

**Programme of work and budget
of the International Bureau of Weights and Measures
for the years 2013 to 2015**

1. Introduction

At its 24th meeting in October 2011, the General Conference on Weights and Measures (CGPM) discussed the programme of work (PoW) of the BIPM submitted by the CIPM and adopted Resolution 3 “Dotation of the BIPM for the years 2013 to 2015”. As the CGPM agreed on a dotation at a level significantly below what would be needed to fully implement the submitted PoW and adopted a dotation for a three year period when the submitted PoW was for a four-year period (2013 to 2016), there was therefore a need to revise the PoW and to adjust the corresponding budget in line with the agreed dotation. This revision is now called PoW 2013 to 2015.

This programme of work was adopted by the CIPM at Session I of its 101st meeting, 6-8 June 2012.

2. General

At its 24th meeting, the CGPM decided that:

- The 2013-2015 PoW will run only for 3 years;
- The dotation, compared to the 2012 dotation to which was added the 2012 contributions of those States that acceded to the Metre Convention since the previous CGPM meeting, will only be increased by 1 % per year to compensate for inflation;
- The additional discretionary contribution of 3.8 % of the dotation agreed for the period 2009-2012 will no longer be continued;
- Subscriptions of Associates will be increased in accordance with Resolution 4 (2011);
- There is a need to replenish the capital investment fund (CIF) (Resolution 3);
- The expenditures during the years 2013 to 2015 should be fully balanced by the income;
- The activities of the 2009 to 2012 PoW should be continued to a maximum possible extent.

Mindful of the constraints imposed on Member States by the global financial crisis, it was anticipated that the required dotation to support the full proposed Programme of Work might not find the support of all Member States and three alternative scenarios requiring a lower dotation were therefore prepared in 2011 (See **BIPM programme of work 2013 to 2016 under various funding scenarios**).

The revised PoW is based on scenario III which consisted of restricting the programme of work to the continuation of the present activities and delaying any expansion. However this scenario

relied on a compensation of 2% for inflation and included a transfer from the CIF of about 900 k€ to support the estimated investments. Moreover given that Resolution 4 (2011) on the status of Associate State of the CGPM brings significant changes to the level of the subscriptions of Associate States, it is unlikely that the subscriptions of all Associate States will be settled.

This document starts with the impact of the revision on the activities, provides short descriptions of the activities planned for the period 2013-2015 and finally presents the revised corresponding budget.

3. Impact on the activities

3.1 General

The mission of the BIPM and the drivers for the BIPM activities were detailed in the *Programme of work and budget of the BIPM for the four years 2013-2016* and were the result of a long and careful review and prioritization process by involving the Consultative Committees of the CIPM, the BIPM and ultimately the CIPM itself. Therefore the drivers for the BIPM activities and priorities remain unchanged.

The proposal for the 2013 to 2016 PoW was split in a first part consisting of the continuation of activities and a second part regarding new activities that would be undertaken if the necessary funding would be available. Based on the dotation approved by the Member States, the expected subscriptions from the Associates of the CGPM and other revenue, none of the new activities can be funded.

However dropping the new activities still did not balance expected income and expenditures and further reductions needed to be contemplated.

Cost reductions and efficiency measures including amendment to the conditions of employment have been identified that help to limit the reduction of activities. These include a limitation of the compensation for inflation of 1% p.a. applying to salaries and a number of allowances adjusted with inflation in accordance with the *Regulations, Rules and Instructions applicable to BIPM staff members* (saving of about 530 k€). Also included is a modification of the distribution rate between the BIPM and the staff regarding the health, incapacity and death insurance of the BIPM and between the BIPM and the pensioners regarding the health insurance (savings of about 150 k€). *For details see a CIPM document which will be supplied later.* Notwithstanding these measures some restrictions have to be applied to the continuation of the activities which were part of the 2009 to 2012 PoW.

As the programme has been reduced from four to three years the total number of comparisons and calibrations will be reduced accordingly. The annual number of comparisons and calibrations will remain the same for those activities where no major development work is needed for their execution.

No new permanent staff posts are planned for the years 2013 to 2015 with the exception of the position for the Quality, Health & Safety Manager which is at present a fixed-term position. One staff member will retire during 2013-2015 in the Time department and will not be replaced. Therefore the total workforce will decrease from the present level of 75 to 74 in 2015.

3.2 Mass metrology

The development of a cryogenic version of the BIPM watt balance which was originally planned to start in 2015 will be delayed until the 2016 to 2019 PoW. The watt balance work during the period 2013 to 2015 will concentrate on the room temperature version in order to reduce the uncertainty in the determination of h . Depending on the time when the numerical value of h will be fixed this might allow the BIPM to make a modest contribution to the CODATA value that will be the basis for the kg re-definition. Delaying the development of the cryogenic version will bring a substantial reduction in investment cost of about 400 k€

The increase of the permanent staff for the Ensemble of Reference Mass Standards (ERMS) of 1 scientist and half a technician as proposed in the PoW submitted to the CGPM will not take place (savings of about 400 k€ with respect to the PoW 2013 to 2015). The preparations for the redefinition of the kilogram and its *mise en pratique* will be supported by a Research Fellow appointed in 2012 for 3 years as included in the 2012 budget. This position was left vacant after the end of the contract in 2011 of a Research Fellow working on the watt balance project. The completion of the humidity facility will be delayed until the 2016-2019 PoW (savings of about 20 k€) in order to allow the staff to concentrate on the development of the ERMS.

The proposed measures represent savings of about 820 k€ compared to the PoW 2013 to 2016.

3.3 Time

The activities described in the 2013 to 2015 PoW will be fundamentally unchanged. By delaying the purchase of one new GNSS receiver until the 2016 to 2019 PoW, the investment and operating costs will be reduced by about 65 k€. The retirement of one of the six scientists in the time department in 2014 will lead to a re-prioritization of the time department's relations with international organizations.

