Chair's Advisory Group meeting.

9.11 Activities related to the work of Committees

P. Espina participated in the following meetings:

- CCL WGDM meeting, 11 September 2007;
- CIPM, 7 November 2007;
- CGPM, 12-16 November 2007;
- CCRI RMO WG meeting, 29-30 November 2007;
- BIPM-ILAC meeting, 13 December 2007;
- BIPM-ILAC-OIML meeting, 5 March 2008;
- BIPM-OIML meeting, 5 March 2008;
- BIPM-ILAC meeting, 6 March 2008;
- CMC-BMC workshop, 8 March 2008;
- CCM WGFF meeting, 17 April 2008.

P. Espina and L. Mussio participated in the following meetings:

- RMO-RCAB meeting, 10-11 March 2008;
- CCQM KCWG meeting, 28-29 March 2008;
- CCM Working Group on CMCs, 23 April 2008.

P. Espina and M. Streak participated in the following meetings:

- BIPM-UNIDO meeting, 6 March 2008;
- JCDCMAS meeting, 7 March 2008;
- Meeting of the steering committee of the Forum on Metrology Programmes for States in Development, 30 June 2008.

L. Mussio participated in the following meetings:

- CCQM meeting, 3-4 April 2008;
- CCM meeting, 24-25 April 2008.

9.12 Visitors

- A Paraguayan delegation (7 visitors from various ministries), 3 July 2007.
- Dr W. Schmid (EURAMET Secretary), 18 January 2008.
- Mr I. Dunmill (Assistant Director BIML, OIML), 23 January 2008.
- A Chinese delegation (5 visitors), 3 March 2008.
- Dr M. Benková (SMU), 16 April 2008.

- Mr J. Dajes Castro (INDECOPI) and Mr C.F. Wolff (PTB), 17-18 April 2008.
- A Bolivian delegation, for the signature of the CIPM MRA, 16 May 2008.
- A Brazilian delegation (24 visitors from various ministries), 10 June 2008.

10 PUBLICATIONS OF THE BIPM AND INFORMATION TECHNOLOGY (J. WILLIAMS)

10.1 Reports of the CIPM and Consultative Committees (D. Le Coz, J.R. Miles*, C. Thomas and J. Williams)

Since July 2007 the following have been published:

- *International Committee for Weights and Measures, 95th meeting (2006)*, 2007, **74**, 258 pp.
- *Director's Report on the Activity and Management of the BIPM (2007)*, 2008, **8**, 306 pp.
- *The International Bureau of Weights and Measures*, 2007, 44 pp.

The period of this Report has also seen the publication on the BIPM website of two documents from the two working groups of the JCGM (see below for details). Working Group 2 has published the *International Vocabulary of Metrology – Basic and General Concepts and Associated Terms* (this is the third edition of the 'VIM') and Working Group 1 has published *Supplement 1 to the Guide to the Expression of Uncertainty in Measurements (Propagation of distributions using a Monte Carlo method)*. These two documents have also been published by ISO as ISO Guides 99 and 98, respectively.

Note: all scientific publications are listed in the appropriate sections of the report.

Following a decision made by the International Committee for Weights and Measures at its 92nd meeting in October 2003, reports of meetings of

* Webmaster absent 7 October 2007 – 4 May 2008.

Consultative Committees are published only on the BIPM website. Full bilingual printed versions in French and English no longer appear.

10.2 *Metrologia* (J.R. Miles*, D. Saillard and J. Williams)

Since the beginning of 2003, *Metrologia* has been produced in partnership with Institute of Physics Publishing (IOPP) Ltd., the publishing arm of the Institute of Physics.

The technical details of the production of *Metrologia* between the BIPM and IOPP are continuing to work well. The journal appears on time and we benefit from the extensive marketing network of IOPP to assist in maintaining the subscriptions levels of the journal at a time when subscription levels are falling for the majority of technical scientific journals. Special issues of the *Metrologia* are still organized by an invited specialist editor in cooperation with the editor at the BIPM. Over the period of this report, there was one special issue of *Metrologia* published in the period of this report: Radionuclide metrology, **44**(4).

In addition to appearing in the printed journal, all submissions that have been accepted are made freely available for one month on the *Metrologia* section of the website for IOPP (www.iop.org/EJ/journal/Met).

The impact factor of *Metrologia* continues to increase. The impact factor (IF) is defined as being: number of citations in the current year to papers published in previous two years/number of papers published in previous two years.

Year	2000	2001	2002	2003	2004	2005	2006	2007
IF	0.820	0.945	0.842	0.983	1.314	1.479	1.657	1.667

It is important for us to achieve and maintain an impact factor above 1.0 as this is typically the cut-off value that librarians and subscriptions managers look at when they are seeking which journals to cut from their budgets.

