

**CIML: October 2010  
Orlando**

**REPORT FROM THE BIPM  
Andy Henson  
BIPM International Liaison Officer**

1. At the end of 2010 BIPM will say “Goodbye” to Professor Wallard, who retires after a number of years at the helm of the BIPM. Following a period as Deputy Director/Director Designate Andrew became Director of the BIPM in 2004, steering the CIPM MRA to its now mature state, and building up the collaboration with other international organisations. Andrew sends his best wishes to all at the BIPM and CIML. Professor Kühne, the current Deputy Director/Director Designate, will take over as Director of the BIPM from the beginning of 2011.

2. BIPM’s main work.

As we prepare for the meeting of the General Conference on Weights and Measures in October 2011, we have been looking hard at our vision and mission and the way in which we go about achieving this. Essentially, the main activities of the BIPM are the following:

- Provision and improvement of unique international reference facilities which are used by NMIs in Member States so as to provide comparisons, calibrations and associated studies in a cost effective way;
- Liaison with other bodies with similar or complementary missions and interests so as to advance the state of world metrology;
- Maintenance and updating of the SI so as to meet metrological requirements:
  - To promote metrology vigorously, and
  - To maintain the operation of the CIPM MRA to meet national and international needs for worldwide uniformity of measurement and to help reduce technical barriers to trade.

All these four activities have been the subject of great activity and development in the last year.

3. Science progress.

Scientifically, significant progress has been made with our flagship project, the watt balance, and the facilities associated with the maintenance and dissemination of the unit of mass after a redefinition of the kilogram at some point in the future. The team has been strengthened by scientists drawn from

across the BIPM as well as through recruitment of permanent as well as short term staff. The balance is working well in its initial phases and is showing great reproducibility – we even have a preliminary measurement of the Planck Constant, but at the 1 in  $10^6$  level, so there is some way to go to achieve the few parts in  $10^8$  goal. Better performance will be achieved when the apparatus moves to its final purpose-built destination.

The Mass Department has been preparing for the transition from its present Director (R. Davis) to its Director Designate (A. Picard) upon the retirement of Dr. Davis on 1 November 2010. In addition, the laboratory for calibrations of 1 kg standards is being completely renovated to accommodate a new vacuum mass comparator. This will complement our existing vacuum comparator and, at the same time, replace a comparator that is now obsolete. This upgrading of lab space and equipment is motivated in large part by our desire to continue to provide traceability to the kilogram after the redefinition. A second major upgrade which is now well underway is the creation of a pool of 1 kg artefacts. We envision that the weighted average mass of the pool will be more robust than the mass of the present international prototype, and that the mass of the pool will be tightly linked to the most accurate realizations of the new kilogram definition.

In collaboration with NMIA, the initial commissioning of the calculable capacitor has, perhaps, represented the most exciting achievement of the year in the electricity department. Achieving the mechanical specifications and the electrical and the optical systems have proven to be extraordinarily challenging but with the delivery of the electrode bars enabled the final assembly to take place. The Department has also been active in the provision of on-site voltage comparisons as part of a programme based on increased demand from NMIs.

In chemistry, the gas metrology activities continue to develop international equivalence of gas standards for air quality and climate change, in particular comparisons of ozone reference standards, nitrogen monoxide (which is aimed at providing the WMO GAW network with a Central Calibration Laboratory), nitrogen dioxide and methane. The organic analysis team is, through carefully prepared pure materials intended for use as primary calibrators and a study of comparison results, able to identify previously unknown, or un-assessed, influences from structurally related or other impurities or from method-dependent analyses. The trend is towards molecules of greater molecular weights, particularly those relevant to health care, and to the extension of SI-traceable measurements. We have started a new project on insulin, carried out with the collaboration of the WHO and the National Institute of Biological Standards and Control in the UK.

In ionizing radiation, the first two accelerator dosimetry comparisons using the BIPM travelling graphite calorimeter have been held. The new primary standard for mammography dosimetry is fully operational and the first two comparisons held. Guest scientists from four NMIs have helped launch the first three brachytherapy comparison participations. The Department is on

target for NMI comparisons and standards characterizations, with Egypt participating for the first time.

Seventeen BIPM ongoing radionuclide activity comparisons using the unique International Reference System (SIR) took place including the radionuclide,  $^{64}\text{Cu}$  for the first time. The first comparison of the short-lived  $^{99\text{m}}\text{Tc}$  radionuclide using the SIR Transfer Instrument (SIRTI) was successful and the next comparisons are being prepared. Major effort has been invested in developing the triple-to-double coincidence ratio technique (TDCR) for activity measurement to extend the SIR to pure beta emitters.