3.4 Electricity

The electricity department of the BIPM has started a collaboration with NIST in the field of an ac Josephson system. In the framework of this collaboration NIST has offered to provide an ac system to the BIPM. This allows the BIPM to reduce the investments by about 40 k€

3.5 Ionizing Radiation

In the field of dosimetry due to the budget limitations the realization of the high-energy photon dosimetry facility based on a clinical linear accelerator has had to be postponed. In the field of radionuclide metrology the extension of the SIR to alpha emitters will be postponed to the next PoW saving about 40 k€

3.6 Chemistry

The postdoctoral Research Fellow position in the area of method development for international equivalence of large molecule standards will be continued for 2013. The cost for this measure which was not included in the original PoW 2012 to 2016 is 130 k€ This will allow the continuation of the highly successful development work during the present PoW which had become possible through support by a NIST grant. Maintaining that position beyond 2013 will require additional third party funding (the probability for receiving the additional third party funding is seen as high).

As the planned additional technical support (half a technician) for the gas programme had to be cancelled, the work package “dynamic reference standards and primary facilities for global monitoring of air quality” has to be reduced in scope, deleting proposed work on the establishment of a facility for a new reactive gas species comparison relative to air quality (NH₃) and reducing the proposed extended operating range of the NO₂ facility to below 10 µmol/mol rather than to below 1 µmol/mol. The savings compared to the proposed 2013 to 2016 PoW of 50 % of a technician amounts to about 120 k€.

The work package “comparisons of primary references for organic large molecules” will not be expanded to provide comparisons during the 2013 to 2015 PoW but will be limited to the continuation of method development. The provision of comparisons in this area will be proposed for prioritization and approval in the 2016-2019 programme of work.

3.7 International Coordination and Liaison

The 2013 to 2015 PoW included a metrology summer school in 2014. As the Italian Physical Society is organizing a metrology summer school for 2012 (the well established Varenna summer school), organizing a BIPM metrology summer school in 2014 or 2015 would be too early. It was therefore decided to postpone the next BIPM metrology summer school to the 2016 to 2019 PoW. This corresponds to savings of about 100 k€

4. Programme of work 2013 to 2015

On the basis of the impact on the activities as detailed above, the programme of work 2013 to 2015 will be as follows:

4.1 Mass and watt balance

Programme activities and deliverables for 2013-2015

The overall aim of the activity is to provide all Member States with calibrations, traceable to the current definition of the kilogram onr to the new definition of the kilogram (if it occurs during the 2013 to 2015 PoW), of their national mass standards. Almost all Member States request this service at least once over a 10-year period. In addition, the BIPM will monitor the equivalence of realizations of the kilogram definition for NMIs that operate a watt balance.

There are no new proposed activities, and the seven sub-activities are an evolution of the present work:

M-A1 Establish and maintain a fully operational watt

The BIPM watt balance experiment will be one of the major activities of the Mass Department. This experiment should be capable of ultimately realizing the definition of the kilogram at the internationally set target level of a few parts in 10^8 . This would ensure the continuity, the independence and the availability of the BIPM primary realization of the mass unit.

M-A2 Pilot a watt balance key comparison

The dissemination of the kilogram should use a scheme which ensures robustness, continuity, stability and traceability to the International System of Units (SI) while nevertheless allowing for innovative improvements. For this purpose, the BIPM through the CCM will organize periodic CCM key comparisons (KCs) among primary realizations (including watt balances and the isotopic enriched silicon 28 spheres). For the time between those CCM-KCs the BIPM will carry out BIPM-KCs as a series of bilateral comparisons. The key comparison reference values and associated uncertainties deduced from the comparisons will be evaluated, and degrees of equivalence among the primary standards of the participating NMIs will be established. This programme of comparisons will also provide a constantly updated link to the BIPM ensemble of reference mass standards (activity M-A3).

M-A3 Establish and maintain the appropriate average value and within-group coherence of the ensemble of new mass standards

The BIPM is committed to the long-term maintenance of an ensemble of stable reference mass standards as of Resolution 1 of the 24th meeting of the CGPM (2011) which encourages the BIPM to develop “*a pool of reference standards to facilitate the dissemination of the unit of mass when redefined*”. This pool is now referred to as the ERMS (Ensemble of Reference Mass Standards). The BIPM ERMS is the second major activity of the Mass Department and it is presently composed of twelve 1 kg artefacts of materials (Pt-Ir, Silicon, stainless steel) that have been chosen to minimize known or suspected sources of mass instability. The mass of each of these standards will be calibrated to be traceable to the updated key comparison reference value (see M-A2). In addition, frequent mass comparisons among the standards of the BIPM ERMS will be carried out by gravimetric methods to monitor the relative mass stability of the standards (see M-A4). A suitable average mass of the BIPM ERMS together with the associated uncertainty that includes an appropriate drift contribution of the ERMS is computed and will be used by the BIPM to disseminate the mass unit.

M-A4 Maintain mass artefact dissemination facilities.

- The Department will continue to disseminate the mass unit for the Member States which represent the third major activity of the Mass Department. The task during this period is:
- to provide calibrations of the National prototypes or mass standards traceable to the international prototype of the kilogram (IPK).

- to anticipate the *mise en pratique* of the upcoming new definition of the kilogram by calibrating our working prototypes and standards against the ERMS for which it will be linked to the upcoming primary key comparison reference value (see M-A3).
- to confirm the traceability of BIPM prototypes to the international prototype of the kilogram as has been recommended by the CCM 2010 (recommendation G1).

M-A5 Maintain measurement capabilities in volume (density) and magnetic properties for calibrations of mass standards from NMIs.

Within the framework of calibration services offered to National Metrology Institutes the Mass Department carries out:

- Auxiliary determinations of the volume, the location of the centre of gravity and the magnetic properties of the mass standards.
- Volume determinations for the new national prototypes fabricated at the BIPM for the Member States.

In addition the BIPM will provide on request susceptometers to NMIs, including calibrated magnets, transfer standards and software used for measurement data computing and uncertainty evaluation.

M-A6 Maintain internal calibration services for mass and pressure to support work of the Mass and other departments of the BIPM.

The Mass Department provides further calibration services for its own use and for the others BIPM scientific Departments.

The activity includes:

- Submultiple mass calibrations from kilogram level to milligram mass. This inner calibration chain allows the Mass Department to have submultiple mass references linked to the International Prototype of the kilogram. This is necessary for the determination of the sensitivity of the mass comparators as well as for mass comparisons to compensate the apparent mass of the standards when their masses are too far from the nominal values.
- Accurate mass calibration must be carried out for the test masses of the watt balance experiment. These mass calibrations need to be done under vacuum and linked to our reference standards in air.
- Periodically, adapted masses used by the Chemistry Department for their gravimetry measurements must be calibrated.

