

Annual Review: Supplement Activities of the BIPM Departments

1 October 2017 – 30 September 2018

Bureau
| **International des**
| **Poids et**
| **Mesures**

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This supplement reports activities on the projects detailed under the [BIPM Work Programme \(2016 – 2019\)](#).

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I Physical Metrology					
#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 – 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 – 30 Sept. 2018)
1.	International reference standard for voltage	E-A1.1	<ol style="list-style-type: none"> 1) Maintenance of the transportable dc Josephson voltage standard, supporting also A1.3 and A1.4 2) Bilateral on-site comparisons at 1 V and 10 V as part of BIPM.EM-K10.a/b (4 NMIs) with relative uncertainty of 1×10^{-10}. 	<ul style="list-style-type: none"> This year no on-site comparison of DC voltage (BIPM.EM-K10) was organized to allow concentration on the development of the AC Josephson voltage standard (E-A1.2) and of two Josephson systems for the BIPM watt balance (M-A3.4). 	<ul style="list-style-type: none"> This year no on-site comparison of DC voltage (BIPM.EM-K10) was organized to allow concentration on the development of the AC Josephson voltage standard (E-A1.2) for a future comparison program. Two comparisons for next year are in the planning stage.
		E-A1.2	<ol style="list-style-type: none"> 1) Development and maintenance of an ac JVS standard 2) Development and characterization of an ac voltage secondary standard for on-site comparisons 3) Pilot studies to establish the new protocol for BIPM ongoing on-site ac JVS key comparison (2 NMIs) with a target uncertainty $< 1 \times 10^{-6}$. 	<ul style="list-style-type: none"> The BIPM is a collaborator to the EURAMET EMPIR project “Towards the propagation of AC quantum voltage standards”. In August 2017 the BIPM transportable quantum AC voltage standard was compared at the PTB with their AC quantum voltage standard by using an AC voltage source as transfer standard. The relative voltage difference was 3 parts in 10^7 for 6.5 V and 2 parts in 10^7 for 0.7 V, with sub-ppm uncertainties. A number of parameters which have to be taken into account in the technical protocol for a future key comparison have been identified. The BIPM has started investigations on a suitable secondary standard for such a comparison. This work will be continued by a secondee from KRISS, starting on 1 October 2017. 	<ul style="list-style-type: none"> The BIPM continued to be a collaborator to the EURAMET EMPIR project “Towards the propagation of AC quantum voltage standards”. The BIPM transportable quantum AC voltage standard was compared at the NPL with their AC quantum voltage standard. Under specific conditions an agreement within several parts in 10^7 could be obtained. Further investigation is needed on the influence of the sampler and the AC voltage transfer standard. A secondee from KRISS contributed until September 2018 to this project by investigating the differential sampling technique. A number of AC voltage sources have been investigated for their suitability as secondary standard for a future comparison.
		E-A1.3	<ol style="list-style-type: none"> 1) Maintenance of the BIPM secondary dc voltage standards (Zeners), also for E-A1.4 2) Bilateral comparisons of Zener diode transfer standards as part of BIPM.EM-K11.a/b (4 NMIs) with relative uncertainty of 5×10^{-8}. 	<ul style="list-style-type: none"> During April-June 2017 a comparison of Zener secondary voltage standards was carried out with NMISA (South Africa). The Draft A report is being written. The BIPM is a member of the support group and a participant of one of the first key comparisons of GULFMET, GULFMET.EM.BIPM-K11. The comparison coordinator from SCL (Hong Kong) spent 	<ul style="list-style-type: none"> A comparison of Zener secondary voltage standards was carried out with KEBS (Kenya). As a member of the support group and a participant to GULFMET.EM.BIPM-K11, the BIPM measured the transfer standards twice, in September 2017 and in July 2018.

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				<p>two months in the BIPM voltage laboratory in preparation of this comparison. The BIPM contributes to the characterization of the travelling standards. This work was done in the framework of the CBKT programme.</p> <ul style="list-style-type: none"> In order to minimize the uncertainty of the K11 comparisons (calibrations of Zener voltage standards), the temperature coefficients of the BIPM travelling standards have been re-evaluated, for the first time since 2002. A new thermal enclosure allows carrying out these measurements faster and with a lower uncertainty than in 2002. The re-determination of the pressure coefficients is under way. 	<ul style="list-style-type: none"> To confirm the measurements of the GULFMET comparison coordinator, the BIPM determined the pressure and temperature correction coefficients of the transfer standards. The re-determination of the pressure coefficients of the BIPM travelling standards used in the BIPM.EM-K11 comparison has been completed.
		E-A1.4	Calibration of Zener diode secondary standards for NMIs without a primary realization (six certificates for four NMIs) and for internal customers (Ionizing Radiation and the watt balance).	<ul style="list-style-type: none"> A Zener voltage standard was calibrated for SMD (Belgium). Calibrations of 7 Zener voltage standards for BIM (Bulgaria), SASO (Saudi Arabia), SIQ (Slovenia) and SIRIM (Malaysia) are scheduled for late September and October 2017. 	<ul style="list-style-type: none"> Zener voltage standards were calibrated for BIM (Bulgaria, 1 standard), SASO (Saudi Arabia, 2), SIQ (Slovenia, 3) and SIRIM (Malaysia, 1). Seven certificates were issued for four NMIs.
2.	International reference standard for resistance	E-A2.1	<ol style="list-style-type: none"> Development of a new transportable QHR standard based on graphene for simplified operation and cost reduction Bilateral on-site comparisons of quantum Hall standards (including new graphene samples) as part of BIPM.EM-K12 (4-6 NMIs) with relative uncertainty 1×10^{-9} 	<ul style="list-style-type: none"> An on-site comparison of quantum Hall resistance standards has been carried out with CMI (Czech Rep.). This comparison was very successful and the frequency dependence of 1Ω resistors, observed in the recent comparison with the PTB, was further investigated. Another comparison, with METAS (Switzerland), is scheduled for later in 2017. The realization of the ohm from the quantized Hall resistance and the transfer 	<ul style="list-style-type: none"> Two on-site comparisons of quantum Hall resistance standards have been carried out successfully with METAS (Switzerland) and NRC (Canada). A comparison with NMIJ (Japan) is under preparation. The realization of the ohm from the quantized Hall resistance and the transfer to the capacitance unit, the farad, have been carried out three times.

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			3) Providing the basis for the realization of the farad, E-A3.	to the capacitance unit, the farad, have been carried out three times.	
		E-A2.2	1) Maintenance of BIPM secondary resistance standards, also for E-A2.3 2) Bilateral comparisons of resistance transfer standards as part of BIPM.EM-K13.a/b (4-6 NMIs) with relative uncertainty of 5×10^{-8} .	<ul style="list-style-type: none"> The report for a resistance comparison with SMD (Belgium) has been finalized. A bilateral comparison of resistance standards (BIPM.EM-K13) has been carried out with NMISA (South Africa). 	<ul style="list-style-type: none"> Bilateral comparisons of resistance standards have been carried out with NSAI (Ireland), INMETRO (Brazil) and A*STAR (Singapore).
		E-A2.3	Calibration of resistance secondary standards for NMIs without primary realizations (100 certificates for 20 NMIs) and for internal customers (Mass, Ionizing Radiation, watt balance).	<ul style="list-style-type: none"> Resistance standards were calibrated for GUM (Poland, 5 standards), IPQ (Portugal 2), DMDM (Serbia, 6), MKEH (Hungary, 4), SMD (Belgium, 6), A*STAR (Singapore, 2), MSL (New Zealand, 2), NMCI (Iran, 3), EIM (Greece, 4), BEV (Austria, 4), INM (Romania, 4). 	<ul style="list-style-type: none"> Resistance standards were calibrated for INM (Romania, 4 standards), SIQ (Slovenia, 3), INMETRO (Brazil, 3), A*STAR (Singapore, 1), NIMT (Thailand, 9), EMI (United Arab Emirates, 3). Twenty-three certificates were issued for six NMIs.
3.	International reference standard for capacitance	E-A3.1	1) Maintenance of the measurement systems to derive the capacitance unit from the quantum Hall effect and/or the calculable capacitor, also supporting E-A3.2 and A3.3 2) Bilateral comparisons of capacitance transfer standards as part of BIPM.EM-K14.a/b (4-6 NMIs) with relative uncertainty of 5×10^{-8} .	<ul style="list-style-type: none"> Maintenance on the various measuring bridges used to establish traceability of the farad to the dc-QHR was performed to maintain optimum operating conditions and to provide the best uncertainties for services to Member States. In particular, the two-terminal pair bridge has been equipped with a new injection device and pre-amplifier, both of which were designed and built at the BIPM. Also, the upgrading of the computer equipping the bridge has required the development of a new acquisition and control software. The BIPM had participated over several years in the supplementary comparison of capacitance and capacitance ratio, EURAMET.EM-S31. This work has been completed at the end of 2016. Several circulations of the travelling capacitance 	<ul style="list-style-type: none"> Maintenance of the measurement bridges as well as of the transfer standards equipping them has been performed to keep the best uncertainty on capacitance calibration measurements undertaken within the framework of the services to member states. The triennial verification of the frequency dependence of the ac-resistors of the quadrature bridge has been carried out. A complete renovation of the resistance bridge used to determine the frequency coefficient of standard resistors with reference to a calculable resistor has been carried out by a secondee from NMIJ (Japan).

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				<p>and resistance standards were necessary due to initially unsatisfactory results. This comparison has allowed several NMIs to identify systematic errors in the measuring instrumentation.</p> <ul style="list-style-type: none"> The bilateral comparison of capacitance standards with NSAI (Ireland) has been finished. 	<ul style="list-style-type: none"> A new set of improved resistors with calculable frequency dependence has been fabricated and characterized with the help of a secondee from NIM (China). Two resistors are for the BIPM, and two each will be sold to the NIM and the LNE (France).
		E-A3.2	Organization of a CCEM key comparison (15-20 NMIs), following the protocol of BIPM.EM-K14 (E-A3.1) and coordinated by the BIPM.	<ul style="list-style-type: none"> The capacitance comparison piloted by the BIPM is well on schedule. The travelling standards of the seven NMI participants arrived at the BIPM on time for the comparison measurements from May to June. They are now back at the NMIs for the final measurements. Once the measurement reports will have been received, the preparation of the report will start. It is planned that the Draft A report shall be ready around the end of 2017. The BIPM participates in this comparison with its own realization of the farad, derived from the quantized Hall resistance. 	<ul style="list-style-type: none"> The CCEM capacitance comparison CCEM-K4, piloted by the BIPM, with participation from seven NMIs and the BIPM, has been completed successfully. The efficient comparison scheme allowed to issue the first Draft A report just one year after the start of the comparison. The final report was approved four months later. The comparison scheme will serve as a model for future CCEM comparisons.
		E-A3.3	Calibrations of capacitance secondary standards for NMIs without primary realizations (100 certificates for 20 NMIs).	<ul style="list-style-type: none"> At the end of 2016, capacitance standards were calibrated for IPQ (Portugal, 1 standard), SIRIM (Malaysia, 4), EIM (Greece, 4), BEV (Austria, 3), NPLI (India, 2), NIMT (Thailand, 6). During the first half of 2017, no capacitance calibrations were accepted due to the workload with the comparison CCEM-K4 (E-A3.2). A large number of requests (32) has been registered for September-December 2017. 	<ul style="list-style-type: none"> Capacitance standards were calibrated for SIQ (Slovenia, 1 standard), SMD (Belgium, 4), CENAM (Mexico, 4), CEM (Spain, 4), A*STAR (Singapore, 3), NIS (Egypt, 3), GUM (Poland, 5), NRC (Canada, 2) and NMIJ (Japan, 2). Twenty-eight certificates were issued for nine countries.
		E-A3.4	Continued metrological characterization of the ac quantum Hall effect for improved	<ul style="list-style-type: none"> Not scheduled for 2017. 	<ul style="list-style-type: none"> An expert on the ac quantum Hall effect from PTB stayed one week at the BIPM to provide information. Two staff

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			measurement of the von Klitzing constant with a target uncertainty of 5×10^{-9} and to establish a primary ac impedance standard.		members of BIPM will visit PTB in October 2019 to learn about the implementation of the ac-QHR effect.
4.	Mass dissemination based on IPK	M-A1.1	1) Fabrication of 1 kg Platinum/Iridium prototypes for Member States (workshop) 2) Calibration of new 1 kg Pt/Ir prototypes.	<ul style="list-style-type: none"> • Prototype n° 110 has been delivered to China in December 2016. • Prototype n° 111 has been delivered to the Rep. of Korea in July 2017. • Prototype n° 107, attributed to Pakistan, waiting to be picked up, has been recalibrated. • An additional prototype, which is not yet allocated, is close to finalization. 	<ul style="list-style-type: none"> • The fabrication of prototype n° 112 is completed. • The fabrication of three more prototypes is under way.
		M-A1.2	1) Re-calibration of 1 kg Pt/Ir prototypes 2) Calibration of 1 kg stainless steel mass standards.	<ul style="list-style-type: none"> • Following the measurement procedure established after the Extraordinary Calibrations in 2014, the masses of the BIPM working standards in platinum-iridium for current use were re-determined in June 2017 with respect to the BIPM working standards for limited use. • Calibrations were carried out for Pt-Ir prototypes from KRISS (Rep. of Korea, 2 prototypes), UME (Turkey) and NPSL (Pakistan). • The measurement strategy was optimized by further reducing the number of weighings, to improve the integrity of the mass standards, while maintaining the same uncertainty as before. 	<ul style="list-style-type: none"> • The masses of the BIPM working standards in platinum-iridium for current use were re-determined in June 2017 with respect to the BIPM working standards for limited use. • Calibrations were carried out for a Pt-Ir prototype from BKFH (Hungary) and for stainless steel standards from LATU (Uruguay, 1 standard), KIM-LIPI (Indonesia, 3), EIM (Greece, 2), EMI (United Arab Emirates, 2), HMI (Croatia, 2), DMDM (Serbia, 1) and VSL (The Netherlands, 2). Fourteen certificates were issued for eight NMIs. • The BIPM has participated in the EURAMET.M.M-K4 comparison of calibrations of 1 kg stainless steel standards.
		M-A1.3	Traceability of the working standards to the BIPM ensemble of reference mass standards (M-A2).	<ul style="list-style-type: none"> • Not scheduled before the redefinition. 	<ul style="list-style-type: none"> • Not scheduled before the redefinition.