Looking further forward the BIPM are examining options for a dedicated high energy beam calibration facility - effectively a clinical type linear accelerator - however this would require a very significant investment by the Member States, or identification of alternative sources of funding.

In 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. The stability of TAI, expressed in terms of an Allan deviation, is estimated to be at, or below, 4 parts in  $10^{16}$  for averaging times of one month. During the period of this report thirteen primary frequency standards contributed to improving the accuracy of TAI, including nine caesium fountains. Following the approval by the CCTF of the use of the GPS Precise Positioning Technique (PPP) for clock comparisons for TAI, solutions based on this method (TAI PPP) have been used in the routine computation of *Circular T* from October 2009, with the progressive inclusion of 15 such links. The first GLONASS common-view civil-code link (between PTB and SU) has been introduced into the UTC computation in November 2009.

The Department continues to organize and run round-trips to calibrate GPS receivers, with the aim of characterizing the relative delays of the time-transfer equipment in the contributing laboratories. The first measurements of relative delays of GLONASS equipment have also been made, and more are being organized.

Studies continued for improving the algorithm used to calculate TAI and UTC. A limited programme of research in the Department is dedicated to space-time reference systems. The cooperation with the USNO for the provision of the Conventions Product Centre of the International Earth Rotation and Reference Systems Service (IERS) is continuing; updates to the Conventions (2003) have been posted on the website (<http://tai.bipm.org/iers/>), and a new version is on preparation.

Concerning the realization of reference frames for astrogeodynamic applications, staff of the Department have participated in the construction of a new international celestial reference frame which has been recommended by the IAU as the primary access to the international celestial reference system. The International Comparison of Absolute Gravimeters, ICAG-2009, which included a Key Comparison and a Pilot Study is almost concluded. The

measurements took place at the BIPM between July and October 2009 and the final results are ready for publication after receiving the agreement of all participants.

#### 4. International Liaison.

2009 has been a year in which the BIPM has continued to strengthen its liaisons and links with a number of intergovernmental organizations and international bodies. Our work with the World Meteorological Organization continues to intensify and the two bodies will hold a joint symposium on the broad subject of Metrology and Climate Change, and how satellite-based, ground-based, and other monitoring techniques can be improved by the adoption of best-practice metrology. Led by a series of high-level expert speakers, parallel discussion sessions helped create and a great deal of commitment by our colleagues in the meteorological community to take much greater advantage of the expertise that is in National Metrology Institutes.

For the BIPM, the workshop was a major step forward because, although there have been many working-level contacts in a variety of different disciplines between the metrologists and parts of the observation networks - the Global Atmospheric Watch and GEOS networks for example - the workshop provided the opportunity to complete a long negotiation when the WMO Director General Michel Jarraud signed the CIPM MRA.

The general conclusions were that:

- measurement results from climate monitoring and earth energy balance by remote sensing from satellites as well as ground-based methods and observation should, where practical, be traceable to the SI so as to help provide continuous, quality – assured data sets over the long term;
- the meteorological community should continue to specify its measurement needs and that these should be formally communicated to NMIs;
- the WMO, the BIPM, the NMIs and the academic communities should work together to meet stated requirements for measurement standards with accuracies and uncertainties that meet the needs of climate scientists and modellers and, where relevant, legislators and regulators; and
- calibrations of instruments used by the meteorological community should be made at all stages in space missions as well as for earth based projects and that the NMI community should be involved in planning and execution.

The WMO and the BIPM have established a common strategy to identify the need for accurate measurements and to ensure that the recommendations of the workshop are fully followed up, implemented, and monitored.

The result is a commitment of two of the world intergovernmental organizations to collaborate to tackle the metrology and measurements issues

in one of the most major challenges of the world at the moment. A report is being finalized and will be circulated very widely, including governments, intergovernmental organizations, NMI Directors, the International Panel on Climate Change, and the UNCCC.

Under the BIPM's Memorandum of Understanding with UNIDO, we continue to collaborate on promotion of "MAS" (metrology, accreditation and standardization) one outcome of which was a UNIDO -supported programme to enhance activity within the newly-formed AFRIMETS Regional Metrology Organization. Together with BIML the BIPM provide advice to the project through its Steering Committee. Joint Planning for an AFRIMETS "Metrology School" in February 2011 is well advanced, and BIPM will provide a number of Speakers.

With ISO, the BIPM is increasing its representation at meetings of committees concerned with metrology, notably in nanoscience, and areas where traceability to the SI is an important component of written standards, and will look at creating stronger links between these committees and the CIPM's Consultative Committees.