Periodic calibrations (every three months) of BIPM manometers, with respect to the pressure balance maintained in the Mass Department are also needed.

M-A7 Maintain coordination activities

The Department provides support to the Consultative Committee for Mass and Related Quantities (CCM) and the Consultative Committee for Thermometry (CCT) by organizing the committee meetings and the working groups meetings. In addition, the BIPM participates in the work of

some of these working groups, for example the CCM Working Group on Mass Standards and the CCT Working Group on Strategy and SI. The coordination activity represents the fourth major activity of the Mass Department.

Delivery of the watt balance programme is crucially dependent on technical support from the Electricity Department.

4.2 Time

Programme activities and deliverables for 2013-2015

The overall aim of the activity is to compute, and distribute the world time scales TAI and UTC to laboratories in Member States, and to improve the international time transfer infrastructure. This would allow, in particular, the BIPM to meet increasing demands for accuracy from new global time systems. A longer term aim is to prepare for a potential redefinition of the second.

T-A1 Frequency stability and accuracy of TAI

This activity includes:

- the calculation of TAI and UTC;
- improvement of time transfer for clock comparison between participating laboratories;
- enhancements of two-way links, and establishment of more robust multi-GNSS time links with GPS, GLONASS, the new Galileo GNSS system and with others as new systems emerge;
- improvement of algorithms and associated software for the inclusion of data from new microwave and optical frequency standards which are, and will continue to be, recommended as secondary representations of the second and for improving the frequency accuracy of TAI.

Decreasing the uncertainty due to the statistical noise in clock comparisons and including multi-GNSS time links will have the impact that the international time system will become more robust and more reliable. Adapting the algorithms for the use of highly accurate frequency standards will render TAI more accurate, enhancing the traceability to the SI.

T-A2 Publication of the values of $[UTC - UTC(k)]$, where $UTC(k)$ is the local realization of UTC kept by laboratory k , gives traceability to the reference UTC to NMIs and other participants through the BIPM's *Circular T*. The values $[UTC - UTC(k)]$ together with their uncertainties constitute the degrees of equivalence for the key comparison in time CCTF-K001.UTC. The BIPM's *Circular T* is also the unique means of dissemination of TAI and UTC to NMIs.

Publication of the values of $[UTCr - UTC(k)]$. The current publication of *BIPM Circular T* allows NMIs to assess the steering of the local timescales with a delay that can reach up to 45 days. Present applications require more frequent validations of the steering strategies, in particular for $UTC(k)$ serving to align the time scales of GNSS. The CCTF welcomed the

initiative of the BIPM for starting the production of a “rapid UTC” (UTC_r) based on a weekly calculation and publication.

T-A3 Underpinning of the accuracy of time links through characterization of delays in GNSS equipment in laboratories

This activity includes:

- maintenance by the BIPM of travelling standards for relative delay measurements and the coordination of campaigns of measurements in NMIs and other participating laboratories;
- coordinating campaigns with RMOs, with their own travelling standards;
- linking RMO results with the BIPM comparisons;
- assessing the potential application of measurement of absolute delays in GNSS equipment, as output of research in the period 2009-2012.

Characterization of delays in time transfer equipment is essential to the laboratories, since it supports the accuracy of time dissemination, and to the calculation of TAI and UTC since it avoids time steps provoked by changes in the equipment.

T-A4 Secondary representations of the second

As the ability to perform highly accurate frequency comparisons is needed to exploit the full potential of the new secondary representations of the second, which may provide the basis for a redefined second, the Department will continue to:

- support the joint activities of the CCTF and CCL in the evaluation of optical and other frequency standards as candidates for secondary representations of the second and for the *mise en pratique* of the metre;
- contribute to studies, and to the CCTF activity, on frequency transfer techniques for highly accurate optical standards based on novel methods (optical fibres, microwave links to atomic clocks in space, time transfer through TW and laser ranging in T2L2, frequency combs) and determine the methods to be implemented for enabling the data of these frequency standards to contribute to TAI in order to improve its accuracy.

T-A5 Coordination activities

In addition to its work on management of the Consultative Committee for Time and Frequency (CCTF) and the Consultative Committee for Length (CCL), together with their joint activities, the activities already listed for time and frequency work all contain a considerable amount of international collaboration and coordination as the field involves a number of other bodies such as:

- International Telecommunications Union - Radio Communication Sector (ITU-R);
- International Earth Rotation and Reference Systems Service (IERS);
- International GNSS Service (IGS);

- International Astronomical Union (IAU);
- International Committee for GNSS (ICG).

T-A6 Internal Services

The Department will maintain the BIPM's internal UTC-traceable frequency dissemination service.

Resources

Guest workers or secondees will be needed as follows:

- for the work on alternatives to the measuring of relative delays of GNSS equipment;
- for the microwave link for time transfer, in cooperation with the Atomic Clock Ensemble in Space project (ACES). This is to start in 2015 and to extend into the following PoW by one further year.

Both projects could be within a cooperation arrangement with the CNES and the Paris Observatory sharing the costs. This has been done successfully before and the projects would not lead to additional positions at the BIPM.

4.3 Electricity

Programme activities and deliverables for 2013-2015

The overall aim of the activity is to ensure that NMIs have access to a means of comparing or calibrating their national standards of voltage, resistance and capacitance based on international reference facilities. These facilities will be enhanced in the programme so as to provide NMIs with an ability to demonstrate equivalence in ac measurements.

E-A1 International comparisons of primary standards for voltage, resistance and capacitance and related calibrations

- The existing programme of comparisons (voltage, resistance, capacitance) will continue as it allows NMIs to validate and demonstrate the performance of high-level electrical primary standards. As requested by many NMIs, a priority will be to resume the on-site comparisons of QHR systems using the BIPM transportable QHR system to overcome the present limitations due to transfer standards and to reduce the uncertainty by a factor close to 5.
- The existing calibration services will continue as they enable NMIs without primary realizations to establish SI traceability. These services make use of equipment needed for the BIPM's own standards and for comparisons. The new calculable capacitor is expected to become the primary standard for the dissemination of the capacitance unit. The Department will continue to provide calibrations for other departments of the BIPM.