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		M-A1.4	Improved, highly-reproducible cleaning technique in air.	<ul style="list-style-type: none"> Not scheduled for 2017. 	<ul style="list-style-type: none"> Not scheduled for 2018.
		M-A6.1	Calibration of mass standards, including Si spheres, under vacuum, for the calibration service and for the BIPM key comparison of primary realizations (M-A4).	<ul style="list-style-type: none"> No requests for calibration under vacuum received. 	<ul style="list-style-type: none"> No requests for calibration under vacuum received.
		M-A6.2	Provision of water sorption artefacts in Pt/Ir to NMIs.	<ul style="list-style-type: none"> No request received from Member States. 	<ul style="list-style-type: none"> No request received from Member States.
		M-A7.1	1) Volume determination of newly fabricated prototypes (M-A1.1) 2) Volume determination of stainless steel standards as part of the mass calibration service (M-A1.2).	<ul style="list-style-type: none"> Mr Damien Bautista was seconded to the NPL (UK) in October 2016 for knowledge transfer by the NPL on the use of solid density standards, FC40 as transfer liquid, and the density measurement of silicon spheres. During his secondment Mr Bautista was also trained in the use of the M_{one} mass comparator for weighings in air and under vacuum. The upgrade of the hydrostatic balance to use silicon density standards and FC40 liquid is close to completion. The density of two samples from a new Pt-Ir ingot fabricated by Johnson Matthey was determined. The new ingot will serve for the fabrication of three new Pt-Ir 1 kg prototypes. 	<ul style="list-style-type: none"> The density and volume of the new prototype n° 112 was determined.
		M-A7.2	Centre of gravity determination of stainless steel standards with a knob, as part of the mass calibration service (M-A1.2).	<ul style="list-style-type: none"> No request during this period. 	<ul style="list-style-type: none"> One determination of the center of gravity of a national stainless steel standard was carried out.
		M-A7.3	Calibration of small masses for the determination of the sensitivity of the mass comparators.	<ul style="list-style-type: none"> No activity in 2017. 	<ul style="list-style-type: none"> The small masses for the determination of the sensitivity of the mass comparators have been re-calibrated.

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		M-A8.1	Calibration of mass standards for the watt balance, the Chemistry Department and the Ionizing Radiation Department.	<ul style="list-style-type: none"> A Pt-Ir mass and a stainless steel mass have been calibrated for use in the Kibble balance. 	<ul style="list-style-type: none"> A Pt-Ir 1 kg mass, a stainless steel 1 kg mass and a tungsten 500 g mass have been calibrated for use in the Kibble balance.
		M-A8.2	Calibration of pressure gauges for several BIPM departments (incl. Mass).	<ul style="list-style-type: none"> In November 2016 a calibration campaign was organized for the pressure gauges used in the Physical Metrology Department. A calibration campaign planned for summer 2017 had to be postponed due to technical problems with the pressure balance. 	<ul style="list-style-type: none"> In February and September 2018 two calibration campaigns were organized for the pressure gauges used in the department. A long standing issue with the pressure balance could be solved. It is functioning properly again.
5.	Ensemble of reference mass standards	M-A2.1	<ol style="list-style-type: none"> Characterization of the performance of the storage system Improvement of the storage conditions, based on results of M-A2.2 and M-A2.3. 	<ul style="list-style-type: none"> Main achievement: this year for the first time all the standards of the ensemble are stored in their final environments. The first development phase of the experiment is therefore completed. This marks the official start of the ensemble as a whole. Efforts are now devoted to the optimization of the data treatment to extract as many information as possible from all the collected data. 	<ul style="list-style-type: none"> The Argon gas flow was reduced by 20 %. The analysis of the gas analyzer data has been automated. The operation of the “black box” gas chromatography system has been integrated into the general experiment control software.
		M-A2.2	<ol style="list-style-type: none"> Mass comparison of standards within the ensemble Linking the average mass of the ensemble to values deduced from primary realizations Modelling of mass changes in-between calibrations against primary realizations. 	<ul style="list-style-type: none"> The yearly comparison of the elements of the ensemble among themselves has been postponed to the second half of 2017 due to staff availabilities. 	<ul style="list-style-type: none"> The planned annual calibration of the standards of the ensemble had to be postponed again due to the continued absence of a critical staff member of the mass laboratory.
		M-A2.3	Characterization of surface contamination of standards.	<ul style="list-style-type: none"> To be started 2018 	<ul style="list-style-type: none"> According to our experience gained during the last few years, the main issue limiting mass stability is usage-related wear, not contamination. The best way to ensure mass stability is to limit the

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					usage and to implement a hierarchical system of mass standards with different levels of usage. At the present state we do no longer envisage surface analysis of the standards of the Ensemble.
		M-A2.4	Provide a model to deduce mass change from surface analysis, in particular for Si spheres.	<ul style="list-style-type: none"> To be started 2019 	<ul style="list-style-type: none"> We have received a quasi-primary realization Si-sphere from the PTB on loan.
		M-A2.5	Understanding of the sensitivity of the mass of the standards of the ensemble to cleaning techniques. Development of cleaning procedures for the standards of the ensemble, adapted to the storage environments	<p>According to the present understanding, efforts in developing a cleaning procedure for reference standards of the BIPM ensemble that are stored under gas or vacuum will not be pursued.</p> <p>Experience with mass standards has shown that the process of cleaning and washing leads to mass losses that cannot be well predicted in advance. In addition, the cleaning disrupts the prior mass evolution behavior, which is very well predicted when no cleaning takes place. For these reasons, we have decided to monitor the mass evolution of the standards and to keep them in extremely clean environments to avoid having to clean them.</p>	<ul style="list-style-type: none"> See left column.
		M-A5.1	Absolute realization of the kg after the redefinition, within about 20 µg, based on surface characterization by ellipsometry of previously characterized Si-spheres (M-A2.4). Since the volume properties are assumed to be stable in time, this is equivalent to a repeated XRCd project.	<ul style="list-style-type: none"> To be started 2019 	<ul style="list-style-type: none"> Not to be started before the redefinition. Since we concentrate on the development of our Kibble balance, the relevance of this activity needs to be re-evaluated.

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6.	Watt balance	M-A3.1	<p>Fully operational watt balance at the level of several parts in 10^8. This requires:</p> <ol style="list-style-type: none"> 1) Analysis of alignment uncertainties and reduction at the level of about 1×10^{-8} 2) Study of the performance of the new interferometer 3) Measurement series to characterize the performance of the apparatus as a whole 4) Comparison of the conventional two-phase operation and the BIPM specific simultaneous operation to identify systematic errors 5) Study of vacuum operation 6) Continued improvement of the apparatus as a result of (2) to (5) with the objective to reach a target uncertainty of several parts in 10^8. 	<ul style="list-style-type: none"> • A new experimental set-up has been designed and assembled. The magnetic circuit has been re-aligned horizontally within $20 \mu\text{rad}$. The new set-up includes a suspension which is more stable and which facilitates the coil alignment as well as a stiffer mass loading and exchanger system allowing us to work with a mass standard up to 1 kg. • The refined experiment is fully operational in both air and vacuum. The apparatus is using a new bifilar coil which moves at a larger velocity of 1 mm/s. The data acquisition and synchronization scheme has been improved in order to suppress the dead time between measurements. Two PJVS systems were routinely used to calibration the DVMs. Several preliminary measurements were carried out in vacuum during the last months, using either the BIPM one-mode one-phase or the one-mode two-phase schemes. Preparations are also well advanced to operate following the classical two-phase approach. The preliminary measurements showed a day-to-day repeatability of several parts in 10^7. The type B uncertainty of a few parts in 10^7 is still limited by the alignment and the voltage measurement. • The self-attraction correction on the local gravitational acceleration due to the apparatus was evaluated using finite element analysis and the absolute gravity value at the test mass center was updated. The results were published in <i>Metrologia</i>. 	<ul style="list-style-type: none"> • A revised suspension was designed and installed in order to properly align each element of the upper suspension. The mass center of the middle support has been adjusted for the first time. The suspension was fully aligned according to a new alignment procedure. Consequently, the coil alignment is presently no longer a limiting factor of the apparatus. • Studies were conducted to evaluate additional alignment issues such as the determination of the parasitic vertical torque and the optical center adjustment. It was found that the adjustable optical mounts of the interferometer were not rigid enough. A novel interferometer mounted on a much more stable support is being designed. • A PJVS system is now routinely used reducing the type B and type A uncertainties on the current and the induced voltage measurements. • The S/N ratio of the weighing phase was improved by a factor of 100 thanks to the adoption of the new one-mode two-measurement-phase scheme. This scheme additionally allows working with a coil velocity ten times larger than before. The reliability of the operation of the apparatus in vacuum was further improved. A run of one week of the Planck constant measurements in vacuum was carried out this summer. The result was in agreement with the

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				<ul style="list-style-type: none"> The effect of the coil-current carrying was intensively studied by theoretical modelling and experimental investigation. The results of the study and the influence of the effect on the one-mode and two-mode Kibble balances were summarized in a paper published in Metrologia. A second paper is being submitted. 	CODATA 2017 value within the type B uncertainty of about 2×10^{-7} limited by the alignment stability of the interferometer beams.
		M-A3.2	1) Calibration of the angle of the mirrors on the watt balance coil to within about $100 \mu\text{ rad}$ 2) Improvement of the setup to reduce uncertainty to about $50 \mu\text{ rad}$.	<ul style="list-style-type: none"> This activity is no longer required since a novel procedure has been developed to directly align the magnetic circuit with an uncertainty of $25 \mu\text{ rad}$. 	<ul style="list-style-type: none"> See left column
		M-A3.3	Determination of the value of local gravitational acceleration (also included in the Time programme as T-A5.2).	<ul style="list-style-type: none"> Foreseen for 2018 / 2019. 	<ul style="list-style-type: none"> The value of local gravitational acceleration g obtained during the ICAG 2009 is still adequate at the present level of uncertainty of the Kibble balance. It has been decided that new measurements of g shall be made in collaboration with NMIs. A first volunteer has been identified.
		M-A3.4	Maintenance and improvement of two Josephson voltage standards.	<ul style="list-style-type: none"> The prototype bias source tested last year was developed into a complete 13-channel system and has been successfully assembled with the Josephson array and the radiofrequency source. This system will be used to measure the current through the watt balance coil. A second Josephson voltage standard, for the measurement of the induced voltage, was assembled and successfully tested. The Josephson array for this system was also provided by the NIST. 	<ul style="list-style-type: none"> The second Josephson voltage standard has been routinely used in direct opposition for the determination of the current and the induced voltage in early 2018. Only one system is required now as the balance operates the new one-mode two measurement phase scheme.