We are also preparing a joint statement with OIML, ISO and ILAC on the importance of traceability.

With ILAC we are preparing guidance to, and FAQs for, accredited laboratories on traceability and the implications of the CIPM MRA.

Again with ILAC, we are working on:

- guidelines for the accreditation of NMI services
- ILAC's policy ( P10) on metrological traceability of measurement results
- ILAC policy on estimation of uncertainty in calibration and measurement.

As a result of discussions between the BIPM and the International Organization for Legal Metrology, OIML, a number of possibilities for closer liaison and integration were discussed between the CIML Presidential Council and the bureau of the CIPM in a bilateral meeting last March. The options included co-location at the BIPM site or merger of the two organizations. The options had earlier been discussed by the OIML Member States during their 2008 CIML meeting but did not meet with the overall support of the OIML membership. Further discussions have therefore been put on hold for the time being.

## 5. The SI...redefinitions?

For a number of years, there has been a growing activity and interest in the potential redefinition of four base units of the International System of Units (SI) as a result of advances in watt balances and the International Avogadro Collaboration for the Planck Constant, and a number of NMI - based measurements of the Boltzmann constant.

The relevant Consultative Committees continue to monitor and review the situation and there is now the basis of a firm commitment in favour of:

- a kilogram definition based on the Planck constant,  $h$ ;
- a definition of the ampere based on a fixed value of the elementary charge,  $e$ ;
- a definition of the kelvin based on the value of the Boltzmann constant,  $k_B$ ; and
- a definition of the mole based on a fixed value of the Avogadro Constant,  $N_A$ .

The CIPM will continue to consider whether the time is right for a redefinition and for proposals to be made to the CGPM. At the moment, and based on discussions at the meeting of the CIPM in October 2009, it is unlikely that the next meeting of the General Conference on Weights and Measures (in 2011) will be asked to take formal decisions on the numbers associated with the values of the fundamental constants to be used for new definitions of the base units. However, by then, a clear way forward should be visible and as there appears no fundamental urgency in terms of the need for improved uncertainties for realizations of the base units, there is no immediate urgency and no damage to the SI, by waiting until the science is clear and there is agreement on the practical realizations (*mises en pratique*). We also expect greater clarity on the role of the BIPM after any redefinition. The emerging consensus is that watt balances (and possibly realizations of the “silicon Avogadro”) will provide absolute realizations of the definition but they are not so suitable as routine ways of disseminating mass. The current thinking is that the BIPM would continue to provide NMIs in its Member States with a mass calibration service based on traditional platinum - iridium weights as well as a new generation of metallurgically and metrologically improved artefact realizations of a fundamental constant-based definition and that the BIPM should pilot a key comparison of watt balance realizations.

## 6. Raising awareness.

Promotion of metrology takes many forms. The BIPM staff are regular speakers at specialist international and national fora and Scientific Departments actively lead or take part in joint committees, commissions or initiatives to introduce the concepts of metrological traceability and uncertainty into new areas of activity. The latter is almost always a joint effort, with BIPM bringing metrology knowledge and collaborating organizations either providing authority in the application domain or creating the opportunities for joint work. Our BIPM's resources for this task, noted by NMI Directors and Governments as of a high priority for the BIPM, were somewhat limited, but have recently been increased by the appointment of a permanent international liaison officer (Andy Henson), a post initially highlighted in the draft programme of work submitted to, and approved by, the 23<sup>rd</sup> meeting of the CIPM.

World Metrology Day continues as a major promotional activity. Although the BIPM provides the annual theme and poster, the explosion of interest and use by NMIs worldwide as well as by other metrology bodies and companies has

surprised us all. As far as we are aware, over 20 different language versions of the posters were produced – with more than 7000 downloads from the BIPM webpage - and numerous events organized to draw attention to the practical applications of metrology. The 2011 theme will be built around a chemical topic to coincide with World Chemistry Year.

The BIPM and BILM gave coordinated training presentations to the UNIDO technical assistance staff in Vienna on World's metrology Day.

## 7. CIPM MRA

The CIPM MRA has now been signed by the NMIs of 47 Member States and 26 Associates, as well as by three international organizations, bringing the total number of signatory and other designated institutes committed to the CIPM MRA to well over 200. The numbers of CMCs in the kcdb - some 23 000 by mid 2010 - and reports of comparisons continues to grow.

After 10 years of operating, the original CIPM MRA document is showing signs of its age. Some written standards referred to in the 1999 document are superseded and operational practice, approved by the CIPM and implemented through the RMOs does not accord with the old text. A project to revise the document is therefore underway and was presented to the meeting of NM I Directors in June 2010. Further negotiation and discussion is underway, with the intention of coming to a new document by the time of the next meeting of the CGPM in 2011.