E-A2 Development of an ac voltage standard for international comparisons

- An ac Josephson voltage standard, will be developed for comparisons with NMIs. It will be based on the rapid development of programmable arrays as standards for ac voltage, also underpinning ac power standards. A BIPM staff member will receive training during a one-year secondment at a leading NMI. An operational system is expected to be available at the BIPM towards the end of the three-year period.

E-A3 Development of an impedance standard for an improved measurement of the von Klitzing constant

- The dc quantum Hall work will be extended into ac to establish an ac quantum Hall resistance system as a primary standard for impedance, for an improved measurement, together with the new calculable capacitor, of the von Klitzing constant R_K . Better knowledge of the latter will help with setting the basis for a redefinition of the SI. From recent developments, it can be expected that the uncertainty of such a measurement based on the ac quantum Hall resistance standard would be up to three times smaller than for the dc quantum Hall resistance standard. If necessary, this activity could be completed by a comparison between the calculable capacitors which are currently being developed at several NMIs.

E-A4 Watt balance support

- To be able to disseminate the unit of mass after the redefinition of the kilogram, the BIPM is establishing a watt balance, which will be maintained over an extended period of time (activity M-A1). An essential component of a watt balance is a Josephson voltage standard. A quantum Hall resistance standard is also required for regular resistance calibrations. The Electricity Department will ensure the availability and the operation of these quantum standards.

E-A5 Coordination activities

- The Department provides support for the Consultative Committee for Electricity and Magnetism (CCEM) and the Consultative Committee for Photometry and Radiometry (CCPR), by organizing the biannual Committee meetings and the annual working group meetings. In addition the BIPM participates in the work of some working groups, for example by providing advice in particular on questions related to the execution of the CIPM MRA.

4.4 Ionizing Radiation**Programme activities and deliverables for 2013-2015**

The overall aim of the ionizing radiation programme is to continue to provide Member States with the ability to compare, or to characterize, their national standards for dosimetry and radionuclide activity based on a well defined and stable set of international reference facilities.

These reference facilities help provide confidence for NMIs' services to their users in medicine, nuclear and other industries.

RI-A1 Dosimetry

- **RI-A1-1** maintaining the BIPM's range of x-ray standards to provide comparisons for up to sixteen NMIs that need to update their results, including three comparisons for mammography; characterizations of national standards on request; and completing the development of the absorbed dose standard for medium energy x-rays;
- **RI-A1-2** maintaining the BIPM's cobalt and caesium dosimetry standards to provide comparisons for up to eleven NMIs; characterizations of national standards on request at these internationally accepted reference energies; and the robust evaluation of the ^{60}Co absorbed dose to water using the BIPM calorimeter;
- **RI-A1-3** maintaining the BIPM calorimeter standard to provide high-energy photon dosimetry comparisons for at least four NMIs; identifying funding possibilities for a fully characterized and stable international linear accelerator reference facility in a future programme;
- **RI-A1-4** maintaining the BIPM transfer standards for brachytherapy to provide comparisons for up to three NMIs; and piloting a comparison for I-125 seeds as used for prostate cancer brachytherapy;

RI-A2 Radionuclides

In radionuclide measurements, the priority will be to continue the development of the successful SIR travelling transfer instrument; the project on extending the SIR to pure alpha emitters that are being used for therapy having been further delayed due to the financial constraints. The construction of an ionization chamber related to the SIR to realize the becquerel that had been postponed to reduce costs in order to fund the linear accelerator facility, may be started during this programme if the IRMM and the BqWG complete the designs and the prototype is successful. Consequently, the proposed programme deliverables for 2013-2015 to address this activity are the following:

- **RI-A2-1** maintaining the SIR facilities for up to forty-five on-going SIR comparisons of gamma emitting radionuclide activity measurements; maintaining the gamma spectrometry facilities particularly for impurity measurements for the SIR; providing SIR comparisons for pure beta emitters once the ESWG approves the appropriate liquid scintillation methods; and constructing a becquerel chamber as a back-up to the SIR chambers; while considering the challenge of low-level activity measurement to assist in environmental comparison measurements in the following programme;
- **RI-A2-2** providing up to six off-site comparisons of short half-life radionuclides $^{99\text{m}}\text{Tc}$ and ^{18}F using the SIR transfer instrument (SIRTI) and developing the SIRTI for other short lived

radionuclides used for example in positron emission tomography (PET) and in particular for ^{64}Cu , ^{11}C , ^{153}Sm , ^{211}At , and ^{15}O , in priority order;

- **RI-A2-3** maintaining the BIPM's primary methods for CCRI comparisons to enable the BIPM to organize and participate in CCRI comparisons, at the rate of not more than one per year in accordance with the CCRI strategy; to provide SIR entries and establish missing KCRVs.

RI-A3 Coordination activities

The Ionizing Radiation Department also has responsibility for some international coordination and the proposed programme deliverables are:

- supporting activities of the Consultative Committee of Ionizing Radiation (CCRI) including annual CCRI and biennial Section meetings, 11 working groups mainly meeting annually with BIPM participation, roundtables to meet CCRI needs, publication of *Monographies*, preparation of comparison reports for publication;
- supporting activities of the Consultative Committee for Acoustics, Ultrasound and Vibration (CCAUV) including biennial CCAUV meetings, two working groups and preparation of comparison reports for publication;
- supporting activities of the JCGM/WG1 (the GUM), including the *rapporteur*;
- providing representation at the ICRU (annual plus standing and report committees as required), IAEA Scientific Committee (biennial), International Committee for Radionuclide Metrology (ICRM) Board and Programme Committee (biennial) and other international organizations as requested.

4.5 Chemistry

Programme activities and deliverables for 2013-2015

The BIPM Chemistry programme for 2013-2015 has been developed along three major themes:

C-A1 International equivalence of gas standards for air quality and climate change monitoring

This activity includes:

- maintenance and development of an international reference standard for surface ozone;
- development and maintenance of dynamic reference standards and primary facilities and comparisons for global monitoring of air quality;
- development of an international reference facility for demonstrating the comparability of standards for greenhouse gases.