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		M-A3.5	Support for the watt balance in all issues related to electrical measurements.	<ul style="list-style-type: none"> The electronic boards for the final version of the bias source for the watt balance Josephson voltage standard have been designed and successfully tested. 	<ul style="list-style-type: none"> No support needed in this period.
7.	Comparisons of primary realizations of the new kilogram definition	M-A4.1	<ol style="list-style-type: none"> Pilot comparison of primary realizations of the new definition Transfer to and maintenance of the reference value by the BIPM ensemble of mass reference standards. 	<ul style="list-style-type: none"> The data analysis and the publication of the report on the CCM Pilot Study have been finalized according to schedule. The results were presented to the CCM in May 2017. Good agreement has been found between the four realizations with the smallest uncertainties (NIST, NMIJ, NRC, PTB). The result of the fifth participant (LNE) agrees with the others within the expanded ($k=2$) uncertainty. The weighted mean of calibration results traceable to the five realization experiments agrees within its uncertainty of 10 μg with results traceable to the IPK. A publication for <i>Metrologia</i> is under preparation. 	<ul style="list-style-type: none"> The comparison is completed. The results have been published in <i>Metrologia</i>.
		M-A4.2	<ol style="list-style-type: none"> Ongoing BIPM key comparison of primary realizations composed of bilateral exercises between individual primary realisations and the BIPM ensemble of mass reference standards Update of the average mass value attributed to the BIPM ensemble. 	<ul style="list-style-type: none"> Activity to start after the redefinition. 	<ul style="list-style-type: none"> Discussions on the organization of the first key comparison of kilogram realizations in late 2019 have started within the CCM WGR-kg.
8.	International Liaison and Coordination Activities	CM-A1	Provision of the CCM Executive Secretary, general support to the CC and WGs plus specifically support for: <ol style="list-style-type: none"> Two CCM meetings: Four annual meetings of CCM working groups 	<ul style="list-style-type: none"> Organization of the CCM meeting and the CCM Working Group meetings in May 2017. The CCM Executive Secretary coordinated the registration, follow-up and review of the final reports of a large number of comparisons. 	<ul style="list-style-type: none"> Coordination of the registration, follow-up and review of the final reports of a large number of comparisons. Attendance of EURAMET TCM meeting in Dublin and presentation of news from the BIPM.

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I Physical Metrology					
#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 – 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 – 30 Sept. 2018)
			3) Coordinate review of CC and RMO comparison reports before publication 4) Related liaisons with RMOs.	<ul style="list-style-type: none"> The CCM Executive Secretary was strongly involved in the major revision of the CCM strategy and in the CCM actions addressing the recommendations from the CIPM MRA working group. The BIPM took the lead on the publication of a paper on the future maintenance and dissemination of the kilogram, for the Metrologia Focus Issue on the kilogram redefinition. Attendance of EURAMET TCM meeting in Helsinki and presentation of news from the BIPM. Review of a large number of papers for the Metrologia Focus Issue on the kilogram redefinition. 	<ul style="list-style-type: none"> The CCM Executive Secretary and other members of the Department are involved in the definition of the strategy for the future mass dissemination through the “consensus value”, during the period when individual realizations will not yet be sufficiently in agreement. The CCM Executive Secretary was strongly involved in the finalization of the Draft <i>mise en pratique</i>, the revision of the KC report template and the finalization of the CCM guidelines for submission and review of CMCs.
		CE-A1.1	Provision of the CCEM Executive Secretary, general support to the CC and WGs plus specifically support for: 1) Two CCEM meetings 2) Four annual meetings of CCEM working groups (12 meetings) 3) Coordinate review of CC and RMO comparison reports before publication 4) Related liaisons with RMOs.	<ul style="list-style-type: none"> Organization of the CCEM meeting, CCEM working group meetings and a one-day workshop on future measurement challenges in electrical metrology in March 2017. The CCEM Executive Secretary was involved in the writing of the “100 words” statement from the CCEM for the joint CC statement on the revised SI, and of the CCEM Guidelines on how to implement the changes of the electrical units. The CCEM Executive Secretary coordinated the registration, follow-up and review of the final reports of a number of comparisons. Attendance of EURAMET TCEM meeting in Vienna and presentation of news from the BIPM. 	<ul style="list-style-type: none"> Coordination of the registration, follow-up and review of the final reports of a number of comparisons. Attendance of EURAMET TCEM meeting in Dubrovnik and presentation of news from the BIPM. Information on news from the BIPM and the CCEM provided to APMP TCEM. Finalization of the Draft <i>mise en pratique</i> for electrical units and the CCEM Guidelines on how to implement the changes of the electrical units. The CCEM Executive Secretary revised and updated the CCEM Guidelines on key comparisons and CMCs.

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I Physical Metrology					
#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 – 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 – 30 Sept. 2018)
		CU-A1.1	Provision of the CCU Executive Secretary, general support to the CCU. Participation in the elaboration of the 9th edition of the SI Brochure.	<ul style="list-style-type: none"> • Organization of the CCU meeting in September 2017 • Coordination and editing of the Draft 9th Brochure • Coordination and editing of the Joint CC Statement • Coordination of the work of the CIPM Task group on the promotion of the SI • Liaison activities between the CCU and the other CCs 	<ul style="list-style-type: none"> • Coordination and editing of the Draft 9th edition of the SI Brochure. • Coordination of the work of the CIPM Task group on the promotion of the SI. • Maintaining and updating the web site on the revised SI. • The CCU Executive Secretary was strongly involved in the development of the CCU strategy document. • Liaison activities between the CCU and the other CCs. • Liaison activities with ISO TC12 and TC25.

II Time Metrology					
#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 – 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 – 30 Sept. 2018)
1.	Computation of UTC-KC Time and frequency transfer	T-A1.1	<p>1) New and refined methods for clock comparison for application on existing and new techniques for the full exploitation of the time transfer systems.</p> <p>Benefits - redundancy of data, impacting on:</p> <p>(a) the reliability of the time links system;</p> <p>(b) improvement of the uncertainty and better traceability of UTC(k) to UTC and the SI second;</p> <p>(c) the characterization of clocks;</p> <p>(d) the ultimate impact is on the stability of the time scales.</p> <p>2) Distribution of data, results, comparisons to UTC participants and other relevant users.</p> <p>3) CCTF-K001.UTC, <i>Circular T (70 participants in 2013, 10 % increase expected).</i></p>	<ul style="list-style-type: none"> • Long-term comparisons of GNSS and TW time links ongoing. Available results have been presented at the PTTI 2017 meeting and published at the Proceedings of the PTTI2017. • The validation of the SDR progressed, Most TW operating laboratories have equipped with the SDR facility and the others are in preparation. Measurements performed at OP, PTB, ROA, INRIM, VNIIFTRI, TL, NICT, NIST, INRIM showed that the statistical uncertainty is significantly reduced on short baselines, and that the effect is less on long ones. Results have been presented at the PTTI 2017 meeting and published at the Proceedings of the PTTI2017. The project is ongoing. • The new algorithm for the computation of uncertainties of UTC-UTC(k) has been presented to the CCTF in June 2017, and agreement to its implementation has been given. The first step in the introduction of the new algorithm will be introduced in the computation of UTC of September 2017. • Within the cooperation between the Time Department and NIM, progress has been done since the arrival of Dr Liang Kun in February 2017. One remarkable step done is the operation at the BIPM of several multi-constellation NIM receivers at the BIPM, with the aim of studying the use of BeiDou satellites. With the coordination of Liang Kun, a BeiDou pilot experiment 	<ul style="list-style-type: none"> • The responsibility of the BIPM software to generate the UTC circular T and the data provided to CCTF-K001.UTC was handed over due to retirement. • In collaboration with NIM and thanks to a stage of Dr Liang Kun at the BIPM from February to Dec 2017, new Beidou receivers developed by NIM are under test at the BIPM and first results on the use of Beidou signals for the UTC time transfers have been obtained and published on Metrologia. • First tests on the use of the European GNSS Galileo for time transfer have also started and presented at the Euramet meeting in March 2018. • The use of the Software Defined Radio (SDR) Receiver in the TWSTFT techniques has been deeply evaluated in collaboration with the leading NMIs and the SDR baseline are now used as “alternative” (back up) solutions in the computation of UTC. The results appear on the link comparison regularly published on ftp://ftp2.bipm.org/pub/tai/timelinks/ Results were also presented at the 2018 PTTI meeting. • To support the further development of the SDR technique to allow for example calibration, transmission, and test on other codes, the BIPM with the CCTF Working Group on TWSTFT has created a platform running GitLab for a collaborative open source code

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II Time Metrology					
#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 – 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 – 30 Sept. 2018)
				started with the partnership of laboratories in Asia, Europe and US.	development. A task group has been created to validate the different versions of the software and provide to NMIs a convenient and safe way for its download.
2.	Algorithms	T-A1.2	<ol style="list-style-type: none"> 1) Improved frequency stability and accuracy. Target is improving both the present frequency stability (3×10^{-16}) and frequency accuracy (few parts in 10^{16}) by a factor of two. 2) Larger data and results distribution. 3) Generation of a time scale for scientific applications requiring long-term stability and higher accuracy (yearly TT(BIPM)). 	<ul style="list-style-type: none"> • TT(BIPM2016) has been computed and published in January 2017 (http://www.bipm.org/en/bipm-services/timescales/time-ftp/ttbipm.html); • The new algorithm for the uncertainties of UTC-UTC(k) has been validated and presented to the CCTF in June 2017. An article is in preparation. 	<ul style="list-style-type: none"> • TT(BIPM2017) has been computed and published in the FTP server. • The Time dept annual report has also been produced and published in https://www.bipm.org/en/bipm/tai/annual-report.html with some novelties with respect to the previous years. Most of the data are available on the Time Dept data base and FTP server allowing to retrieve data and plots. • The change in the drift estimation allowing a better stability of EAL has been introduced
3.	Rapid UTC	T-A1.3	<ol style="list-style-type: none"> 1) Publication of UTCr, rapid UTC providing weekly access to a UTC Rapid solution for better synchronization of local realizations of UTC(k) in contributing laboratories. (40 participants in 2013, 100 % increase expected over the programme). 	<ul style="list-style-type: none"> • UTCr has been published without interruption every Wednesday; • A number of laboratories steer the UTC(k) using UTCr as reference; • The number of laboratories participating to UTCr is 53. • The algorithm of computation of UTCr has been updated and modifications have been introduced (clock weighting procedure, for ex.), for correcting the increasing offset wrt UTC. Since July 2017 the offset remains in average smaller than 3 ns. 	<ul style="list-style-type: none"> • UTCr has been published without interruption every Wednesdays (once on Thursday due to black out). • The number of laboratories participating to UTCr is 57. • Offset to UTC within +/- 2 ns since July 2017.
4.	Calibration campaigns for UTC	T-A2.1	<ol style="list-style-type: none"> 1) Characterization of equipment compatible with those operated in NMIs. 	<ul style="list-style-type: none"> • The set of BIPM receivers has been monitored in permanence, to assure their stability; 	<ul style="list-style-type: none"> • The set of BIPM receivers has been monitored to assure their stability. • A new commercial GNSS receiver has been tested for one month thanks to a

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#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 – 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 – 30 Sept. 2018)
			2) Reliable/redundant travelling and fixed-reference standards. 3) Guidance documents and support for contributing NMIs. 4) Technical protocols for calibration. 5) Methods of calibration aimed at improving the time link uncertainty. The target is improving the present 5 ns value of the Type B uncertainty by a factor of at least 2.		loan from the manufacturing company. The same type of receiver has then been purchased and installed in the time lab. It is now under characterization for future use in the calibration campaign. <ul style="list-style-type: none"> • A new measurement set up has been installed in the lab generating the BIPM Time and Frequency reference (BTFR) signal. This reference signal is continuously monitored in stability and accuracy and it is distributed to the other BIPM labs.
5.	Calibration campaigns for UTC	T-A2.2	Typically two characterization campaigns (requiring the sending of BIPM travelling system without staff) to each of approximately 15 contributing laboratories (G1 labs) during the programme. 1) Provision of Guidelines for the calibrations organized by the RMOs. 2) Regular assessment of the the calibrations by the RMOs and their link to the UTC system for for approximately 60 contributing laboratories. 3) Generating Input data for time links used in CCTF-K001.UTC, BIPM <i>Circular T</i> and rapid UTC.	<ul style="list-style-type: none"> • Calibration campaigns have been implemented by the BIPM at APMP (NIM, NICT, TL) between; at EURAMET between, ongoing at the moment of the report at SIM (NIST, USNO) and under organization at COOMET (SU). • RMOs calibrations campaigns have been reported by APMP and EURAMET and linked to Circular T covering 13 laboratories. <ul style="list-style-type: none"> • Updated information is available at http://www.bipm.org/jsp/en/TimeCalibrations.jsp. 	<ul style="list-style-type: none"> • Two new GNSS calibration campaigns have started. The first one by sending a GNSS Receiver to Russia, the measurement are still in progress. The second campaign visited 3 Group 1 labs in Asia and the receiver has arrived to the BIPM in Sept 2018. A calibration report is expected in the next month. • RMOs calibrations campaigns have been reported by APMP, EURAMET and SIM, covering 13 laboratories.