The *Technical Supplement to Metrologia* is doing well with 37 Abstracts published during the period of this Report, with many more in the pipeline.

The following table gives details of the rapidity of the editorial process for manuscripts submitted to *Metrologia*; demonstrating that the editorial and publication processes involving BIPM and IOPP are working well. Indeed, it is difficult to see that it is possible to improve the efficiency of the editorial

and publishing process given that the journal only appears six times each year.

	2004	2005	2006	2007
Receipt of manuscript to Web publication	57 days	36 days	40 days	34 days
Receipt of manuscript to print publication	106 days	97 days	95 days	73 days

10.3 The BIPM website (J. Miles*)

The BIPM's webmaster, Dr Janet Miles, was absent for a substantial part of the year, on maternity leave and then personal leave. An interim "webteam" was put in place to manage essential updates of the website in her absence: this team of colleagues comprised Mrs C. Fellag-Ariouet, Mrs D. Le Coz, Mr L. Le Mée and Dr C. Thomas. Dr Miles adds her thanks to those of the Director for the work accomplished by them.

For much of the period covered by this report, therefore, updates were restricted to essential maintenance rather than the addition of new facilities.

Nonetheless, two new sections on the website deserve particular mention. The first is a new area for Guides in Metrology, following the publication of the 3rd edition of the *International Vocabulary of Metrology – Basic and General Concepts and Associated Terms* (VIM), produced by Working Group 2 of the Joint Committee for Guides in Metrology (JCGM-WG2), and a first Supplement to the *Guide to the Expression of Uncertainty in Measurement*, produced by JCGM-WG1. In conformity with the JCGM Charter, these documents are freely available for download on the BIPM website (see <http://www.bipm.org/en/publications/guides/>).

The second area, on BIPM events, currently includes information on the 2007 IERS Workshop on Conventions and on the forthcoming BIPM Metrology Summer School 2008 (see <http://www.bipm.org/en/events/>).

The publications area has been extended to include two early series of BIPM publications: *Working Party Notes*, now listed at <http://www.bipm.org/en/publications/wpn.html>; and a collection of statistical reports, now integrated under <http://www.bipm.org/en/publications/rappports-bipm/> with the ongoing series *Rappports BIPM*. To provide as complete a service as possible, selected

older publications of the Ionizing Radiation and Mass sections are now listed back to the 1960s.

The main charge of documents on the website remains the restricted-access areas for the many Joint and Consultative Committees and their working groups. The presentation of several of these areas has been improved to include an indication of document status (restricted or open access). The JCRB open area is also being revised and updated, to facilitate access to the most important decisions concerning the CIPM MRA.

There was a flurry of stories about the kilogram in the popular media this year, sparked off by a claim that the international prototype may be losing mass. This led publication on the website of a reply by Dr R. Davis, Head of the BIPM Mass section (see "Is the international prototype losing mass?", under http://www.bipm.org/en/scientific/mass/faqs_mass.html). The watt balance area, http://www.bipm.org/en/scientific/elec/watt_balance/, has also been updated.

An internal review of the website is under way, and an external review panel is being set up. The BIPM metrology portal continues to provide a unique service as a dedicated search engine, and covers an increasing number of documents as more and more laboratories participate in the CIPM MRA. Early feedback is encouraging, and statistics will be made available in a subsequent report.

Finally, Dr J. Williams (BIPM) and Dr C. Pulham (OIML) have collaborated to produce a joint BIPM-OIML web portal, the BIPM-OIML Resource Center, on-line at <http://www.metrologyinfo.org/>.

10.4 Information Technology (L. Le Mée, J.R. Miles*, I. Soltani)

During the period of this report, the IT group has continued to improve the quality, performance and reliability of the Internet and Intranet services by the integration of new hard and the increasing use of freely available software.

In response to the every increasing demand from users for more capacity for the storage of data, the IT group has begun a study and an in-depth consultation of the structure of backup systems for the BIPM's network. This consultation finished with the integration into the BIPM's IT and communication system of a complete area storage network. This new storage network allowed the BIPM to immediately gain a factor of 10 in its data

storage capacity and should allow an additional total storage capacity of about 8.5 To. Thus this new system will allow for future needs of users as the total storage capacity of such a system is about 64 To.

We have made our security system redundant by the replacement of our old system by a pair of identical firewalls, operating as follows: if an error is detected by the principal firewall, the back up or security firewall comes into action in less than 30 seconds and takes over the role of the faulty one. This double system works automatically. The software to run the firewalls has also been changed for the latest version, which will give the BIPM a more secure protection from intrusions coming from the Internet.

By the end of the period covered by this report, the IT group had installed a new system for accessing the BIPM's computer network at a distance, a system involving the technology of VPN SSL. With this system a user can access his or her office computer by using a simple Internet connection at a distance.