The BIPM will coordinate comparisons of surface ozone, nitrogen oxides and formaldehyde standards and support the development of reference methods for key greenhouse and air quality

gases. This will enable national air quality monitoring networks and pollution control strategies for high priority pollutants to be based on accurate internationally recognized standards and to provide measurements that are fit for assessing air quality and monitoring the effects of control measures. The activities will also ensure the stability and reliability of measurements for the long-term monitoring of greenhouse gases (e.g. carbon dioxide and methane) through BIPM coordinated comparisons for these gases, and their use in radiative and climate change models, and monitoring the effectiveness of mitigation activities. The activities will facilitate the establishment of WMO-GAW central calibration laboratories for VOCs and NO_{xy} for the global monitoring of these species.

C-A2 International equivalence of organic primary calibrators for clinical chemistry and laboratory medicine, food analysis, environmental analysis, forensics and pharmacy

This activity includes:

- maintenance and development of the BIPM's organic primary calibrator facility;
- coordination of comparisons of primary references for organic analysis;
- method development for the international equivalence of large molecule standards for diagnostics and therapeutics.

The BIPM will coordinate key comparisons demonstrating the capabilities of NMIs to deliver the primary calibration reference services required to underpin their provision of SI-traceable measurements in organic analysis, and support NMI Calibration and Measurement Capability claims to provide "small organic molecule" primary calibrants (molecular weights smaller than 500) both as pure substances and calibration solutions. The activity will facilitate the demonstration of equivalence of national capabilities for the value assignment of primary calibrators/calibration solutions in support of reference measurement systems for healthcare, food, environmental analysis, pharmaceuticals and forensics.

The activity on the development of methods for the characterization of high molecular weight organic molecule purity determinations, notably for peptides and some proteins in order to support the development of reference measurement systems for these entities and improvements in the quality assurance of diagnostic measurements and therapeutic products will continue. This will enable the development and use of higher order reference materials, methods/procedures and services by NMIs for large molecules and their use by the IVD industry, leading to accurate diagnostic systems, reduced costs from re-testing and improved patient care. It will promote the development of reference measurement systems for therapeutic large molecule analytes where physico-chemical characterization is required and value assignment of properties in SI units is envisioned, allowing improved accuracy in therapeutic product manufacture.

C-A3 Support of CCQM and JCTLM and international liaison activities for Metrology in Chemistry and the Biosciences

This activity includes:

- support of CCQM and its working groups;

- support of the JCTLM, maintenance of the database and processes;
- BIPM liaison and technical representation at international organizations active in metrology in chemistry and biosciences.

Activities and tasks within this theme are linked to the BIPM's role in establishing and supporting international metrology projects and liaisons with other international organizations which benefit from an international infrastructure for chemical metrology. This ensures awareness of the metrology infrastructure available at the international and national level, promotes the activities under the Metre Convention, and facilitates the establishment of activities at the national level.

An important contribution of the BIPM to the field of healthcare is the maintenance of the JCTLM database of higher order reference materials, methods and measurement services for the *in vitro* diagnostics (IVD) industry world-wide. *In vitro* diagnostics are the tests performed on biological samples to diagnose or rule out a disease. They are used for disease screening, monitoring therapy and to ensure the safety of blood used in transfusions. About 64 % of the information held on patient records comes from diagnostic tests. IVDs have a broad scope ranging from sophisticated techniques performed in clinical laboratories to simple self-tests such as for pregnancy. The JCTLM database was set up in response to industry needs to meet the traceability requirements set by the European Directive on *in vitro* diagnostics, and has since become a global reference for information on available reference materials, methods and services to which industry can establish traceability, ensuring the accuracy of test results, aiding proper diagnosis and patient care. The BIPM maintains the JCTLM database and coordinates the nomination and review process of yearly submissions of entries. At present, the JCTLM database contains 208 Certified Reference Materials (CRMs), 146 Reference Measurement Procedures (RMPs) and 128 Reference Measurement Services (RMSs). A substantial number of primary calibrators for diagnostic analytes are prepared and value assigned by NMIs. The international comparisons coordinated by the Chemistry Department demonstrate the degrees of equivalence of these standards, leading to their international acceptance.

4.6 International Coordination and Liaison

Programme activities and deliverables for 2013-2015

In order to increase the efficiency of the operation of the BIPM, at the beginning of 2012 the Department for International Liaison and Communication was created. The new department combines the international liaison activities with the communication and publication activities. The liaison activities described below involve to a significant part also the BIPM secretariat and the scientific departments in particular the scientists working as Executive Secretaries of the CCs.

IL-A1 Coordinating and supporting the work of the ten Consultative Committees (CCs) created by the CIPM

The work of the CCs and their Working Groups (WGs) is at the core of the BIPM's mission. The coordination as well as the administrative and logistical support is one of the essential activities

of the BIPM staff. Over the last few years the workload has significantly increased in particular due to the growing number of WGs in the CCs. During meetings of large CCs such as the CCQM, which meets annually with all of its WGs at the BIPM, the BIPM reaches the limits of its current capacities both in terms of space and administrative support. In the case of the CCQM, due to the large number of WGs, additional meetings rooms need to be rented in a nearby hotel. On such occasions up to 200 persons meet at the BIPM.

The BIPM provides the Executive Secretaries to each of the ten CCs. The Executive Secretaries are experienced scientists, in most cases the directors of the scientific departments of the BIPM. The administrative and logistic support is one of the main tasks of the BIPM secretariat.

IL-A2 Organizing and supporting Scientific Workshops

Scientific and applied metrology is a very dynamic research field. In close consultation with the corresponding CCs the BIPM organizes workshops on selected topics of particular importance or interest to metrology. For example, in the 2009-2012 programme of work, workshops on “Physiological Quantities and SI Units” and “Metrology at the Nano Scale” were conducted at the BIPM bringing together the world’s leading metrologists with the world’s most competent specialists from industry and academia. Another workshop conducted jointly with the WMO on “Measurement Challenges for Global Observation Systems for Climate Change Monitoring” brought together metrologists and meteorologists to improve the climate data quality by ensuring data traceability to the SI. The results of the workshops are then made available to the NMIs of the Member States and to participating international organizations for their programme planning and as guidance for the scientific work at the BIPM.