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#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 – 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 – 30 Sept. 2018)
6.	Very accurate standards and transfer techniques	T-A3	<ol style="list-style-type: none"> 1) Comparison of optical standards with $\sim 10^{-18}$ relative uncertainty over short and long baselines 2) Contributing to the discussion on the redefinition of the second (2018 onwards). 	<ul style="list-style-type: none"> • The method for evaluation of optical clock uncertainties by Robertsson has been used for the computation of entries to the updated list of recommended frequencies for the practical realization of the metre and secondary realizations of the second, as part of the work provided for the CCTF in the first half of 2017. 	<ul style="list-style-type: none"> • The BIPM method for evaluating frequency ratio has been handed over to a new physicist due to retirement. • Different methods to compare optical frequency standards to the SI unit, also for not NMI labs have been studied and presented at the EFTF 2018.
			<ol style="list-style-type: none"> 1) Evaluation of the use of microwave links as a possible candidate for future high level optical clock comparisons based on a comparison of Space-Earth and Earth-Earth Comparison of atomic clocks. 2) Comparison of optical standards with $\sim 10^{-18}$ fractional uncertainty over short and long baselines. 3) Improved time link accuracy. 	<ul style="list-style-type: none"> • Work started on the implementation of IPPP for time transfer on the post-doctoral activity of Julia Leute, in cooperation with the CNRS and Paris Observatory. 	<ul style="list-style-type: none"> • The activity on IPPP in collaboration with Julia Leute has given several results that were presented at the EFTF 2018 and are still in progress. • The BIPM has started working in the Working Group for the exploitation of the ACES experiment on the ISS with the aim of studying high accuracy microwave link.
7.	International Liaison and Coordination Activities	CT-A1.1	<ol style="list-style-type: none"> 1) TAI/UTC/TT(BIPM)/ maintenance 2) GNSS/TW/other time transfer systems and coordination 3) Support to GNSS system times 4) Provision of the Executive Secretary, general support to the CC and WGs and liaison with RMOs for: <ul style="list-style-type: none"> - CCTF - CCL - CCAUV 	<ul style="list-style-type: none"> • Interaction with URSI for the organization of the scientific meetings at the URSI General Assembly and Scientific Symposia (August 2017); • Interaction with the IAU, IUGG and URSI for the provision of time scales definitions to the CCTF; • Interaction with the ITU-R on issues relating to the dissemination and realization of UTC, including a possible redefinition; • Supporting GNSS system times, work started for the computation of offsets between UTC and BeiDou System Time (BST) in view to publication by the BIPM; 	<ul style="list-style-type: none"> • Interaction with URSI for the organization of the sessions on time metrology at the AT RASC in May 2018 (Gran Canaria). • Contribution to the ICG in a workshop devoted to GNSS time scales and interoperability, June 2018, Vienna. • Support to the organization of the CCL and related working group meetings in June 2018 by providing executive secretary. • Publication of Guidelines of the CCTF WG on MRA.

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II Time Metrology					
#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 - 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 - 30 Sept. 2018)
				<p>Organization and participation to the 21st meeting of the CCTF and its Working Groups (May-June 2017)</p> <p>The CCAUV meeting was organized (19-22 September 2017) along with the associated Working and Task Groups:</p> <p>CCAUV strategic plan has been updated and published on the website. Agreement for the revision of List of Services. Recommendation to the CIPM concerning the MRA revision. CCs' and RMOs' comparison reports were reviewed and published in the KCDB.</p>	<ul style="list-style-type: none"> • Support to the activity of CCAUV (updated List of Services). • Organization of a CBKT course on "Effective participation in UTC" for 24 new time laboratories in collaboration with GNSS Receiver manufacturers, METAS (sponsor), and PTB in Feb 2018. About 48 applications received.

III Chemical Metrology					
#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 – 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 – 30 Sept. 2018)
1.	International equivalence of gas standards for air quality and climate change monitoring	C-A1.1	<ol style="list-style-type: none"> 1) Bilateral comparisons as part of BIPM.QM-K1 coordination (2016-2019). <i>NMI participations: 20</i> 2) Comparison with independent methods for system stability verification and accuracy improvement. Improvement of global system performance. 3) Coordination of CCQM-K137 (NO in Nitrogen). <i>NMI participations: 30</i> 	<ul style="list-style-type: none"> • Paper published: Ozone cross-section measurement by gas phase titration, <i>Analytical Chemistry, 2016, 88(21), 10720-10727</i> • BIPM.QM-K1: Measurements of ozone standards with VSL, NPL, ISCIII, INE, NIST and CHMI completed; 2 comparison reports (with VSL and ISCIII) published in the KCDB • First set of measurements for CCQM-K137 (NO in nitrogen) completed at BIPM on 24 submitted standards from 12 NMIs • Prototype electronics module (EM2017) for Ozone SRP completed and tested at the BIPM; electronics and components design for production version (EM2018) and supporting software agreed with NIST. • Review of ozone absorption cross section papers completed with CCQM GAWG Task Group and first draft of paper with combined value and uncertainty prepared 	<ul style="list-style-type: none"> • Paper published: Comparisons of gas standards for climate change and air quality monitoring, 2018, <i>Metrology: from Physics Fundamentals to Quality of Life, 196, 89.</i> • BIPM.QM-K1: 3 Comparisons of ozone standards with FMI, NPLI and NILU completed; 4 comparison reports (with NIST, NPL, CMS-ITRI and INE) published in the KCDB. • 1 ozone calibration performed: NILU. • CCQM-K137 measurements completed, with 24 NMI participations, results analyzed and Draft A report distributed to participants . • Hardware of production version of the new Ozone SRP (EM2018) validated, with supporting software in development at NIST. • Final version of review of ozone absorption cross section paper completed with all comments from members of the CCQM GAWG Task Group. Paper in review in NIST editorial process.
2.		C-A1.2	<ol style="list-style-type: none"> 1) Coordination of CCQM-K74-repeat on Nitrogen Dioxide standards (2017) and PS on Spectroscopy. <i>NMI participations: 15</i> 2) Maintenance and development of a HCHO facility for future CCQM-K90-Repeats. 	<ul style="list-style-type: none"> • Metrology for Clean Air CBKT programme on FTIR operation completed by visiting scientist from CENAM (2 of 6 month period), and started by visiting scientist from NPLI, NPL and LNE (1 month of 3 and 6 month periods respectively). BIPM's B-FOS software for FTIR operation and spectra analysis made available to participating NMIs. 	<ul style="list-style-type: none"> • Metrology for Clean Air CBKT programme on FTIR operation: training completed for visiting scientists from NPLI (5 months), NPL and LNE (3 months), NMISA (6 months), and INRIM (2 months). Training started for a visiting scientist from KazInMetr (1 month). • CCQM-K74 (NO₂ in nitrogen) and associated CCQM-P72 (HNO₃ by

III Chemical Metrology					
#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 – 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 – 30 Sept. 2018)
				<ul style="list-style-type: none"> CCQM-K90 (HCHO in nitrogen) final report completed and published, <i>Metrologia</i>, 2017, 54, Tech. Suppl., 08029 	<p>spectroscopy): two facilities re-started and validated, allowing 33 NMI participations (2 months of 6 months of measurements completed).</p>
3.		C-A1.3	<ol style="list-style-type: none"> Key comparison on Carbon dioxide and maintenance of Methane facility (CCQM-K120). <i>NMI participations: 20</i> Developed methods with reduced uncertainties for greenhouse gas comparisons. Coordination of CCQM-K68.2018 Nitrous Oxide, development of facility and comparison on air greenhouse gas standards. <i>NMI participations: 10</i> 	<ul style="list-style-type: none"> CCQM-K120.a and .b (CO₂ in air) measurements completed on 46 standards from NMIs (comparison of standards by FTIR and GC-FID with isotope ratio measurements with IRIS and oxygen mole fraction in balance gas measurements) 9th months of 12 month secondment of C. Meyer (NIST) completed on CO₂ PVT system, with results from Mark I prototype (glass) submitted to pilot study run in parallel to CCQM-K120.a&b. Mark II prototype (surface coated steel) installed and initial validation measurements completed, Paper published: Calibration strategies for FT-IR and other isotope ratio infrared spectrometer instruments for accurate δ¹³C and δ¹⁸O measurements of CO₂ in air, <i>Anal. Chem.</i>, 2017, 89(6), 3648-3655 6 month secondment T. Zhang (NIM) completed on CO₂ Stable Isotope Reference Mixture Generator validation, covering FTIR operation and measurements of isotope ratios in pure CO₂ by FTIR 3 month secondment J-S Lim (KRISS) completed, validating operating characteristics for laser trace gas monitor for N₂O in air in preparation for CCQM-K68.2019 	<ul style="list-style-type: none"> Paper published: SI traceability and scales for underpinning atmospheric monitoring of greenhouse gases, 2018 <i>Metrologia</i>, 55, S174. CCQM-K120.a and .b (CO₂ in air): special session organized by BIPM during CCQM GAWG April 2018 meeting to discuss results. Draft B report reviewed and final report distributed to GAWG members before publication. 6 additional months of secondment of C. Meyer (NIST) completed on CO₂ PVT system, during which the Mark II system (surface coated steel) was validated and a method developed, allowing further successful comparison with CCQM-K120 via standards from NOAA and NPL. 4 months secondment F. Rolle (INRIM) completed on CO₂ Stable Isotope Reference Mixture Generator validation, during which a method to measure isotope ratios in pure CO₂ with the Isotope Ratio Infrared Spectrometer was developed and validated, and aliquots of CO₂ with different isotopic ratios prepared and sent to IAEA for value assignment by Isotope Ratio Mass Spectrometry. Development of best method to compare N₂O in air standards by Gas

III Chemical Metrology					
#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 – 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 – 30 Sept. 2018)
					Chromatography with Electron Capture Detector started in July 2018.
4.	International equivalence of organic primary calibrators for Clinical Chemistry and Laboratory Medicine, Food Analysis, Environmental analysis, Forensics and Pharma	C-A2.1	<p>1) Method for characterization coordination of CCQM-K55.c.1 repeat (polar organic (300 Da to 500 Da) (2019). <i>NMI participations: 30</i></p> <p>2) Coordination CCQM-K55.a.1 repeat (non-polar organic (100 Da to 300 Da) (2017) and CCQM-K55.d <i>NMI participations: 30</i></p> <p>3) Developed and published spectroscopic methods for purity comparisons.</p>	<ul style="list-style-type: none"> Final report of CCQM-K55.d (Folic acid purity) completed and submitted for approval to OAWG September 2017 meeting. Measurements completed and results submitted for CCQM-P150.b (Organic purity by qNMR) CCQM-K148.a (formerly CCQM-K55.a.1 material (Bisphenol A): BIPM Characterization of related structure impurities and homogeneity and stability studies completed 2nd Draft of IUPAC paper on Small Organic Purity Methods prepared and circulated for comment to drafting group Characterization of 4 qNMR universal calibrator materials in 3 solvents completed during 5 months of 6 month secondment of B. Garrido (INMETRO) 6 month secondment of T. Yamazaki (NMIJ) Final draft of qNMR Internal Standard Reference Data document for Maleic Acid completed and under internal review prior to publication 	<ul style="list-style-type: none"> Final report of CCQM-K55.d (Folic acid purity) published in KCDB April 2018. Final report of CCQM-P117.d (Folic acid purity) published in OAWG working documents September 2018 . CCQM-K148.a (formerly CCQM-K55.a.1 material (Bisphenol A): BIPM value assignment of samples completed and call for participation issued to the OAWG. Proposals on the choice of the comparison material for CCQM-K148.b (purity of high polarity, low molecular weight compounds) developed for discussion within the OAWG. Internal review of IUPAC Technical Report on Small Organic Purity Methods completed and prepared for submission for IUPAC review. Final studies for the characterization of 7 qNMR universal calibrator materials in remaining 3 solvents completed during 3 month secondment of W. Zhang (NIM). qNMR Internal Standard Reference Data documents for Maleic Acid, Dimethyl Sulfone and Potassium Hydrogen Phthalate published online as , , BIPM Rappports 2018/01, 2018/04 and 2018/05, respectively. Presentation given as invited speakers at qNMR conferences in September 2017 (SMASH 2017 in Baveno, Italy) and

III Chemical Metrology					
#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 – 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 – 30 Sept. 2018)
					January 2018 (qNMR Summit 2018 in Tokyo, Japan).
5.		C-A2.2	<ol style="list-style-type: none"> 1) Key Comparison on calibration solution solutions CCQM-K78.a (multi-component polar). <i>NMI participations: 30</i> 2) Preparation for repeat calibration solution key comparison CCQM-K78.b (multi-component non-polar) (2020). 	<ul style="list-style-type: none"> • CCQM-K78.a samples (multicomponent amino acid solutions) distributed with 17 NMI participations; measurements completed; and results presented to OAWG (April 2017) meeting. Draft report in preparation. 	<ul style="list-style-type: none"> • The Draft B report of CCQM-K78.a (multicomponent amino acid solutions) prepared and the KCRV and KCRU for each component amino acid agreed by the OAWG. The draft Final Report of CCQM-K78.a circulated to the OAWG. • Proposals on the choice of the format and makeup of the CCQM-K78.b (multi-component non-polar solution) comparison prepared for discussion with OAWG. • Paper published: Chemical primary reference materials: From valine to C-peptide. Metrology: from Physics Fundamentals to Quality of Life 196, 121.
6.		C-A2.3	<ol style="list-style-type: none"> 1) Developed and published methods for the characterization of large molecule primary calibrators. 2) Completion of purity key comparison CCQM-K115 (2015) C-peptide purity (1 kDa to 5 kDa). <i>NMI participations: 16</i> 3) Coordination of CCQM-115.b Primary organic calibrator (5 kDa to 10 kDa) large organic molecule primary calibrator comparison. <i>NMI participations: 16</i> 	<ul style="list-style-type: none"> • CCQM-K115 final report published: Key comparison study on peptide purity-synthetic human C-peptide, Metrologia, 2017, 54, Tech. Suppl., 08007 • CCQM-P55.2 report published: Pilot study CCQM-P55.2 on peptide purity – synthetic human C-peptide, Metrologia, 2017, 54, Tech. Suppl., 08011 • CCQM-K115.b/P55.2.b (Oxytocin purity) material characterization ongoing; first phase of peptide impurity identification and quantification completed (5 of 14 month secondment of M. Li (NIM); qNMR measurements completed; TGA and DVS measurements completed; KFT measurements on-going; homogeneity 	<ul style="list-style-type: none"> • CCQM-K115.b/P55.2.b (Oxytocin purity) material characterization finalized; peptide impurity identification and quantification completed (14 month secondment of M. Li (NIM)); study protocol agreed, study samples sent out and comparison started, with 12 NMI participations. • CCQM-K115.c/P55.2.c (HbA1c hexapeptide (GE) purity) material characterization started; homogeneity studies and stability studies on-going. • CCQM-K115.2018/P55.2.2018 (HbA0 hexapeptide (VE) purity) material characterization started; homogeneity studies and stability studies on-going.