During the period of this report, the IT group bought, installed and put into the BIPM's network about 200 computers for both office-based activities as well as laboratory work. A major effort was made to improve the homogeneity of the overall computer network, in terms of both the software and hardware.

10.5 Travel (conferences and visits): Publications and Information Technology section

J. Williams to Bristol (United Kingdom), 21 April 2008, for a meeting with IOP Publishing.

J.R. Miles to LNE (Paris, France), 23 August 2007, for a meeting with Mrs N. Le Bever, webmaster at the LNE.

11 MEETINGS AND LECTURES AT THE BIPM

11.1 Meetings

The following meetings were held at the BIPM:

- The CCL met on 13-14 September 2007; it was preceded by meetings of its working groups from 10-12 September.
- A Workshop on IERS Conventions was held on 20-21 September 2007.
- The Directors' meeting was held on 14 November 2007.
- Working Group 1 (GUM) of the JCGM met on 27-28 November 2007 and 13-16 May 2008.
- The CCRI RMO Working Group met on 29-30 November 2007; the CCRI(II) Key Comparison Working Group met on 3 December; the CCRI(II) Uncertainties Working Group on 4 December and the CCRI(II) Working Group on the Realization of the Becquerel on 5 December 2007.
- The Joint Committee for Guides in Metrology (JCGM) met on 7 December 2007.
- Working Group 2 of the JCTLM met on 13 December 2007 and a meeting of the JCTLM Executive was held on 14 December 2007.
- The CCQM Working Group on Key Comparison Reference Values met on 14-15 January 2008.
- A joint meeting of the BIPM/ILAC/OIML Working Group was held on 5 March 2008.
- A meeting of BIPM/UNIDO and OIML/ILAC was held on 6 March 2008.
- The JCDCMAS met on 7 March 2008.
- A BMC/CMC workshop was held on 10 March 2008.
- An RMO/RCAB Workshop was held on 10-11 March 2008.
- The CCQM met on 3-4 April 2008; it was preceded by meetings of its working groups from 28 March to 2 April 2008.
- The CCRI Working Group on Accelerator Dosimetry met on 10 April 2008; the CCRI(I) Key Comparison Working Group met on 11 April 2008.

- The CCM met on 24-25 April 2008; it was preceded by meetings of its working groups from 17 to 23 April 2008.
- The CCT met on 22-23 May 2008; it was preceded by meetings of its working groups from 20 to 22 May 2008, together with a Task Group on the SI.

11.2 External Seminars

The following lectures were given at the BIPM, as part of the regular schedule of External Seminars:

- P. Armishaw (NMIA): Proficiency Testing Using Traceable Assigned Values – A Route to Traceability of Chemical Measurements?, 3 October 2007.
- D. Mondelain and C. Jannssen (PPMA, Laboratoire de Physique Moléculaire pour l'Atmosphère et l'Astrophysique, Paris Jussieu): IR absorption spectroscopy for the measurement of CO₂ and O₃ in the laboratory and in the atmosphere, 28 November 2007.
- P. Espina (JCRB Executive Secretary): Metrology in the Arab World and the possible role for the Metre Convention, 12 December 2007.
- C. Daussy (LPL, Villetaneuse, France) and C. Bordé: Mesure de la constante de Boltzmann par méthode optique – vers une redéfinition du kelvin, 20 February 2008.
- N. Fletcher and T.J. Witt: Time Series Analysis of AC Measurements – Application to Digital Lock-in Amplifiers in Coaxial AC Bridges, 16 April 2008.
- T.J. Quinn: The BIPM *G* experiment – final results, 21 May 2008.
- J. Holden and D. Sayers (NAG, Oxford, UK): Using the NAG Library Toolbox for MATLAB, EXCEL and more, 23 May 2008.
- Nien Fan Zhang (NIST): Allan Variance and the Uncertainty of Auto-correlated Measurements, 26 June 2008.

11.3 Internal Seminars

- R. Josephs and S. Westwood: The Organic Analysis Work Programme of the BIPM's Chemistry Section, 23 October 2007.

12 CERTIFICATES AND NOTES OF STUDY

In the period from 1 July 2007 to 30 June 2008, 66 Certificates and 1 Note of Study were delivered.

For a list of Certificates and Notes see pages 136-139.

13 FINANCE, ADMINISTRATION AND GENERAL SERVICES (B. PERENT)

The BIPM's Finance, Administration and General Services section is responsible for the smooth running of a wide range of support services such as financial, human resources, legal and other services. During the last year, the Finance, Administration and General Services Section arranged the organization of the 23rd meeting of the CGPM, took part in the meetings of the General Conference and of the Working Group on the Dotation and was involved in the drafting of some Resolutions. The Section presented the Staff Rules, Regulations and Instructions to the CIPM at its meeting in November 2007, whose final text was adopted by the CIPM by correspondence on 12 February 2008 and which came into force on 2 May 2008. As a result, the Section completed a number of consequential administrative changes and arrangements, including the process of approval by the Governing Body of the International Labour Office of the BIPM's recognition of the jurisdiction of the ILO Administrative Tribunal.