IL-A3 Support for the CIPM MRA

The BIPM maintains and regularly updates the key comparison database (KCDB) which is at the core of the CIPM MRA. This database holds the results of the key and supplementary comparisons that establish the degrees of equivalence of national measurement standards of the participating NMIs and Designated Institutes (DIs) and lists the Calibration and Measurement Capabilities (CMCs) of these institutes. As of March 2012, some 1 073 key and supplementary comparisons were registered in the KCDB, among which about 65 % had results published. At the same time, more than 24 500 CMC entries, covering all metrology areas, were available from the KCDB website.

New software for analysing the connections to the KCDB website was implemented in January 2009. The average number of monthly visits to the KCDB is around 7 800 corresponding to about 110 000 pages opened every month. While it is very difficult to identify the visitors, except NMIs which constitute a part of the audience, information shows that the site also attracts other communities, including regulators and accreditors, as well as commercial and industrial companies.

The BIPM hosts the secretariat of the JCRB through the combination of an Executive Secretary of the JCRB, seconded from an NMI, and permanent BIPM staff. The JCRB secretariat is

essential to develop and update, in association with the JCRB, the guidance documents for the RMOs and NMIs for the efficient operation of the CIPM MRA.

The BIPM operates and updates its web page for the BIPM's own calibration service uncertainties. This page is available from the KCDB.

All these activities will be continued during the proposed programme of work.

IL-A4 Cooperation with intergovernmental organizations and international bodies

This activity concentrates on the BIPM's links with the International Organization for Legal Metrology (OIML) as well as the accreditation and standardization communities. The BIPM will:

- continue its close cooperation with OIML in all areas of mutual interest;
- use its collaboration with ILAC to ensure greater attention by accreditors and accredited laboratories to the concepts of uncertainty, traceability, and the importance of demonstrating that CMCs from an accredited laboratory are consistent with those of the NMI to which it claims traceability as contained in the KCDB. Numerous examples show that such work contributes significantly to the framework within which technical barriers to trade can continue to be reduced;
- participate in ISO committees concerned with conformity assessment (CASCO) and maintain an overview of related work in terminology and uncertainty;
- if appropriate, be represented on ISO/IEC committees concerned with physiological quantities, as a follow up to the workshop held at the BIPM in November 2009;
- be involved in revisions of ISO standards, especially ISO/IEC 17025 and ISO/IEC 17011.

IL-A5 Outreach

This activity concerns the promotion of the work of the BIPM and also aims at attracting new Member States and new Associates. The deliverables are:

- developing material and arguments to increase Membership of the BIPM;
- liaising directly with potential new Member States/Associates;
- raising awareness of the annual World Metrology Day and the distribution of related promotional material from the BIPM; and
- supporting new RMOs so that they can play a full and competent role in the CIPM MRA.

IL-A6 Developing new opportunities

This activity addresses the policy of developing new opportunities and taking initiatives to extend the coverage, uptake and impact of the SI and the associated concepts of measurement traceability and uncertainty. The deliverables include:

- following up the WMO/BIPM symposium (30 March – 1 April 2010) on “Measurement Challenges for Global Observation Systems for Climate Change Monitoring”, so as to develop cross-disciplinary task forces to address needs in existing, as well as new, areas agreed with the WMO; and
- launching and managing a study on the international needs for metrology in nanoscience and nanotechnology and to recommend an appropriate course of action to the CIPM for inclusion in the 2016-2019 programme of work of the BIPM.

4.7 Support activities and services

4.7.1 Internal calibration services

The BIPM provides internal calibration services in the areas of pressure, mass, electricity and thermometry.

These services provide calibrations of measuring instruments needed by the BIPM's scientific departments for the determination of the values of the quantities that have a non-negligible influence on the total measurement uncertainty of comparisons or calibrations. These calibration services are for internal use only and are covered by the BIPM quality system.

4.7.2 Mechanical workshop

A mechanical workshop is essential for the efficient operation of the BIPM's scientific laboratories. The workshop not only designs and manufactures specific components for the BIPM standards and research instrumentation at the BIPM, such as the watt balance and the calculable capacitor and ionizing radiation measurement standards, but also provides the special parts needed to adapt NMI standards to the BIPM reference facilities. It also repairs damaged equipment on the spot allowing comparisons and calibrations to run without major delays. The operation of such a mechanical workshop is an indispensable prerequisite for the efficient running of the BIPM.

The mechanical workshop also produces platinum/iridium copies of the kilogram prototype against reimbursement of cost. This is a unique service that is only available to Member States.

4.7.3 Secretariat

The **secretariat** handles, among other responsibilities, the ever-growing workload related to the administrative coordination of the Consultative Committees. Specifically this includes:

- issuing all invitations to meetings organized by the BIPM, e.g. CGPM, CIPM, Directors of NMIs, Consultative Committees, Working Groups or workshops, and making the arrangements for attendance, including those related to visa applications;
- assuring the smooth-running of the meetings through support to the scientific Executive Secretaries as well as to the participants;

The **library**, since the beginning of 2012 part of the Department for International Liaison and Communication, continues to be an integral part of the BIPM, essential for its scientific work and to visitors coming for meetings and collaborative work. Following a critical review, the number of journals to which the BIPM subscribes has been further reduced and in many cases the BIPM has switched to electronic-only subscriptions. The librarian also provides translations into French of formal reports such as reports of meetings of the CGPM and CIPM, the Director's annual report on activities of the BIPM, the SI Brochure and other brochures as well as providing translations for the website.

The **Publications** team has also been integrated into the new Department of International Liaison and Communication. The responsibilities of the publications team are in particular:

- editing and producing the BIPM's mandated formal publications such as the proceedings of meetings of the CGPM and CIPM, the annual Director's report on activities of the BIPM, and editing the Annual Report to Governments on the administrative and financial situation of the BIPM;
- editing and producing other publications in French and English such as the SI Brochure;
- editing and publishing the reports of meetings of the Consultative Committees;
- taking responsibility for the BIPM website and enhancing the web as a means of promoting the BIPM and metrology in general;
- editing of *Metrologia* and supervising the production, publication, and marketing of the journal, which is carried out under license by the Institute of Physics Publishing (United Kingdom of Great Britain and Northern Ireland);
- assisting the BIPM staff members with the preparation of texts in English, and in particular the scientific staff with the preparation of papers for publication in the scientific literature or for submission to conferences;
- producing other BIPM publications as required.