III Chemical Metrology					
#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 – 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 – 30 Sept. 2018)
				<p>studies completed and stability studies on-going.</p> <ul style="list-style-type: none"> • Paper published: Impurity determination for hepcidin by liquid chromatography - high resolution and ion mobility mass spectrometry for the value assignment of candidate primary calibrators, <i>Anal. Bioanal. Chem.</i>, 2017, 409(10), 2559-2567 • Paper accepted for publication in <i>Trends in Analytical Chemistry</i>, 'State-of-the-art and Trends for the SI Traceable Value Assignment of the Purity of Peptides Using the Model Compound Angiotensin I' • Paper published: Concept paper on SI value assignment of purity - Model for the classification of peptide/protein purity determinations, <i>Journal of Chemical Metrology; Gebze11.1 (2017): 1-8.</i> • Paper published: "Implementing a reference measurement system for C-peptide: successes and lessons learned." <i>Clinical Chemistry</i> 63.9 (2017): 1447-1456. • Method development on purity determination of peptides with MW (1 kDa to 5 kDa) and 1 cross link undertaken on BNP during 3 month secondment of F. Torma (LGC) • Method development on purity determination of short linear peptides MW (1 kDa to 5 kDa) undertaken on BNP during 1st month of 3 month secondment of M. Fang (NIBSC) 	<ul style="list-style-type: none"> • Paper published: Identification and accurate quantification of structurally-related peptide impurities in synthetic human C-peptide by liquid chromatography-high resolution mass spectrometry, <i>Anal. Bioanal. Chem.</i> 410 (2018) 20, 5059-5070. • Paper published: State-of-the-art and Trends for the SI Traceable Value Assignment of the Purity of Peptides Using the Model Compound Angiotensin I, <i>Trends Anal. Chem.</i> 101 (2018) 108-119. • Review paper drafted for <i>Metrologia</i> Focus on Advances in Metrology in Chemistry and Biology on the Establishment of measurement traceability for peptide/protein quantification through rigorous assessment of peptide/protein purity. • Method development progressed on purity determination of short linear peptides MW (1 kDa to 5 kDa) with and without modification undertaken on HbA1c and HbA0 hexapeptides during 6 of 9 months secondment of J. Nammoonnoy (NIMT).
7.	International Liaison and	CQM-A1.1	Provision of the CCQM Executive Secretary. Support for: 1) Four CCQM Plenary Meetings	<ul style="list-style-type: none"> • Organization and Support for CCQM plenary session meeting held at the BIPM 21-22 April 2017 	<ul style="list-style-type: none"> • Organization and Support for CCQM plenary session meeting held at the BIPM 19-20 April 2018.

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III Chemical Metrology					
#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 – 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 – 30 Sept. 2018)
	Coordination Activities		<p>2) Nine CCQM working groups (36 Meetings)</p> <p>3) Participate in the pool of experts reviewing CC and RMO comparison and pilot study reports before publication</p> <p>4) Development of strategic plans</p> <p>5) Related liaisons with RMOs.</p> <p>Provision of the CCPR Executive Secretary, general support to the CC and WGs plus specifically support for:</p> <p>1) Two CCPR meetings</p> <p>2) Four annual meetings of CCPR working groups (12 meetings)</p> <p>3) Related liaison with International Commission on Illumination (CIE) and RMOs.</p> <p>4) Coordinate review of CC and RMO comparison reports before publication.</p> <p>5) Related liaisons with RMOs.</p>	<ul style="list-style-type: none"> • Organization and support of 10 CCQM Working Group meetings held at the BIPM (April 2017) • Organization of Workshop on CCQM Strategy (20 April 2017) • Drafted of updated CCQM 2017-2016 strategy document, based on input from CCQM WGs and CCQM. Final draft out for comment and publication foreseen in November 2017. • Reviewed and commented on the CCPR strategy document, with final draft expected before July 2018. • Provide support and presentations for APMP Focus Group meeting on Climate Change and APMP/APEC meetings on Contaminants in Grain 	<ul style="list-style-type: none"> • Organization and support of 10 CCQM Working Group meetings held at the BIPM (April 2018). • Finalized and published the updated CCQM 2017-2016 strategy document, in January 2018. • Provided support and input into the Isotope ratio Task group meeting and proposal to establish a new WG in CCQM. • Organization and Support for 3 CCPR Working Groups meetings held at the BIPM 2-4 July 2018. • Organized focus on issue in Metrologia on Advances in Metrology in Chemistry and Biology, and call for abstracts for April 2019 Workshop. • CCPR strategy document for 2017-2026 published in July 2018. • Provided support for CCPR communication to CGPM 2018 (poster and president’s report). • Provided a Technical Assessor in an ISO 34 reaccreditation assessment of Tubitak UME by Turkak (20 January 2018) and an ISO 17034 accreditation assessment of NMIA for pure substance reference material production by NATA (10 May 2018). • Sent BIPM representative to NPL Reproducibility Workshop (1 May 2018)

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#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 – 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 – 30 Sept. 2018)
		CQM-A1.2	Support for: 1) JCTLM Executive and WGs (eight meetings) 2) JCTLM Database entry/nomination review process Maintenance of JCTLM Database.	<ul style="list-style-type: none"> • Rapporteur for the 17th and 18th Executive Committee meetings; reports drafted and 17th published. • Supported new JCTLM TEP WG and organization of JCTLM ‘Accurate Results for Patient care Workshop’ (December 2017) and supporting leaflets. • Organized and launched the JCTLM database 2017 call for nominations, resulting in 80 nominations reviewed by the BIPM, before distribution to review teams. Published 22 new entries into the JCTLM Database. • Updated 26 JCTLM procedures. Edited and published the fourth issue of the JCTLM Database Newsletter. 	<ul style="list-style-type: none"> • Rapporteur for the 19th Executive Committee meeting; report drafted and published. • Supported and ran the 2017 JCTLM Stakeholder’s workshop with 117 participants (December 2017). • Supported new JCTLM TEP WG; organized JCTLM-ICSH meeting. • Organized and launched the JCTLM database 2018 call for nominations, resulting in 141 nominations reviewed by the BIPM, before distribution to review teams. Published 26 new entries into the JCTLM Database. • Performed review of JCTLM and CIPM-MRA processed for CRMs as well as options for treating nominations dealing with replacement CRMs. • Edited and published the fifth issue of the JCTLM Database Newsletter.
		CQM-A1.3	Liaison activities with: IUPAC; ISO TC 212, IFCC, WMO, WHO, WADA, Codex, ISO TC 146.	<ul style="list-style-type: none"> • Paper published: Metrological challenges for measurements of key climatological observables: oceanic salinity and pH, and atmospheric humidity. Part 1: overview, Metrologia, 2016, 53(1), R1-R11 • Preliminary organizational work with NIM started for a Protein and Peptide Therapeutics and Diagnostics Workshop in Chengdu (China) in 2018 • Published report of WADA-BIPM Workshop (Report on the BIPM-WADA Workshop: Standards and Metrology in support of Anti-Doping Analysis, Rapport BIPM-2016/01, 11 pp) and supported 	<ul style="list-style-type: none"> • Provided organizational support for the PPTD-2018 meeting to be held in Chengdu China in October 2018. • Provided liaison to WADA’s Laboratory Expert Group providing expert review of EQAS results. • Provided a Member of JCTLM WG1 Drugs Review team. • Provide liaison to the Meeting of International Organizations working in the field of Methods of Analysis and Sampling (Inter Agency Meeting) prior to Codex CCMAS.

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III Chemical Metrology					
#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 – 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 – 30 Sept. 2018)
				<p>follow on work in identifying priority list of CRMs to support anti-doping analyses</p> <ul style="list-style-type: none"> • Provided liaison to WADA’s laboratory expert group providing expert review of EQAS results • Provided liaison to ISO TC 212 WG2 leading the drafting of ISO 15195 (Calibration Laboratories in Laboratory Medicine) and input into the drafting group of ISO 17511 (Metrological Traceability in Laboratory Medicine) • Provided liaison to ISO REMCO and joint WG with CASCO JWG 43 and input into the drafting of ISO 17034 (Reference Material Producers) • Provided liaison and technical input into IAEA and WMO meetings on VOCs (WMO Expert Group) and Greenhouse gases and isotope ratio standards for CO₂ (IAEA technical meeting and GGMT-2017) • Provided liaison to the WHO Expert Committee on Biological Standardization meeting. • Provide liaison to the Meeting of International Organizations working in the field of Methods of Analysis and Sampling (Inter Agency Meeting) prior to Codex CCMAS 	<ul style="list-style-type: none"> • Provided liaison to ISO TC 212 WG2 progressing ISO 15195 to FDIS stage and ISO 17511 to a committee draft. • Contribution to SIM Mycotoxin Metrology Workshop 17-19 September 2018, and support of planning of future SIM activities in the field. • Provided keynote lectures at the 17th Beijing Analysis Conference and Exhibition and APEC workshop on Capacity Building of Measurement Standards and Technologies in Grain Food Safety. Beijing, (China), 9-13 October.
8.	CBKT	C-A2.4	<ol style="list-style-type: none"> 1) Mycotoxin CBKT Phase 1 (AFB1 and ZON) 2) Mycotoxin CBKT Phase 2 (PAT and DON) 	<ul style="list-style-type: none"> • Provided support to NMISA and NIM in the organization of a Workshop on Standards and Methods of Analysis for Mycotoxins 4-8 June 2018 in South Africa • Organized 2nd Mycotoxin Metrology meeting 15 April 2017 attended by 8 Organizations and drafted follow up action plan 	<ul style="list-style-type: none"> • Training secondments (3 months each) on mycotoxin methods by Visiting Scientists from TUBITAK/UME and NMISA (April to June 2018). • 10 months of 12 months secondment of Z. Guo (NIM) completed on development of characterization

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#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 - 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 - 30 Sept. 2018)
				<ul style="list-style-type: none"> • Training secondments (3 month each) on Mycotoxin Calibration solution preparation and value assignment undertaken by Visiting Scientists from INTI and INMETRO (February to April 2017) and KEBS, NMISA and NMIT (May to June 2017) • 12 month secondment of XQ.Li (NIM) and 8 of 12 month secondment of X.M. Li (NIM) completed on development of characterization methods for AfB1 and ZON mycotoxin pure materials and training of secondees • Training plan for 2018 visiting scientists developed for non-structure related mass balance methods • qNMR measurements on ZEN, and preliminary measurements on PAT and DON undertaken (Secondment of B. Garrido (INMETRO) and 1 month of 3 month secondment of I. Un (UME)) 	<p>methods for DON mycotoxin pure materials and training of secondees.</p> <ul style="list-style-type: none"> • 1 month of 3 months secondment of T. Gokcen (UME/TUBITAK) completed on development of characterization methods for PAT mycotoxin pure materials. • Paper published: Mycotoxin metrology: Gravimetric production of zearalenone calibration solution, J. Phys. Conf. Ser. 975 (2018) 012014. • Supported the organization and provided an invited lecture at the Workshop on Standards and Methods of Analysis for Mycotoxins 4-8 June 2018 in South Africa. • Training secondments (3 month each) on Impurity Characterization of Mycotoxins and value assignment provided for Visiting Scientists from UME and NMISA (April to June 2018). • qNMR measurements on PAT and DON completed during 2nd and 3rd month of 3 month secondment of I. Un (UME)).