13.1 Accounts

Details of the accounts for 2007 may be found in the "*Rapport annuel aux Gouvernements des Hautes parties contractantes sur la situation administrative et financière du Bureau International des Poids et Mesures*". An abstract of Tables taken from this report may be found on pages 140-149.

The headings for the tables may be translated as follows:

Compte I : Fonds ordinaires	Account I: Ordinary funds
Compte II : Caisse de retraite	Account II: Pension fund
Compte III : Fonds spécial pour l'amélioration du matériel scientifique	Account III: Special fund for the improvement of scientific equipment
Compte IV : Caisse des prêts sociaux	Account IV: Social loans fund
Compte V : Réserve pour les bâtiments	Account V: Building reserve
Compte VI : <i>Metrologia</i>	Account VI: <i>Metrologia</i>
Compte VII : Fonds de réserve pour l'assurance maladie	Account VII: Reserve fund for medical insurance

Two additional tables detail the payments made against budget in 2007 and the balance sheet at 31 December 2007. This is done under the headings:

Détail des dépenses budgétaires Bilan au 31 décembre 2007	Statement of budgetary expenditure Balance at 31 December 2007
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It should be noted that in all tables, since 2001, the unit of currency is the euro, according to Resolution 13 of the 21st General Conference.

13.2 Staff

13.2.1 Appointments

- Dr Gianna Panfilo, born 16 March 1975 in Rieti (Italy), Italian nationality, previously Post Doctorate in the Istituto Nazionale di Ricerca Metrologica (INRiM) in Turin (Italy), was appointed as *physicien* in the Time, Frequency and Gravimetry section from 1 August 2007.
- Mr Adrien Kiss, born 17 September 1983 in Nancy (France), French nationality, previously interns in a French private company, was engaged as *assistant* in the Mass section from 5 November 2007.
- Mr Imad Soltani, born 11 September 1974 in Lyon (France), French nationality, previously IT technician in a French private company, was engaged as *technicien* in the Publications and Information Technology section from 1 January 2008.
- Dr Estefania de Mirandés, born 23 October 1980 in Barcelona (Spain), Spanish nationality, previously Post Doctorate in the Laboratoire Kastler-Brossel in Paris (France), was appointed as Research Fellow in the Electricity section from 7 January 2008.

13.2.2 Promotions and change of grade

- Dr Michael Stock*, *physicien principal*, head of special projects, was appointed head of the Electricity section and promoted *physicien chercheur principal* from 1 July 2007.
- Dr Zhiheng Jiang*, *physicien* in the Time, Frequency and Gravimetry section, was promoted *physicien principal* from 1 January 2008.
- Mr Philippe Moussay, *technicien* in the Chemistry section, was promoted *technicien principal* from 1 January 2008.
- Mr Fabrice Boyer, *mécanicien* in the Workshop section, was promoted *mécanicien principal* from 1 January 2008.

* These promotions resulted from a vote of the CIPM during its 96th meeting in November 2007.

13.2.3 Departures

- Mr Guillaume Thibaudeau, *assistant* since 1 April 2007 in the Time, Frequency and Gravimetry section, left the BIPM on 19 December 2007.
- Mrs Ghislaine Negadi, *secrétaire* since 4 May 1998, left the BIPM on 17 January 2008.
- Mr Imad Soltani, *technicien* since 1 January 2008 in the Publications and Information technology section, left the BIPM on 31 May 2008.

13.3 Buildings

13.3.1 Grand Pavillon

- Renovating.

13.3.2 Observatoire

- Repainting of the lower caveau and maintenance of air-conditioning equipment.
- Refurbishment of two offices on the ground floor.
- Refurbishment of rooms 4 and 5.
- Partial replacement of air-conditioning equipment in rooms 15 and 18 and in the time laboratory.
- Maintenance of the drainpipes.

13.3.3 Ionizing Radiation building

- Repainting of the exterior.

13.3.4 Nouveau Pavillon

- Refurbishment of six offices on the ground floor.

13.3.5 Pavillon du Mail

- Maintenance of the roof.

13.3.6 All buildings

- Repair of the fire alarm damaged after a storm.
- Replacement of the generating set.
- Maintenance of the electric generator.

13.3.7 Outbuildings and park

- Refurbishment of the path and creation of a staircase leading Petit Pavillon.
- Felling of a number of dangerous trees.

13.4 Travel: Finance, Administration and General Services section

B. Perent and R. Cèbe attended the "IAAS International Administration seminar" hosted by the BIPM, 5-7 May 2008. Thirty-three international organizations were represented to this seminar.