The peer-reviewed journal *Metrologia* is dedicated to advancing the science of metrology. Through it the BIPM provides another unique service, as *Metrologia* is a journal primarily for the NMI community. *Metrologia* publishes articles that contribute to the significant improvement of fundamental measurements, particularly papers that improve knowledge of the fundamental physical constants or that concern improvements to the International System of Units. During the four years from 2005 to 2008 its impact factor increased from 1.479 to 1.780, and the readership base was extended significantly – such that in 2009 the journal was available at over 2 000 institutes world-wide. In addition to the printed journal, the freely available electronic *Technical Supplement to Metrologia* publishes the abstracts of key and supplementary comparison reports published in the KCDB, and of other pilot study reports published on the BIPM website, and provides links to the complete texts of these reports.

The **BIPM website** is now the BIPM's principal means of communication with the metrology community world-wide. Special restricted-access areas have been set up for almost eighty different user groups (Consultative Committees, Working Groups, and others) to provide access to their working documents. The website also provides a wealth of information of interest to a wide range of audiences, including, in addition to metrologists in the NMIs, government officials, regulators and accreditors, academic and industrial scientists, school teachers and students, journalists and historians. Amongst many essential services, the BIPM website provides, for example, an up-to-date list of institutes participating in the CIPM MRA, open access to data and results on the international timescales, and a local metrology search engine.

Like most scientific institutions, the BIPM relies heavily on a fully operational **IT support service**. In particular the KCDB and JCTLM databases need to be accessible to the

outside world on a permanent basis. Establishing and disseminating International Atomic Time (TAI), Universal Coordinated Time (UTC) and rapid UTC (UTCr) critically depend on the reliability and security of the BIPM's IT services. In addition to these tasks the IT service supports the installation and maintenance of hardware and software for scientific and financial and administrative activities, as well as electronic communications and meetings. During the 2009-2012 programme of work a project to modernize and increase the security of BIPM's IT network and services was initiated and will be completed during the 2013-2015 programme.

4.7.4 BIPM Quality System, Health and Safety

The BIPM maintains a self-declared quality system based, in so far as it applies to the BIPM, on ISO/IEC 17025:2005 "*General requirements for the competence of testing and calibration laboratories*" for its calibrations and measurements. In addition the relevant parts of ISO Guide 34:2009 "*General requirements for the competence of reference materials producers*" are implemented within the Chemistry Department. The quality system is audited internally and externally and has been presented to a group of quality experts from RMOs. The quality manual has been revised in accordance with the suggestions obtained during an on-site peer review by an NMI quality expert. There have been no significant complaints, errors or non-conformities declared to the BIPM during the present PoW.

The quality system is administered by a Quality Manager who is also responsible for health and safety.

The BIPM pays close attention to health and safety issues in relation to its own staff members as well as to that of its visitors. The development and implementation of an occupational health and safety management system was started in the 2009-2012 programme and will continue in 2013-2015.

4.8 Finance, Administration and General Services

The Finance, Administration and General Services Department is responsible for the financial and administrative management of the BIPM which includes:

- drawing up the BIPM's annual accounts and financial statements, medium and long-term plans, annual budget and a range of financial management functions to meet corporate needs as well as those of the scientific departments;
- cash management;
- all procurement issues;
- human resources issues including payroll, training, operation of the BIPM medical insurance scheme, monitoring and reimbursement of travel expenses;
- management of the BIPM Pension and Provident Fund;
- handling all legal issues including those related to the *Regulations, Rules and Instructions applicable to staff members of the BIPM* and the *Regulations and Rules of the BIPM Pension and Provident Fund*, agreements such as Memoranda of Understanding and purchase contracts, international institutional law and international law;

- relations with Member States and Associates regarding financial, legal and administrative affairs;
- logistical matters including customs operations and matters related to site maintenance;
- logistical support of meetings, conferences, summer schools and other events at the BIPM headquarters.

In addition the department ensures smooth running of the general services such as the reception, site security, housekeeping and maintenance of the park and gardens.

4.9 Buildings and site

The BIPM is located in the *Domaine national de Saint-Cloud*, a historic site granted by the French Government without limit of time, and both the historic Pavillon de Breteuil itself and the other buildings erected since the creation of the BIPM and the grounds must be maintained to an appropriate standard.

The maintenance of buildings, ranging in date from the 17th century (the *Pavillon de Breteuil* and the *Petit Pavillon*) to the present day, is expensive and requires a wide range of skills and techniques.

Major renovation of the BIPM's buildings is regularly required to take account of new requirements resulting from changes in the programme of work such as the partial refurbishment of the laser building in 2010 for the installation of additional laboratories for metrology in chemistry or the refurbishment of the Petit Pavillon to install meeting rooms after the transfer of the mechanical workshop to the Pavillon du Mail in 2001. Work is also needed regularly to refurbish old installations. This is presently the case for the IT infrastructure that was put in place in the early 1990s and which now has to be updated and modernized to meet today's needs.

In 2010 the BIPM undertook an energy audit in order to assess the energy efficiency of its buildings with a view to reduce its energy costs. This was in response to a significant increase in its energy costs and the need to face future increases. As a result, a plan with corrective actions was put in place which will be implemented over the course of the next ten years to improve the energy efficiency of the BIPM's buildings. This long term building programme also includes renovation work of the Nouveau Pavillon and the Pavillon du Mail which would have to be performed in the forthcoming periods as they were respectively built in 1988 and in 2000.

The BIPM laboratories are equipped with appropriate air conditioning systems to provide the temperature and humidity stability necessary for precision metrology. The maintenance of adequate air conditioning in the laboratories is a major task that requires continuous attention but in addition some of the air conditioning equipment, the performance of which is critical for the scientific activities, will need to be replaced as it uses a coolant gas which will be forbidden in the European Union from 2015.

4.10 Travel and transport of equipment

Visits by scientific staff and the Director to national laboratories and attendance at conferences and meetings related to metrology are an essential part of the activities of the BIPM and will continue. They provide the opportunity to maintain contact with the NMIs, to maintain an up-to-date knowledge of metrology research and requirements, to present the results of the work of the scientific staff and to promote the activities carried out under the Metre Convention. Travel to attend meetings with intergovernmental organizations and international and regional bodies has increased over the years, reflecting the growing number of liaisons with such organizations and bodies.