## 8. Member States and Associates.

In 2010, Kenya acceded to the Metre Convention and became a Member of the BIPM, and Bangladesh became the 28<sup>th</sup> Associate, Mauritius the 29<sup>th</sup> Associate, and Zimbabwe the 30<sup>th</sup> Associate.. Negotiations and discussions continue with a number of other States regarding the possibility of either Association to the CGPM or Membership of the BIPM.

## 9. Meeting of the CIPM

Dr Y. Duan, Vice Director of the Chinese National Institute of Metrology was elected to membership of the CIPM after the resignation of Professor Gao Jie who has been a member for some sixteen years.

The President, Professor Ernst Goebel will retire after the CIPM meeting in 2010, and Dr Barry Inglis was elected to succeed him.

The CIPM approved a number of policy documents on traceability of measurements for CMCs, the criteria for the membership of the CCU, and

approved two documents developed by the BIPM and the JCRB on the procedure for approval of a new RMO and one on the Rules of Procedure for Consultative Committees and their working groups. The process for approval of a new RMO is particularly important as the GULFMET network is being formalized and guidance was needed on the criteria the CIPM would use to make decisions on the acceptability of a new RMO in relation to the CIPM MRA

## 10 Joint Committee for Guides in Metrology (JCGM)

The representatives of the eight Member Organizations of the Joint Committee for Guides in Metrology (JCGM) met on 2 December 2009 for the annual plenary session. Two main Resolutions were adopted, one concerning the nomination by Member Organizations of experts to Working Groups, and another resolution about the wording of the JCGM Charter relevant to the production and publication of JCGM documents. Reports were also received on the work of the Working Group on the Expression of Uncertainty in Measurement (JCGM WG1 - GUM), the Working Group on International Vocabulary of Basic and General Terms in Metrology (JCGM WG2 - VIM) and the JCGM ad-hoc group on measurement software.

The GUM (Guide to the expression of Uncertainty in Measurement, also known as JCGM 100:2008) is now available in both English and French on the BIPM website. The JCGM WG1 finalized its work on the Introduction to the GUM and related documents. This document extensively hyperlinked to the other JCGM documents has also been adopted by the BIPM and placed on the open website ([www.bipm.org/en/publications/guides/](http://www.bipm.org/en/publications/guides/)) where it is known as JCGM 104:2009.

Since 2008, the 3rd edition of the VIM (International Vocabulary of Metrology – Basic and General Concepts and Associated Terms), the “VIM3”, has been made available from the BIPM website for free access by the metrology community where it is known as JCGM 200:2008 ([www.bipm.org/en/publications/guides/](http://www.bipm.org/en/publications/guides/)). The JCGM WG2, however, recognized that the versions of the VIM3 published by ISO/IEC and OIML were slightly different from the main JCGM/BIPM document, and that, in addition, the three texts contained a number of mistakes requiring formal corrections. During the year covered by this report, the JCGM WG2 drew up the appropriate Corrigenda, to be attached to each of the three versions of the VIM3, in order to produce a corrected and unique master file, which may be used for further extension of the vocabulary. The Corrigendum to be applied to the JCGM/BIPM document, both in French and English, was made available on the BIPM website in June 2010.

## 11. BIPM workshop on physiological quantities and SI units

In addition to a growing number of workshops organized by the various Consultative Committees and Joint Committees, the BIPM has recently

initiated a number of specialist workshops. These relate to current “hot topics” and are designed to bring together cross disciplinary groups to address the challenges and , where possible, to set out a plan of action to deal with them.

The BIPM Workshop on Physiological Quantities and SI Units attracted some 70 people from about 22 countries around the world. Most of the attendees were from National Metrology Institutes (NMIs), and were active in Technical Committees or Working Groups of International Committees, Institutions or Unions such as ISO, IEC, CIE, ICRU, IUPAC and IUPAP.

The workshop was limited to the topic of “Health and Safety for Humans” with presentations by twelve metrology experts covering the six fields selected by the Scientific Steering Committee:

- Optical Radiation (infrared, visible light, ultraviolet);
- Radio Waves and Microwaves;
- Ionizing Radiation;
- Sound and Ultrasound;
- Magnetic Fields; and
- Biological quantities.