B. Perent to Boulder (United States), 8-9 June 2008, for a meeting of the bureau of the CIPM.

14 SECRETARIAT (F. JOLY)

There continues to be a heavy workload on the Secretariat with the high number of meetings held at the BIPM, with fewer staff since the beginning of 2008. These meetings are essentially those of Consultative Committees and Working Groups (some of them being complex with parallel sessions in different parts of the BIPM and even in locations not on the site, for example for the CCQM), and the mailings of publications. In addition to the meetings of Consultative Committees and their working groups, the Secretariat, with the assistance of the Administration section, also ensures the smooth running of an increasing number of other meetings held at the BIPM.

This year was particularly busy with the meeting of the CGPM in November 2007 and the BIPM Summer School on Metrology in June-July 2008.

Amongst its other responsibilities, the BIPM's Secretariat maintains records of the BIPM's wide range of international contacts. This database is revised and integrated with the other BIPM databases.

The Secretariat is continuing to develop its knowledge of IT tools, so that our most important documents for Consultative Committees or for communications with Member States, Associates of the CGPM and NMI Directors can be accessed from the BIPM's website.

**15 WORKSHOP AND SITE MAINTENANCE
(J. SANJAIME)**

The BIPM workshop provides an essential and much-valued contribution to the BIPM work programme. Many of the activities of the workshop are mentioned in the reports of the individual sections, but the core mission of the workshop is to support the technical programme with the construction of specialized apparatus and, where necessary, when NMIs and others bring items to the BIPM for calibration. In this latter case, ancillary equipment is often needed at short notice in response to any problems that may arise or to make repairs if equipment is damaged in transit, so that the calibration may

proceed smoothly. The availability of a rapid response is critical to the efficiency of the BIPM's services to NMI staff who may only be able to visit the BIPM for fixed, short periods of time.

The workshop carries out high-precision mechanical work for the scientific sections of the BIPM. In addition, the workshop is the only source of Pt-Ir prototypes of the kilogram, which are made exclusively for the Member States and which make use of the specialized equipment and unique experience of the workshop staff.

During the year, the workshop has successfully contributed to:

- the manufacture of a large number of elements of the calculable capacitor in a project with the NMIA (Australia) and the NRC (Canada) have been send to Australia;
- the BIPM's watt balance project also benefited this year from the completion of a number of components;
- a number of Pt-Ir prototypes and stainless steel mass standards were manufactured;
- a new mass comparator has been completed and installed at the BIPM; and
- the manufacture of complex detectors in graphite for the Ionizing Radiation section.

In addition, the members of the workshop have assisted in a variety of tasks relating to the maintenance of the site.

LIST OF ACRONYMS USED IN THE PRESENT VOLUME

1 Acronyms for laboratories, committees and conferences*

ACPO*	See CSIRO
AFNOR	Association Française de Normalisation, La Plaine Saint-Denis (France)
AFRIMETS	Inter-Africa Metrology System
AGU	American Geophysical Union, Washington DC (United States)
AIST*	National Institute of Advanced Industrial Science and Technology, see NMIJ/AIST
AMCTM	Advanced Mathematical and Computational Tools in Metrology and Testing Conference
AOS	Astrogeodynamical Observatory, Borowiec (Poland)
APC	Laboratoire “ <i>AstroParticule et Cosmologie</i> ”, University Paris 7, Paris (France)
APMP	Asia/Pacific Metrology Programme
AQSIQ	General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China, Beijing (China)
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency, Sydney and Melbourne (Australia)
A*STAR	Agency for Science, Technology and Research (Singapore)
BAM	Bundesanstalt für Materialforschung und -prüfung, Berlin (Germany)
BARC	Bhabha Atomic Research Centre, Trombay (India)
BERM	Biological and Environmental Reference Materials International Symposium
BEV	Bundesamt für Eich- und Vermessungswesen, Vienna (Austria)
BIML	International Bureau of Legal Metrology/ Bureau International de Métrologie Légale
BIPM	International Bureau of Weights and Measures/ Bureau International des Poids et Mesures
BKG	Bundesamt für Kartographie und Geodäsie, Frankfurt am Main (Germany)