The cost of travel and transport of equipment accounts for more than 3 % of the annual budget. This not only reflects the number of meetings that BIPM's staff attend but also the costs incurred by the programme of international comparisons made by transporting BIPM reference standards to national laboratories and by sending reference materials for comparisons. The costs of travel and transport of equipment will increase during the period 2013-2015 as a result, in particular, of the high-energy photon accelerator dosimetry comparisons referenced to the BIPM calorimeter standard. However efficiency measures will be taken so as to limit this increase.

5. Budget

5.1 Estimated cash budget

Estimated cash budget for 2013-2015

Revenue	2013	2014	2015	Total 2013-2015
1. Dotation	11 577	11 693	11 810	35 080
2. Contributions from Member States having acceded after the 24th CGPM meeting	56	56	57	169
3. Subscriptions ¹	415	452	489	1 356
4. Other revenue	435	432	439	1 306
Total revenue (A)	12 483	12 633	12 795	37 911

¹ Conservative estimation of the payment of subscriptions by the Associates

Expenditure	2013	2014	2015	Total 2013-2015
1. Salaries in EUR	5 184	5 093	5 162	15 439
2. Total allocations	1 139	1 110	1 081	3 330
3. Social contributions	523	520	527	1 570
4. Total staff expenditure (1 + 2 + 3)	6 846	6 723	6 770	20 339
5. Contribution to the Pension Fund	2 409	2 368	2 400	7 177
6. General services	1 114	1 257	1 160	3 531
7. Laboratory expenditure	1 340	1 260	1 294	3 894
8. Building expenditure	667	632	636	1 935
9. Miscellaneous	124	93	94	311
Total expenditure (B)	12 500	12 333	12 354	37 187

Budget balance (C) = (A) - (B)	-17	300	441	724
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Allocation of the budget balance

Replenishment of the Capital Investment Fund	500
Replenishment of the Reserve Fund for Health Insurance	224

5.2 Breakdown of revenue

(in thousands of euros)

Revenue	2013	2014	2015	Total 2013-2015
Dotation	11 577	11 693	11 810	35 080
Contribution of Tunisia	56	56	57	169
Subscriptions	415	452	489	1 356
Other revenue	435	432	439	1 306
Total revenue	12 483	12 633	12 795	37 911

5.3 Breakdown of laboratory expenditure

	in thousands of euros			
	2013	2014	2015	Total 2013-2015
Mass Investment	37	67	107	211
Mass Operating	57	58	92	207
Total Mass	94	125	199	418
Time Investment	45	82	43	170
Time Operating	37	37	37	111
Total Time	82	119	80	281
Electricity Investment	110	114	78	302
Electricity Operating	23	27	28	78
Total Electricity	133	141	106	380
Watt balance Investment	20	47	135	202
Watt balance Operating	24	31	32	87
Total watt balance	44	78	167	289
Ionizing Radiation Investment	115	145	176	436
Ionizing Radiation Operating	39	42	45	126
Total Ionizing Radiation	154	187	221	562
Chemistry Investment	226	153	84	463
Chemistry Operating	250	234	213	697
Total Chemistry	476	387	297	1 160
Workshop Investment	41	11	13	65
Workshop Operating	66	68	69	203
Total Workshop	107	79	82	268
IT Investment	137	30	25	192
IT Operating	35	35	36	106
Total IT	172	65	61	298
General usage Investment	20	20	21	61
General usage Operating	58	59	60	177
Total General usage	78	79	81	238
Total Investment	751	669	682	2 102
Total Operating	589	591	612	1 792
Total laboratory expenditure	1 340	1 260	1 294	3 894

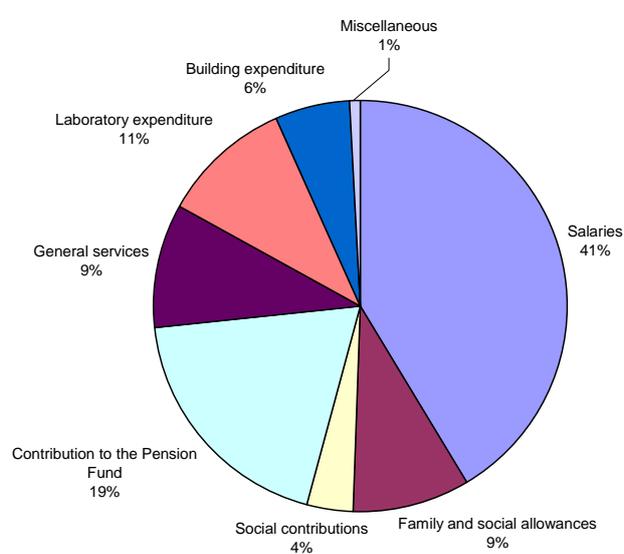
5.4 Breakdown of general services

(in thousands of euros)

	2 013	2 014	2 015	Total 2013-2015
Heating, water, electricity	245	258	271	774
Insurances	41	43	46	130
Publications	47	48	59	154
Office furniture	154	158	168	480
Costs of meetings	142	244	149	535
Travels and transport of material	292	310	267	869
Library	153	156	159	468
Bureau of the CIPM	40	40	41	121
Total general services	1 114	1 257	1 160	3 531

5.5 Distribution of the budget in %

**Distribution of the budget in %
2013-2015**



ESTIMATED 2013-2015 STATEMENT OF FINANCIAL PERFORMANCE

(in thousands of Euros)	2013	2014	2015
Operating revenue			
Contributions	11 633	11 749	11 867
Subscriptions	415	452	489
Other income	435	432	439
Total operating revenue	12 483	12 633	12 795
Operating expenses			
Staff	6 846	6 723	6 770
Contribution to the BIPM Pension and Provident Fund	2 409	2 368	2 400
General services	1 114	1 257	1 160
Laboratory operating expenses	590	590	612
Building maintenance	261	266	271
Depreciation and amortization	2 551	2 314	2 257
Other operating expenses	86	55	55
Total operating expenses	13 857	13 573	13 525
Result from operating activities	(1 374)	(940)	(730)
Financial expenses	38	38	39
Result from ordinary activities	(1 412)	(978)	(769)
Net result for the period	(1 412)	(978)	(769)

Estimated Net value of the assets

	As at 31 December 2011	As at 31 December 2015 (estimate)	Difference
Net value of the assets	38 735	35 422	(3 313)