The subject of “Physiological Quantities and SI Units” encompasses many different subjects in Physics, Chemistry and Biology that are, or which could be addressed by NMIs and Institutes, and which may need written standards, vocabularies, documentation etc. These written standards could be addressed by dedicated bodies such as ISO, CIE, etc. A direct link should probably be made wherever possible between the relevant Consultative Committee (CC) of the CIPM or the relevant Joint Committee (for instance the JCTLM) and the relevant Technical Committee of the standardization body (often a member of the CC), field by field. There was a strong consensus that the individual CC Working Groups in charge of Strategic Planning should take on board any new challenge related to physiological quantities in their domain of activities, and propose to their CC any appropriate steps forward.

Presentations at the Workshop showed that physiological quantities follow a general pattern, in which the challenge lies in developing an appropriate “action spectrum” [or “weighting function”, “weighting factor”, “model”, etc.]. When this is established, the resulting quantity is generally expressed in SI units.

- Each community designs its action spectra and models: this involves the relevant metrology community, often at the level of the appropriate CC, and international bodies which carry out standardization activities in the field (for example: collaborative development by the CCPR and the CIE of a new model involving a global parametric weighting function for scotopic, mesopic and photopic vision).
- The uncertainty is generally not well established.
- Biological relevance and suitability are not always satisfactory.
- Psychophysical, mental and behavioural processes are known to affect significantly the human response to various stimuli, making an action spectrum highly variable in some cases.

- There are limitations in the application of the models, for instance to low-level effects or in case of saturation effects, and there is certainly a case for model development, especially computer models.
- It could be worthwhile to establish a connection with the JCGM WG 1, concerning modelling of “action spectra”, and possibly to include appropriate guidance on this topic in the planned GUM supplement on modelling.
- Though formal regulation and legislation exist in most of the fields, they may not be uniform throughout the world. Regulators should inform the NMIs and the other bodies on how they could be involved most appropriately. In an increasing number of regulatory fields, traditional physiologically-based regulations are now incorporating human factors such as cognitive ability, reflecting the fact that human responses also need to account for psychophysical, mental and behavioural processes.

Two cases arose where direct actions could be taken:

- Contact should be established between the CCEM and the ICNIRP, the International Committee for Non-Ionizing Radiation Protection [The ICNIRP provides advice on this matter which is often taken on board by regulatory bodies]. Effects induced by magnetic fields on the human body have not been considered in the framework of the CCEM: an appropriate action from the CCEM WG on Strategic Planning may be required;
- It would be desirable for the Working Groups on Strategic Planning of the CCEM and of the CCPR to consider the case of radiation at frequencies of the order of terahertz. This field might best be tackled through the creation of a joint group of the CCEM and the CCPR.

## 12. BIPM workshop on Nanometrology.

The BIPM Workshop on Metrology at the Nanoscale brought scientists from the NMIs and industry together with experts from the regulatory and standards development community. The two day Workshop, held on 18-19 February 2010, was attended by more than 100 delegates and approached the very broad topic of nanotechnology with thematic lectures and round-table discussions in eight topical areas:

- Toxicological testing;
- Nanobiology;
- Aerosols;
- Microscopy;
- Surface analysis;
- Thin films and coatings;
- Mechanical metrology; and
- Electrical and magnetic applications and measurements.

The program was very lively, and the presentations were uniformly excellent, allowing the attendees to address the focal question of the meeting: “What activities are required to establish an effective international infrastructure for metrology at the nanoscale”

The full report, which will be released within the next few months, includes a comprehensive summary of the discussions on this question, including the drivers to work on the topic, technical issues and barriers to progress, status and needs for traceability to the SI, as well as the anticipated use and need for reference materials and documentary standards. Briefly, however, it can be said that the principal drivers for international involvement are in environment, health and safety, in supporting and defining an appropriate regulatory framework, in encouraging and fostering industrial and therefore economic advantage. While the element of curiosity to explore new areas was an overarching theme, one principal barrier to progress was the long lead time required to develop research into innovation. Although there is a varied level of maturity in metrology and standardization, it was acknowledged that there is growing awareness and a high level of anticipation for results.

The current and potential applications of nanotechnology are vast, and there is a great deal of work required to advance the state of the science to ensure the safe and responsible introduction of these new technologies. Perhaps the most rewarding element of the Workshop was the opportunity to meet and establish connections outside of our normal communities: a sentiment echoed with equal enthusiasm by participants from the world of metrology, by the industrial delegations, and by the attendees from international standards and policy development. We were presented with a very broad spectrum of measurement techniques and instrumentation, of new and very challenging measurands, and of the need to act across traditional organization- and discipline-based boundaries to ensure that these pressing needs are met. There will, I expect, be a follow up workshop within a few years but, as far as the specific case of a proposal for the BIPM's 2013-2016 programme of work is concerned, the conclusion was that this is premature.