IV Ionizing Radiation Metrology					
#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 – 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 – 30 Sept. 2018)
1.	X-ray standards dosimetry	IR-A1.1	<p>1) Maintaining the BIPM primary standards for:</p> <ul style="list-style-type: none"> - air kerma in low- and medium-energy x-rays, - absorbed-dose to water in medium-energy x-rays developed in 2013-2015 (4 qualities), - air kerma for mammography (4 qualities). <p>2) Providing bilateral key comparisons BIPM.RI(I)-K2, -K3, -K7, on request.</p> <p>3) Calibration and characterization of NMIs standards for x-rays (C2, C3, C7), on request.</p> <p>4) Replacement of the HV generator for low-energy x-rays.</p>	<ul style="list-style-type: none"> • This year has seen a significant improvement in the traceability chain for patient dosimetry in radiotherapy: a new absorbed dose to water standard has been developed for medium-energy x-rays. The new standard is very stable, easier to implement than calorimetry and measurement uncertainties have been reduced from $\pm 2-3\%$ to $\pm 0.7\%$ compared to previous techniques based on air kerma. The first comparison using the standard has been carried out with the PTB and the approach was approved by the CCRI in June 2017. • The refurbishment of the laboratory and control room (R6) has been completed, and the instrument control and data acquisition system re-validated. • New software has been developed to control the HV generator for low-energy x-rays. • The HV generators continue to work well but are obsolete so cannot be repaired in the event of a breakdown. Quotations are being sought for replacements. • Improvements have been made to the HV divider for medium-energy X-rays and the system is now stable. • The following comparisons were carried out during the year: BIPM.RI(I)-K2 (KRISS), -K3 (KRISS, NIM) & -K7 (KRISS). • Eleven calibrations were carried out for the NMIs and the IAEA. 	<ul style="list-style-type: none"> • The following comparisons were carried out during the year: BIPM.RI(I)-K2 for the NPL (UK), the NRC (Canada) and the NIM (China), BIPM.RI(I)-K3 for the NPL (UK) & BIPM.RI(I)-K7 for the NRC (Canada) and the NIM (China). • Seven calibrations were also completed for CRRD and the IAEA. • Maintenance and quality control checks have been completed to plan. • Paper published in <i>Metrologia</i> on the implementation of the recommendations of ICRU Report 90 for the BIPM x- and gamma-ray standards. • A successful external audit was conducted of dosimetry services.

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#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 – 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 – 30 Sept. 2018)
2.	γ-ray standards dosimetry	IR-A1.2	<ol style="list-style-type: none"> 1) Maintaining the BIPM primary standards for: <ul style="list-style-type: none"> - air kerma in ⁶⁰Co and ¹³⁷Cs beams for radiotherapy and radioprotection, respectively (BIPM.RI(I)-K1, K5), - absorbed dose to water in ⁶⁰Co beam (radiotherapy, BIPM.RI(I)-K4), - providing reference to the graphite calorimeter standard for absorbed dose to water in high-energy beams (BIPM.RI(I)-K6). 2) Providing bilateral key comparisons BIPM.RI(I)-K1, -K4, -K5, on request. 3) Characterization and calibration of national standards (C1, C4, C5), on request. 4) Replacement of the ⁶⁰Co source in 2017. 	<ul style="list-style-type: none"> • New software has been developed and implemented to control the test chamber positioning system. • The following comparisons were carried out during the year: BIPM.RI(I)-K1 (SCK, SMU) & -K5 (SMU). • A total of 25 calibrations were carried out for the IAEA and NMIs. • BIPM radiological protection instrumentation was calibrated. • A long term strategy is being developed for the replacement of sealed sources including the ⁶⁰Co source. 	<ul style="list-style-type: none"> • The following comparisons were carried out during the year: BIPM.RI(I)-K1 for the NPL (UK) and the -VSL (Netherlands), BIPM.RI(I)-K4 for the NPL (UK) and the VSL (Netherlands). • The ¹³⁷Cs source has had to be taken out of service in order to comply with local regulations for sealed sources. An agreement has been reached with the IAEA to transfer comparisons and calibrations to the IAEA Siebersdorf Laboratory. Detailed technical work starts in November 2018 with the intention of re-starting the service (BIPM.RI(I).K5) as soon as possible. • Measurements requiring a ⁶⁰Co beam have been transferred to the Theratron irradiator, with no loss of precision or interruption to the service. The old ⁶⁰Co units will be decommissioned and removed from the site by the end of 2018.
3.	High-energy dosimetry (accelerator dosimetry)	IR-A1.3	<ol style="list-style-type: none"> 1) Maintaining the transportable photon calorimeter standard to provide robust traceability for absorbed dose through on-site comparisons and characterizations of national standards. 2) Providing the BIPM.RI(I)-K6 comparisons on-site at the NMIs. 3) Continued study of long-term optimal scenario for a sustainable maintenance of BIPM.RI(I)-K6 	<ul style="list-style-type: none"> • An agreement has been signed with the CEA/LNE-LNHB, granting BIPM use of the LINAC at the DOSEO facility. The agreement ensures that BIPM will be able to maintain and develop high-energy standards for radiotherapy into the long term. • New equipment has been specified and purchased for DOSEO, including a new water phantom. • Beam characterisation and validation of chambers have been completed. 	<ul style="list-style-type: none"> • Comparisons have been completed for the METAS (Switzerland) and the KRISS (Korea) using the DOSEO facility. • The software has been improved to enable 'real time' data analysis so that any problems with the measurements can be identified rapidly and corrective actions taken. • Studies are underway to establish the optimum technique for correcting for instabilities in the beam. • A secondee has joined the department to investigate the possible dependence of

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#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 – 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 – 30 Sept. 2018)
			comparisons, using the BIPM graphite calorimeter standard.	<ul style="list-style-type: none"> The first comparison using DOSEO is starting (October/November with KRISS). Further modifications were made to the software for the transportable photon calorimeter to improve functionality, following experience of using the software at the NIM. A new graphite transfer chamber has been constructed (to act as a back-up chamber) and validation studies are underway using ^{60}Co. A BIPM.RI(I)-K6 comparison has been completed with the NIM. 	the response of secondary standards on the type of accelerator used, to verify the accuracy of dissemination of the KCRV.
4.	Brachytherapy	IR-A1.4	<ol style="list-style-type: none"> Maintaining the BIPM transfer standards (thimble and well-type chambers) for ^{192}Ir brachytherapy comparisons. Providing BIPM.RI(I)-K8 on-site comparisons for reference air kerma for HDR ^{192}Ir sources, as adopted by the CCRI, on request of NMIs. Study of the convenience and feasibility of future development of a primary standard. Proposal/discussion at CCRI-2017. 	<ul style="list-style-type: none"> Periodic quality control checks have continued – no discrepancies have been observed. The x-ray imaging system was used to check the construction of the ion chambers needed for the DOSEO facility. The expected comparison with the ENEA has been postponed to 2018 (at ENEA's request). Other NMIs are developing standards in this field and are anticipated to request comparisons in due course. Previous BIPM comparisons have also enabled regional comparisons, notably an APMP comparison which is underway. 	Periodic quality control checks have continued.
5.	International Reference System for γ emitters (SIR)	Meas. of γ emitters IR-A2.1	<ol style="list-style-type: none"> Maintenance and development of SIR facility for core comparisons of γ emitters. Providing on demand the BIPM.RI(II)-K1 comparisons covering (at least): 	<ul style="list-style-type: none"> Comparisons were carried for ^{60}Co (PTB), ^{231}Pa (NPL, linked to Euramet comparison), ^{113}Sn (LNHB), ^{54}Mn (PTB), ^{131}I (NMISA), $^{166\text{m}}\text{Ho}$ (NMISA). 	<ul style="list-style-type: none"> A new data acquisition system for the SIR is making good progress, using new LabView software and a new hardware interface to replace obsolete equipment. Validation of the new system is underway.

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#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 – 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 – 30 Sept. 2018)
			<p>3) ¹¹C, ¹⁸F, ²²Na, ⁴⁶Sc, ⁴⁷Sc, ⁵¹Cr, ⁵⁴Mn, ⁵⁶Mn, ⁵⁶Co, ⁵⁷Co, ⁵⁸Co, ⁶⁰Co, ⁵⁹Fe, ⁶⁴Cu, ⁶⁵Zn, ⁶⁷Ga, ⁷⁵Se, ⁸⁵Kr, ⁸⁵Sr, ⁸⁸Y, ⁹⁵Nb, ⁹⁹Mo, ^{99m}Tc, ¹⁰³Ru, ¹⁰⁶Ru, ¹⁰⁹Cd, ^{110m}Ag, ¹¹¹Ag, ¹¹¹In, ¹¹³Sn, ¹²³I, ¹²⁴Sb, ¹²⁵Sb, ¹²⁵I, ¹³¹I, ¹³³Ba, ¹³³Xe, ¹³⁴Cs, ¹³⁷Cs, ¹³⁹Ce, ¹⁴⁰Ba, ¹⁴¹Ce, ¹⁴⁴Ce, ¹⁵²Eu, ¹⁵³Gd, ¹⁵³Sm, ¹⁵⁴Eu, ¹⁵⁵Eu, ^{166m}Ho, ¹⁶⁹Yb, ¹⁷⁷Lu, ¹⁸²Ta, ¹⁸⁶Re, ¹⁹²Ir, ¹⁹⁵Au, ²⁰¹Tl, ²⁰³Hg, ²⁰³Pb, ²⁰⁷Bi, ²²²Rn, ²²⁸Th, ²³⁷Np, ²⁴¹Am, ²⁴³Am.</p> <p>4) Contribution to the development of the Measurement Method Matrix (MMM, CCRI(II)) to reduce the total number of comparisons for γ emitters.</p>	<ul style="list-style-type: none"> • KCRV updates for 8 radionuclides were submitted to the KCWG(II) for approval by the CCRI(II). • Contributions to the development of an approach to reduce the number of key comparisons needed (the Measurement Matrix Method (MMM)) continued in conjunction with the CCRI. • BIPM and NPL have collaborated on a new protocol to use the SIR facility to compare radionuclides in complex decay chains. • A high resolution gamma spectrometer has been set up and calibrated, to be used to check for cross-contamination of SIR samples if needed and also for radiation protection issues. • A presentation was given at the ICRM Conference in May 2017 on ¹³¹I measurements linked to the SIR. 	<p>SIR measurements of ¹⁵²Eu, ¹³³Ba, ⁶⁰Co, ⁶⁸Ge and ¹³⁷Cs have been completed for the TAEK (Turkey), ²²³Ra for LNE-LNHB (France), and ¹⁶⁶Ho for the CMI-IIR (Czech Republic).</p>
		Physical backup to SIR ²²⁶ Ra sources IR-A2.7	<p>1) Feasibility and eventual construction and operation of an electronic current source of high stability and reproducibility for gradual elimination of ²²⁶Ra sources used in the SIR.</p> <p>2) In case of negative answer to point 1), study of an alternative to ²²⁶Ra sources for the long-term operation of the SIR.</p> <p>3) Measurements of natural ²²²Rn emanation in room S11 and study of its possible contribution to the background current measured in the SIR ionization Chambers (SIR IC).</p>	<ul style="list-style-type: none"> • The use of new technologies to replace the use of sealed reference sources will be studied in detail in 2018. • A suitable instrument for radon measurements was identified and purchased and long-term measurements of the radon concentration are on-going. • The design of a metal gas container developed by IRA has been reviewed. A holder has been designed and a prototype constructed using a 3D printing technique. Some modifications are needed to ensure that the gas container can be accurately located for use in the SIR. 	<ul style="list-style-type: none"> • An initial feasibility study of new technologies to replace sealed reference sources has been completed and an abstract submitted to the ICRM Conference. The options were reviewed at a joint NIST-BIPM / CCRI-CCEM workshop. The conclusion was that Ultrastable Low noise Current Amplifiers (UCLA) and resistive-feedback electrometers showed promise, and the intention is to form a new working group under CCRI, including representatives from CCEM, to co-ordinate the work. A secondee will be sought for this work for 2019.