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

BSWG	CCRI(I) Brachytherapy Standards Working Group
CARICOM	Caribbean Community
CC	Consultative Committee of the CIPM
CCAUV	Consultative Committee for Acoustics, Ultrasound and Vibration/Comité Consultatif de l'Acoustique, des Ultrasons et des Vibrations
CCEM	Consultative Committee for Electricity and Magnetism/Comité Consultatif d'Électricité et Magnétisme
CCL	Consultative Committee for Length/Comité Consultatif des Longueurs
CCM	Consultative Committee for Mass and Related Quantities/Comité Consultatif pour la Masse et les Grandeurs Apparentées
CCMAS	Codex Committee on Methods of Analysis and Sampling
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	Consultative Committee for Ionizing Radiation/Comité Consultatif des Rayonnements Ionisants
CCT	Consultative Committee for Thermometry/Comité Consultatif de Thermométrie
CCTF	Consultative Committee for Time and Frequency/Comité Consultatif du Temps et des Fréquences
CCU	Consultative Committee for Units/Comité Consultatif des Unités
CENAM	Centro Nacional de Metrología, Mexico (Mexico)
CENAMEP	Centro Nacional de Metrología de Panamá, Panamá (Panamá)
CGGTTS	CCTF Group on GPS Time-Transfer Standards
CGPM	General Conference on Weights and Measures/Conférence Générale des Poids et Mesures
CHMI	Czech Hydrometeorological Institute, Prague (Czech Rep.)
CIEMAT	Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas, Madrid (Spain)
CIPM	International Committee for Weights and Measures/Comité International des Poids et Mesures
CMI	Český Metrologický Institut/Czech Metrological Institute, Prague (Czech Rep.)

CNAM*	Conservatoire National des Arts et Métiers, Paris (France), see LNE
CNEA	Comisión Nacional de Energía Atómica, Buenos Aires (Argentina)
CNES	Centre National d'Études Spatiales, Toulouse (France)
CNRS	Centre National de la Recherche Scientifique, Paris (France)
CODATA	Committee on Data for Science and Technology
Codex Alimentarius:	Commission created by FAO and WHO
CONICET	Argentine Council of Research
COOMET	Cooperation in Metrology among the Central European Countries
CPEM	Conference on Precision Electromagnetic Measurements
CSIRO-ACPO	Commonwealth Scientific and Industrial Research Organisation, Australian Centre for Precision Optics, Lindfield (Australia)
DFM	Danish Institute of Fundamental Metrology, Lyngby (Denmark)
DI	Designated Institute
DZM	State Office for Metrology, Zagreb (Croatia)
EETWG	CCQM Effective Testing of CMC Claims Working Group
EFTF	European Frequency and Time Forum
ENFSI	European Network of Forensic Science Institutes
ENS	École Normale Supérieure
ESA	European Space Agency
EU	European Union
EURAMET	(the former EUROMET) European Association of National Metrology Institutes
EUROMET*	European Collaboration in Measurement Standards, see EURAMET
FAO	Food and Agriculture Organization of the United Nations
FCS	Frequency Control Symposium
FMI	Finnish Meteorological Institute, Helsinki (Finland)
FYROM	The Former Yugoslav Republic of Yugoslavia
GAWG	CCQM Working Group on Gas Analysis
GGEO	Laboratory of Geodesy and Geomatics Engineering, Chania, Crete (Greece)
GSO	Gulf Standardization Organization
GT-RF	CCEM Working Group on Radiofrequency Quantities/ Groupe de travail du CCEM pour les Grandeurs aux Radiofréquences

GUM	Central Office of Measures/ Główny Urząd Miar, Warsaw (Poland)
HAEC	Hellenic-American Educational Foundation, Athens (Greece)
HIRCL	Ionizing Radiation Calibration Laboratory of the Greek Atomic Energy Commission, Athens (Greece)
IAC	International Avogadro Coordination
IAEA	International Atomic Energy Agency
IAG	International Association of Geodesy
IAM	Inter-agency Meeting
IAU	International Astronomical Union
IBMETRO	Instituto Boliviano de Metrología, La Paz (Bolivia)
ICAG	International Comparison of Absolute Gravimeters
ICG	International Committee for GNSS
ICMM	International Conference on Magnetic Materials
ICRM	International Committee for Radionuclide Metrology
ICRP	International Commission on Radiological Protection
ICRU	International Commission on Radiation Units and Measurements
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers, Piscataway, NJ (United States)
IERS	International Earth Rotation and Reference Systems Service
IFIN	Institute of Physics of the Romanian Academy, Bucharest (Romania)
IGS	International GNSS Service
IIAS	International Institute of Administrative Sciences
IJNO	International Journal of Navigation and Observation
ILAC	International Laboratory Accreditation Cooperation
ILO	International Labour Organization
IMEKO	International Measurement Confederation
iMERA	implementing Metrology in the European Research Area, EUROMET project
INDECOPI	Instituto Nacional de Defensa de la Competencia y de la Protección de la Propiedad Intelectual, San Borja (Peru)
INER	Institute of Nuclear Energy Research, Taipei (Chinese Taipei)
ININ	Instituto Nacional de Investigaciones Nucleares, Mexico (Mexico)
INM	National Institute of Metrology, Bucharest (Romania)
INM*	Institut National de Métrologie, see LNE-INM

INMETRO	Instituto Nacional de Metrologia, Normalização e Qualidade Industrial, Rio de Janeiro (Brazil)
INRiM	Istituto Nazionale di Ricerca Metrologica, Turin (Italy)
IOP	Institute of Physics, London (United Kingdom)
IOPP	Institute of Physics Publishing, London (United Kingdom)
IRD*	see LNMRI
IRMM	Institute for Reference Materials and Measurements, European Commission
ISCI	Institute of Health Carlos III, Madrid (Spain)
ISO	International Organization for Standardization
ISO DEVCO	International Organization for Standardization, Committee on Developing Country Matters
ISO REMCO	International Organization for Standardization, Committee on Reference Materials
ITN	Instituto Tecnológico e Nuclear, Savacém (Portugal)
ITU	International Telecommunication Union
IUGG	International Union of Geodesy and Geophysics
IUPAC	International Union of Pure and Applied Chemistry
IUPAP	International Union of Pure and Applied Physics
IVS	International VLBI Service
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 for Traceability in Laboratory Medicine
JWG	Joint Working Group
KAZInMET	Kazakhstan Institute of Metrology, Astana (Kazakhstan)
KCWG	Key Comparison Working Group
KEBS	Kenya Bureau of Standards, Nairobi (Kenya)
KIM-LIPI	Indonesian Institute of Sciences, Serpong-Tangerang (Indonesia)
KRISS	Korea Research Institute of Standards and Science, Daejeon (Rep. of Korea)
LACOMET	Laboratorio Costarricense de Metrología, San Pedro Montes de Oca (Costa Rica)
LATU	Laboratorio Tecnológico del Uruguay, Montevideo (Uruguay)
LGC	Laboratory of the Government Chemist, Teddington (United Kingdom)

LISA	Laser Interferometer Space Antenna, ESA mission
LNE	Laboratoire National de Métrologie et d'Essais, Paris (France)
LNE-CNAM	Laboratoire National de Métrologie et d'Essais, Conservatoire National des Arts et Métiers, Paris (France)
LNE-INM	Laboratoire National de Métrologie et d'Essais, Institut National de Métrologie, Paris (France)
LNE-LNHB	Laboratoire National de Métrologie et d'Essais, Laboratoire National Henri Becquerel, Gif-sur-Yvette (France)
LNE-SYRTE	Laboratoire National de Métrologie et d'Essais, Systèmes de Référence Temps Espace, Paris (France)
LNHB*	Laboratoire National Henri Becquerel, see LNE
LNMRI	Laboratório Nacional de Metrologia das Radiações Ionizantes, Rio de Janeiro (Brazil)
LNMRI-IRD	Laboratório Nacional de Metrologia das Radiações Ionizantes, Instituto de Radioproteção e Dosimetria, Rio de Janeiro (Brazil)
LPL	Laboratoire de Physique des Lasers, Villetaneuse (France)
LPNHE	Research unit of the « Institut National de Physique Nucléaire et de Physique des Particules » and of the Universities Paris 6 and Paris 7, Paris (France)
METAS	Federal Office of Metrology, Bern-Wabern (Switzerland)
MIKES	Mittatekniikan Keskus/Centre for Metrology and Accreditation, Helsinki (Finland)
MKEH	(the former OMH) Hungarian Trade Licensing Office, Budapest (Hungary)
MoU	Memorandum of Understanding
MRA	Mutual Recognition Arrangement
MSL-IRL	Measurement Standards Laboratory of New Zealand, Industrial Research Limited, Lower Hutt (New Zealand)
NAS	National Academy of Sciences of Ukraine, Kiev (Ukraine)
NCSLI	National Conference of Standards Laboratories, Boulder, CO (United States)
NEDO	New Energy and Industrial Technology Development Organization, Kawasaki (Japan)
NICT	National Institute of Information and Communications Technology, Tokyo (Japan)
NIM	National Institute of Metrology, Beijing (China)
NIS	National Institute for Standards, Cairo (Egypt)
NIST	National Institute of Standards and Technology, Gaithersburg, MD (United States)