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			4) Study of the design of a new metallic gas container to improve the measurements of radioactive noble gas in the SIR IC.		<ul style="list-style-type: none"> In parallel, a new project has started in collaboration with the IRA (Switzerland), NPL (UK), LNHB (France) and Triskem to develop sources to replace the ²²⁶Ra reference sources. The radionuclide to use has been identified (^{166m}Ho) and a method to produce the sources has been tested. The next step is validation of the approach with the aim of replacing all the ²²⁶Ra sources by the end of 2019.
6.	International reference facility for short-lived γ emitters	SIR Transfer Instr. (SIRTI) IR-A2.4	<ol style="list-style-type: none"> Maintenance and development of the SIR Transfer Instrument for on-site comparisons and extension to new short-lived radionuclides. Providing the BIPM.RI(II)-K4 bilateral comparisons covering on demand ^{99m}Tc, ¹⁸F, ⁶⁴Cu, and, for example, ¹¹C, ⁶⁸Ga, ²¹¹At, ⁵⁶Mn, or other radionuclides requested by the NMIs. Contribution to the development of the Measurement Method Matrix (MMM, CCRI(II)) to reduce the total number of comparisons for short-lived γ emitters. 	<ul style="list-style-type: none"> The analysis of results linking SIRTI and SIR measurements of ⁶⁴Cu has been completed. The first comparison of the PET radionuclide ¹¹C was completed at NRC. SIRTI comparisons were carried at POLATOM (^{99m}Tc, ¹⁸F and ⁶⁴Cu) Preparations are underway for a comparison using SIRTI at ANSTO. The results of the ¹⁸F and ⁶⁴Cu comparisons at NIST have been submitted for publication. Agreement has been reached within the KCWG(II) on how to group measurements together using the SIRTI, to reduce the work associated with the comparison exercises for both the NMIs and BIPM. 	<ul style="list-style-type: none"> Measurements of the short-lived medical radionuclides ^{99m}Tc, ¹⁸F and ⁶⁴Cu were completed at the ANSTO (Australia). This was the first time that traceability was established for these radionuclides in Australia. Preliminary results have been evaluated for the SIRTI measurements of ^{99m}Tc, ¹⁸F, ⁶⁴Cu and ¹¹C at the NRC (Canada). The ¹¹C results showed that additional measurements of the half life may be needed, these results have been submitted to the ICRM Conference in 2019. It was agreed with the KCWG(II) that the SIRTI instrument would now be calibrated at the BIPM for additional radionuclides, to prepare for a more efficient approach to organize comparisons. The results of the ¹⁸F and ⁶⁴Cu comparisons at NIST have been published; the measurements for ⁶⁴Cu were in good agreement with results

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#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 – 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 – 30 Sept. 2018)
					using the SIR, the first time that this link has been made.
7.	Extensions of SIR	Meas. of pure β emitters IR-A2.2	<ol style="list-style-type: none"> 1) Implementation, operation and maintenance of SIR facility for β emitters future core comparisons for reduction of the heavy logistics of CCRI(II)-K2 comparisons. 2) Establishing the BIPM.RI(II)-K1 bilateral comparisons covering on demand ^3H, ^{14}C, ^{55}Fe, ^{63}Ni, and, for example, ^{32}P, ^{89}Sr, $^{90}\text{Sr}/^{90}\text{Y}$, ^{99}Tc, ^{147}Pm, ^{204}Tl, or other radionuclides requested by the NMIs. 3) Contributions to the development of the Measurement Method Matrix (MMM, CCRI(II)) to reduce the total number of comparisons for β emitters. 	<ul style="list-style-type: none"> • A detailed investigation has been carried out of a draft protocol to extend the SIR to beta emitters by liquid scintillation counting. • Two secondees (one from NIST, one from NIM) made significant contributions to the project which involved dispensing and testing 1000 sources. The results highlighted technical issues with the approach that need further investigation. • The project will be continued by a new recruit to BIPM in 2018. • An initial presentation of the work was given at the ICRM conference in 2017. • Consensus is yet to be reached on the approach to establish the extended SIR. Further tests will be conducted in 2018 with comparisons to start in 2019. 	<ul style="list-style-type: none"> • A new member of staff joined the BIPM in September 2018 to focus on the development of the ESIR. • Historical studies have been reviewed in depth. • A project team has been formed involving staff from the LNHB (France), POLATOM (Poland), PTB (Germany) and NPL (United Kingdom). A project start-up meeting has been held and consensus was reached on the most promising technical approach, taking into account lessons learned from the previous work. • A detailed project plan has been developed.
		Meas. of α emitters IR-A2.3	<ol style="list-style-type: none"> 1) Development and implementation of SIR facility (LSC or defined solid angle) for α emitter future core comparisons for reduction of the heavy logistics of CCRI(II)-K2 comparisons. 2) This will allow to complete (with IR-A2.1, IR-A2.2) the frame for the core comparisons of most common α-, β- and γ-emitters. 3) BIPM.RI(II)-K1 bilateral comparisons, covering on request for example ^{241}Am, ^{223}Ra, ^{211}At, ^{238}Pu, ^{210}Po or other 	<ul style="list-style-type: none"> • Postponed until 2020, with priority being given to extending the SIR to beta emitters. 	<ul style="list-style-type: none"> • Work on this task has been postponed until 2020, with priority being given to extending the SIR to beta emitters.

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IV Ionizing Radiation Metrology					
#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 – 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 – 30 Sept. 2018)
			radionuclides demanded by the NMIs. 4) Contributions to the development of the Measurement Method Matrix (MMM, CCRI(II)) to reduce the total number of comparisons for α emitters.		
8.	Reference instruments for primary measurements	Coincidence counting IR-A2.5	1) Maintenance and further development of $4\pi\beta\text{-}\gamma$ coincidence counting and TDCR LSC systems. 2) Organization of one CCRI comparison for ^{109}Cd and participation in two CCRI comparisons according to the Rolling Plan and the MMM table. 3) Establish missing KCRVs for: ^{47}Sc , ^{68}Ge , ^{111}Ag , ^{140}Ba , ^{155}Eu , ^{195}Au and improve KCRVs for: ^{24}Na , ^{56}Co , ^{123}I , ^{124}Sb , ^{125}Sb , ^{153}Sm , ^{154}Eu , $^{166\text{m}}\text{Ho}$, ^{177}Lu as priorities.	<ul style="list-style-type: none"> The requirements for establishing coincidence counting systems will be reviewed discussed further with the KCWG(II) to determine the scope of the work. The CCRI comparison of ^{109}Cd is now scheduled to take place in 2019. 	<ul style="list-style-type: none"> The CCRI comparison of ^{109}Cd is now scheduled to take place in 2019. The focus of the work has moved to using the TDCR LSC system to establish the ESIR. The ^{109}Cd comparison exercise is scheduled to take place in 2019.
		Low-level meas. of γ and β emitters IR-A2.6	1) Acquisition, Monte Carlo simulation and setup of a $4\pi\text{-}\gamma$ NaI(Tl) well-type detector for γ emitters. 2) Operational use of the Quantulus 1220-LSC spectrometer for low-level measurements of β and α emitters. 3) Coordination/participation in one CCRI comparison on low-level measurements of contaminated materials.	<ul style="list-style-type: none"> This work is scheduled to start in 2018, the first step being to establish a user requirements specification for the measurements. 	<ul style="list-style-type: none"> The focus of this work has also moved to concentrate on the TDCR LSC system. Priority has also had to be given to the replacement of the ^{226}Ra sources for the SIR to ensure that this service can be maintained.

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IV Ionizing Radiation Metrology					
#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 – 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 – 30 Sept. 2018)
9.	International Liaison and Coordination Activities	CIR-A.1.1	Provision of the CCRI Executive Secretary, general support to CCRI and CCRI-WGs including: <ol style="list-style-type: none"> 1) Biennial CCRI and sections I, II and III meetings 2) Regular meetings of five working groups 3) Review of CCRI and RMO-TC-IR comparison reports before publication 4) Development of strategic plans 5) Publication of BIPM <i>Monographies</i> 6) Related liaisons with RMOs. 	<ul style="list-style-type: none"> • The consultation arrangements for ionizing radiation were changed this year, with the CCRI membership being expanded and specialist topics being discussed in the three section meetings. • Participated in meetings of CCRI, a workshop on the CCRI strategic plan, and the associated section meetings (June 2017). • 8 comparison reports were published in the KCDB and the <i>Metrologia Tech.Suppl.</i> 	<ul style="list-style-type: none"> • Participated in the first meeting of the CCRI Strategy Working Group and worked with the CCRI President to draft a new version of the CCRI strategic plan (for publication later in 2018). • Participated in the meeting of the CCRI Section II Key Comparison Working Group and the RMO Working Group. • Reviewed, edited and arranged publication on the KCDB of reports on comparison exercises of ^3H, ^{54}Mn, ^{125}I, ^{204}Tl and ^{238}Pu. • 25 comparison reports were published in the KCDB and the <i>Metrologia Tech.Suppl.</i>
		CIR-A1.3	Provision of the CCT Executive Secretary: support and advice to CCT and CT-WGs including: <ol style="list-style-type: none"> 1) Biennial CCT and ten WG meetings 2) Pro-active interaction on strategy and communication 3) Related liaisons with RMOs. 	<ul style="list-style-type: none"> • The CCT plenary meeting was organized (1-2 June 2017) along with the associated Working and Task Groups. • On-going support to the CCT included monthly newsletters and updating the CCT Strategy. Two guides were also published on the BIPM website: first, the preliminary version of the 'Mise en Pratique' concerning absolute & relative primary methods to realize the Kelvin and, second, a guide to measurement issues for the international temperature scale (ITS-90). 	<ul style="list-style-type: none"> • The 'Mise en Pratique' completed.
		CIR-A1.4	Provision of the Scientific Secretary and support including: <ol style="list-style-type: none"> 1) <i>Rapporteur</i> 2) Two annual meetings. 	<ul style="list-style-type: none"> • Two meetings of the working group (WG1) were organized this year. • Two summary reports have been written. 	<ul style="list-style-type: none"> • Two meetings of the working group (WG1) were organized this year. • Two summary reports have been written.
		CIR-A1.5	Support to/from (inter)national bodies:	<ul style="list-style-type: none"> • BIPM contributed to writing a major ICRU Report 90 on Key Data for Radiation 	<ul style="list-style-type: none"> • Contributed to final drafting of the ICRU Report on Operational Quantities for

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IV Ionizing Radiation Metrology					
#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 – 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 – 30 Sept. 2018)
			1)International Commission on Radiation Units (ICRU) (Commissioner and sponsor of Report Committees), 2)International Atomic Energy Agency (IAEA) (SSDL Scientific Committee), 3)International Committee for Radionuclide Metrology (ICRM) (Scientific Committee and technical refereeing). 4)LNE-LNHB (Scientific Committee Ionizing Radiations) 5)Autorité de Sécurité Nucléaire (ASN, France)	Dosimetry. These data underpin measurement standards for dosimetry at all NMIs and consequently the clinical instruments that are traceable to these standards. <ul style="list-style-type: none"> • There is on-going work with the ICRU to develop new operational quantities for radiation protection, to simplify the existing system. The report is scheduled to be published in 2018. • Participated in the annual ICRU meeting in April 2017. • Continued to provide calibration services to support the IAEA/WHO Secondary Standards Dosimetry Laboratories, including a campaign in July/August 2017. The next review will take place in March 2018. • Participation in the revision of the international Code of Practice TRS-398 for external beam radiotherapy with a meeting in October 2016 and new text supplied. • BIPM has continued to participate actively in the work of the ICRM, contributing to the successful conference on radionuclide metrology held in Buenos Aires in May 2017 including acting as a referee for papers. • Work is underway with the French regulatory authorities to establish a long term plan for the use of sealed radioactive sources on the BIPM site. 	radiation protection, to be review at next annual meeting (October 2018). <ul style="list-style-type: none"> • Participated in ongoing revision of the IAEA Code of Practice for radiotherapy dosimetry (TRS-398), supplying new text for the document and attending several meetings at the IAEA headquarters. • Contributed as member of IAEA SSDL Scientific Committee to the biennial review in March 2018, a report was written and submitted to the IAEA. • A presentation on the work at the BIPM was given to the EURAMET IR-TC in February 2018. • Established a new liaison with ISO (TC85 SC2), leading a project to develop a new international standard for gamma-ray spectrometry. • Participated in the planning meeting for the IAEA IDOS2019 conference. • Continued involvement with the ICRM, participated in ICRM working group meetings at NIST in September 2018 and the scientific committee meeting is scheduled for the end of October 2018. • A long term plan has been agreed with the ASN for the use of sealed sources on the BIPM site and the site license has been renewed. However, strict deadlines have been placed on the use of some of the sealed sources, so work replacements for the ²²⁶Ra sources for the SIR has had to be brought forward.

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V International Liaison and Coordination					
#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 – 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 – 30 Sept. 2018)
1.	CIPM MRA	ILC-1.2	JCRB Executive Secretary and CMC review website KCDB Office and databases entry/nomination review process Maintenance and upgrade of the KCDB	<ul style="list-style-type: none"> Submission of 60 CMC sets, publication of 32 CMC sets covering 793 new, 54 grayed out, 686 withdrawn, 24 reinstated and a number of revised CMCs. 71 new comparisons were registered and 83 comparisons published. The specifications KCDB 2.0 were drafted. A call for tender was launched and a service provider was selected amongst the proposers. CIPM MRA ad hoc WG on the Implementation and Operation of the CIPM MRA organized and held in March 2017, 10 participants, resulting 4 Actions to the CCs, JCRB and RMOs. JCRB meeting organized and held in March 2017, 34 attendees from 6 RMOs, resulting 4 Actions, 4 Resolutions (1 tasked to the BIPM, completed). JCRB meeting organized and held in (September 2017, Switzerland) 31 attendees from 6 RMOs, resulting 2 Actions, 3 Resolutions. Continuous support at CC meetings and WGs, and information given on KCDB 2.0. 	<ul style="list-style-type: none"> Submission of 45 CMC sets, publication of 44 CMC sets covering 794 new, 275 grayed out, 464 withdrawn, 25 reinstated and 590 revised CMCs. 53 new comparisons were registered and 65 comparisons published. The development specifications KCDB 2.0 for the CMC part were validated and the development of this is in progress. Consultative Committees were informed and contacted on legacy data issues. Continuous support at CC meetings and WGs, and information given on KCDB 2.0. JCRB meeting organized and held in March 2018, 31 attendees from 6 RMOs and CIPM/BIPM, resulting 4 Actions, 6 Resolutions (3 tasked to the BIPM, completed). CIPM MRA ad hoc WG on the Implementation and Operation of the CIPM MRA organized and held in March 2018, 10 participants, resulting 6 Actions to the CCs, JCRB and RMOs. RMO and CC Presidents organized and held in June 2018 resulting agreement on the “representative CMCs” issue, discussion on the ‘hybrid’ bilateral comparisons (based on routine calibrations) to underpin CMCs.