NMi VSL	Nederlands Meetinstituut, Van Swinden Laboratorium, Delft (The Netherlands)
NMI	National Metrology Institute
NMIA	National Measurement Institute, Australia, Lindfield (Australia)
NMIJ	National Metrology Institute of Japan, Tsukuba (Japan)
NMIJ/AIST	National Metrology Institute of Japan, National Institute of Advanced Industrial Science and Technology, Tsukuba (Japan)
NMISA	National Metrology Institute of South Africa, Pretoria (South Africa)
NML	National Metrology Laboratory, Dublin (Ireland)
NPL	National Physical Laboratory, Teddington (United Kingdom)
NPLI	National Physical Laboratory of India, New Delhi (India)
NPSL	National Physical and Standards Laboratory, Islamabad (Pakistan)
NRC	National Research Council of Canada, Ottawa (Canada)
NRC-INMS	National Research Council of Canada, Institute for National Measurement Standards, Ottawa (Canada)
OAWG	CCQM Working Group on Organic Analysis
OIML	International Organization of Legal Metrology/ Organisation Internationale de Métrologie Légale
OMH*	Országos Mérésügyi Hivatal/National Office of Measures, Budapest (Hungary), see MKEH
OMP	Observatoire Midi-Pyrénées, Toulouse (France)
ONERA	Office National d'Études et Recherches Aérospatiales, Châtillon (France)
OP	Paris Observatory/Observatoire de Paris (France)
ORB	Observatoire Royal de Belgique, Brussels (Belgium)
PTB	Physikalisch-Technische Bundesanstalt, Braunschweig and Berlin (Germany)
RCAB	Regional Coordination of Accreditation Bodies
RMO	Regional Metrology Organization
ROA	Real Observatorio de la Armada, San Fernando (Spain)
RPA	Radiation Protection Advisers
RWTH	Rheinisch-Westfälische Technische Hochschule, Aachen (Germany)
SIM	Sistema Interamericano de Metrología
SMU	Slovenský Metrologický Ústav/Slovak Institute of Metrology, Bratislava (Slovakia)

SSDL	Secondary Standards Dosimetry Laboratories
SSI	Swedish Radiation Protection Institute, Stockholm (Sweden)
SUNAMCO	Symbols, Units, Nomenclature, Atomic Masses and Fundamental Constants, IUPAP Commission
SYRTE*	Systèmes de Référence Temps Espace, see LNE
TC	Technical Committee
TG	Task Group
TGSMM	Terrestrial Gravimetry, Static and Mobile Measurements International Symposium
UBA	Umweltbundesamt/Federal Environmental Agency, Dessau-Roßlau (Germany)
UFFC	IEEE Ultrasonics, Ferroelectrics, and Frequency Control Society, see IEEE
UNIDO	United Nations Industrial Development Organization
USNO	U.S. Naval Observatory, Washington DC (United States)
VAMAS	Versailles Project on Advanced Materials and Standards
VMI	Vietnam Metrology Institute, Hanoi (Viet Nam)
VNIIM	D.I. Mendeleev Institute for Metrology, Rostekhnregulirovaniye of Russia, St Petersburg (Russian Fed.)
VSL*	Van Swinden Laboratorium, see NMI VSL
WBTM	Watt Balance Technical Meeting
WG	Working Group
WGDM	CCL Working Group on Dimensional Metrology
WGFF	CCM Working Group on Fluid Flow
WGG	CCM Working Group on Gravimetry
WGkg	CCEM Working Group on Electrical Methods to Monitor the Stability of the Kilogram
WGLF	CCEM Working Group on Low-frequency Quantities
WGRMO	Working Group on Regional Metrology Organizations
WGSP	Working Group on Strategic Planning
WHO	World Health Organization
WMD	World Metrology Day
WMO	World Meteorological Organization

2 Acronyms for scientific terms

BMC	Best Measurement Capability
CMC	Calibration and Measurement Capability
DSC	Differential Scanning Calorimetry
EAL	Free Atomic Time Scale/Échelle Atomique Libre

FTIR	Fourier Transform Infrared Technique
GC	Gas Chromatography
GLONASS	Global Navigation Satellite System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GUM	Guide to the Expression of Uncertainty in Measurement
IT	Information Technology
KCDB	BIPM Key Comparison Database
KCRV	Key Comparison Reference Value
LC	Liquid Chromatography
LS	Liquid Scintillation
MS	Mass Spectrometry
NMR	Nuclear Magnetic Resonance
PFS	Primary Frequency Standard
PPT	Precise Point Positioning
QHR	Quantum Hall Resistance
QS	Quality System
SI	International System of Units/Système International d'Unités
SINIS	Superconductor-insulator-normal metal-insulator-super- conductor
SIR	International Reference System for gamma-ray emitting radionuclides/Système International de Référence pour les mesures d'activité d'émetteurs de rayonnement gamma
SNS	Superconductor-normal metal-superconductor
SRP	Standard Reference Photometer
SSL	Secure Sockets Layers
TAI	International Atomic Time/Temps Atomique International
TDCR	Triple-to-Double Coincidence Ratio Technique
TGA	Thermogravimetric Analyzer
TLD	Thermoluminescent Dosimetry
TT	Terrestrial Time
TWSTFT	Two-way Satellite Time and Frequency Transfer
UTC	Coordinated Universal Time
UV	Ultraviolet
UVO	Ultraviolet Light and Ozone
VIM	<i>International Vocabulary of Metrology, Basic and General Concepts and Associated Terms</i> (3rd edition)
VLBI	Very Long Baseline Interferometry
VOC	Volatile Organic Compound
VPN	Virtual Private Network

VTS	Vacuum Transfer System
WMD	World Metrology Day
YAG	Yttrium Aluminium Garnet

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