V International Liaison and Coordination					
#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 - 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 - 30 Sept. 2018)
2.	Liaison and Coordination work	ILC-1.1	<p>Support for and representation to:</p> <ul style="list-style-type: none"> - RMOs - (AFRIMETS, APMP, COOMET, EURAMERT, SIM and GULFMET). - International/intergovernmental : OIML, ILAC, ISO, WMO, WTO, IUPAC, IUPAP, IEC, IFCC, CODATA TGFC. 	<ul style="list-style-type: none"> • Attended and BIPM presentations given in RMO meetings: GULFMET GA + TCQ (UAE); COOMET GA + TC Joint Committee meeting (Belarus) + COOMET young metrologists competition 2017 (Kazakhstan); EURAMET GA + Anniversary Symposium (Spain); AFRIMETS GA (South Africa); SM GA (Uruguay) • NCSLI Board meeting and Symposium attended (August 2017, USA). • Attended and the BIPM presentation in Metrology Symposium (September 2017, Cuba). • EURAMET BoD WG for Capacity Building attended (October 2016, Dublin). • Attended the ILAC/IAF GA + ILAC AIC WG Metrology + ILAC Accreditation Committee (October 2016, India). ILAC Accreditation Committee (March 2017, Germany). • WTO Roundtable on National Quality Infrastructure (Switzerland) attended. Attended WTO TBT informal and formal meetings (December 2016, March and June 2017, Switzerland). • Participation in UNECE Working Party on regulatory cooperation and standardization policies. • Contributed to the UNIDO trade capacity building training course (December 2016, Bahrain). Participated in the UNIDO Quality Infrastructure meetings (February 	<ul style="list-style-type: none"> • Attended and BIPM presentations given in RMO meetings: GULFMET GA (Turkey); COOMET GA + TC Joint Committee meeting (Bosnia and Herzegovina); EURAMET GA (Romania); AFRIMETS GA (Nigeria); SM GA + QSTF WG (USA). • NCSLI Board meeting (August 2018, USA). • Presentations on the redefinition of the SI were given at different events: WMD event organized by IPQ (May 2018, Spain); Metrology Workshop of RCM-LIPI (May 2018, Indonesia); International Conference on Properties of Water and Steam (September 2018, Czech Republic); EURAMET's "International Metrology" Summer school (September 2018, Greece). • Attended the ILAC/IAF GA + ILAC AIC WG Metrology + ILAC Accreditation Committee (October 2017, Canada). ILAC Accreditation Committee (April 2018, Germany). • Attended WTO TBT Committee regular meetings (March 2018 and June 2018, Switzerland). • Attended 'Technical assistance' session of "Advanced course on the TBT Agreement" on the margins of the WTO TBT Committee meeting (March 2018, Switzerland)

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V International Liaison and Coordination					
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				<p>and September 2017, Austria). Contributed to the UNIDO-BIPM-OIML joint brochure on “The role of metrology in the context of the 2030 Sustainable Development Goals” published in May 2017.</p> <ul style="list-style-type: none"> • DCMAS meeting attended (June, 2017). • Fourth Annual Meeting of International Organizations at OECD (April 2017, France) attended. Involvement and contribution to the work of WG2, WG4 and WG5 within the OECD International Regulatory Cooperation (IRC) initiative (and involvement in discussion to draft a study by the OECD about the BIPM activities). • At the BIPM organized: Annual meetings of BIPM-ILAC, BIPM/OIML/ILAC/ISO (March 2017). • Relevant guidance to European Aviation Safety Agency provided and guideline document revised. • Participation in European Commission review of EMRP/EMPIR (Belgium). • Attended ISO-CASCO plenary and WG44 (April and May, 2017 Canada). ISO-CASCO WG44 + ISO Academy attended (July 2017, Switzerland). • CODATA-TGFC organized at BIPM (September, 2017) 	<ul style="list-style-type: none"> • Attended UNIDO side event “Good governance in developing modern quality infrastructure systems” held on the margins of the WTO TBT Committee meeting (June 2018, Switzerland). • Attended and contributed to the UNIDO QI Workshop (May 2018, Nigeria). • Attended fifth Annual Meeting of International Organizations at Palais des Nations jointly organized by OECD, UNECE and ISO (April 2018, Switzerland). Involvement and contribution to the work of WG2, WG4 and WG5 within the OECD International Regulatory Cooperation (IRC) initiative. • Drafting a study within IRC initiative with the support of the OECD about the BIPM activities and impact of the CIPM MRA. • At the BIPM organized: Annual meetings of BIPM-ILAC, BIPM/OIML/ILAC/ISO (March 2018).
		ILC-1.3	Support to the BIPM Director, CIPM, Member States and Associates Promotion of the Metre Convention and support to potential Member States and Associates	<ul style="list-style-type: none"> • Promotional and supporting visits at BIPM for Iran, Kazakhstan, Chinese Guangdong Province and Ukraine organized. 	<ul style="list-style-type: none"> • Support to the BIPM Director, CIPM President and CIPM Secretary in organization of the 26th CGPM.

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V International Liaison and Coordination					
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				<ul style="list-style-type: none"> • Ethiopia completed the process to become an Associate State of the CGPM as from 1 January 2018. • Portfolio of Associate States encouraged to accede to the Metre Convention and thus become a Member State of the BIPM (Ukraine, Costa Rica, Paraguay, Bosnia and Herzegovina and Montenegro) managed. • Portfolio of Member States (Israel, Brazil, Pakistan, Uruguay, India, Tunisia, Venezuela and Iran) and Associate States (Azerbaijan, Panama, Ghana, Mongolia, Botswana, Macedonia, Yemen and Cuba) with outstanding contributions and subscriptions managed. • Portfolio of potential Member States and Associate States (Tanzania, Kuwait, Uzbekistan and Armenia) managed. 	<ul style="list-style-type: none"> • Promotional and supporting visits at BIPM for <i>Ethiopia, Uzbekistan and Kuwait</i> organized. • Promotional and supporting visit at BIPM for professors from US, Australia and Sweden Universities organized. • As of August 2018 there are 60 Member States, and 42 Associate States of the CGPM; <p>2 Associate States became Member States:</p> <ul style="list-style-type: none"> - <i>Montenegro</i> became a Member State as from 24 January 2018, after having been an Associate State of the CGPM for more than 7 years. - <i>Ukraine</i> became a Member State as from 7 August 2018, after having been an Associate State of the CGPM for 16 years. <p>4 states became Associate States:</p> <ul style="list-style-type: none"> - <i>Ethiopia</i> completed the process to become an Associate State of the CGPM as from 1 January 2018 and signed the CIPM MRA on 8 January 2018. - <i>Tanzania</i> completed the process to become an Associate State of the CGPM as from 1 January 2018 and signed the CIPM MRA on 16 April 2018. - <i>Kuwait</i> completed the process to become an Associate State of the CGPM as from 23 March 2018 and signed the CIPM MRA on 12 July 2018. - <i>Uzbekistan</i> completed the process to become an Associate State of the CGPM as from 13 July 2018.

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V International Liaison and Coordination					
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					<p>1 Associate State was excluded:</p> <ul style="list-style-type: none"> - <i>Yemen</i> ceased to be an Associate State at the beginning of 2018 due to persistent non-payment of its subscriptions. • Portfolio of Associate States encouraged to accede to the Metre Convention and thus become a Member State of the BIPM (<i>Costa Rica, Ecuador, Panama, Viet Nam, Latvia and Bosnia & Herzegovina</i>) managed. • Portfolio of Member States (<i>Brazil, Indonesia, Iraq, Iran, Mexico, Pakistan, Tunisia, Uruguay and Venezuela</i>) and Associate States (<i>Azerbaijan, Bangladesh, Costa Rica, Cuba, Jamaica, Macedonia, Mongolia, Moldova, Namibia, Seychelles, Sudan, Syria, Zambia and Zimbabwe</i>) with outstanding contributions and subscriptions managed. • Portfolio of potential Member States and Associate States (<i>Bahrain, Comoros, Nigeria, Morocco, Samoa, Togo, Uganda, etc.</i>) managed.
		ILC-1.5	Provision of JCGM (one annual meeting) and JCGM WG2 (two annual meetings) Executive Secretary and rapporteur, general support to JCGM, representation in JCGM WG2.	<ul style="list-style-type: none"> • JCGM plenary session organized and held in May 2017. Ten attendees, six decisions. • JCGM-WG2 meetings held at the BIPM in December 2016 and May 2017 (total of 9 full days). • New approved annotations to the VIM published. • CIPM position developed and agreed 	<ul style="list-style-type: none"> • JCGM-WG2 meetings held at the BIPM in December 2017 and June 2018 (total of 10 full days). • Report of December 2017 meeting drafted, edited and published. June 2018 report in progress • Ongoing work in WG2 to prepare VIM4 CD for presentation to the JCGM plenary in December 2018.
3.		ILC-2.1	Drafting/Minuting reports, including editing, translation into French,		

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	Publications and the BIPM website		typesetting and publication of CIPM and BIPM reports, publications and posters.	<ul style="list-style-type: none"> • Proceedings of the 105th CIPM meeting (2016) minuted, drafted, edited, translated into French, typeset and published (website and hardcopy). • New style 'BIPM Annual Review' drafted, edited, typeset and published (website and hardcopy, EN version only). Director's Report departmental supplements 2016 edited and published on the website. • Financial Report 2016 edited, translated into French, typeset and published (website and hardcopy). • Reports of the CCRI 2015; CCU 2016; CCPR 2016; CCM 2017; CCT 2017; Time Annual Report (2016) edited, typeset and published on website. • News from the BIPM laboratories 2016 – edited and published. Three issues of BIPM eNews (December 2016, March 2017 and July 2017). • JCTLM Newsletter 2017 edited, typeset and published on website + JCTLM Leaflet designed and edited. • New posters and rollups for the "Objectives of the BIPM" and "Vision and mission" edited and printed. • CC interactive registration and convocation forms designed and printed for the Secretariat. • METROLOGIA: Increased Impact Factor (2016) announced in June 2017: 3.411 • During the period to 1 October 2016 to 31 August 2017: 231 manuscripts submitted; 106 manuscripts accepted, including 21 	<ul style="list-style-type: none"> • Proceedings of the 106th CIPM meeting (2017) published (website and hardcopy, FR and EN versions). • Proceedings of the 107th CIPM meeting (2018) prepared. • 'BIPM Annual Review 2017/2018' published (website and hardcopy, EN version only). Director's Report departmental supplements 2017 published on the website. • Financial Report 2017 (FR and EN versions) published (website and hardcopy). • Reports of the CCEM 2017; CCM 2017; CCQM 2017; CCRI 2017; CCTF 2017; Time Annual Report (2017) published on website. • News from the BIPM laboratories published. Three issues of BIPM eNews (October 2017, February 2018 and May 2018). • JCTLM Newsletter 2018 published on website + JCTLM workshop flyer designed and edited. • 26th CGPM convocation edited, typeset and published (website and hardcopy). • New "Safety info for short-term visitors" leaflet designed and edited. • qNMR Internal Standard Reference Data (ISRD-01) document designed and edited. • Redesign and reprogramming an internal <i>Metrologia</i> database to
		ILC-2.2	Editing and publication of <i>Metrologia</i> .		
		ILC-3.0	Journal subscriptions (on-line or hard copy) buy-per-view scientific articles and books for BIPM staff)		
		ILC-4.0	Provision of BIPM internet.		

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				<p>papers published ahead of the 1 July 2017 cutoff date presenting input data (and other support material) related to the CODATA-2017 special adjustment; 87 reports published in the Technical Supplement; 180 900 article downloads</p> <ul style="list-style-type: none"> • Open Focus Issues: Realization, Maintenance and Dissemination of the New Kilogram; Metrology in Electricity and Magnetism; Metrology for Dynamic Measurements; Mathematics and Statistics for Metrology; Metrology for Meteorology and Climate; Pressure and Vacuum Metrology • Informal promotion of Metrologia during the majority of BIPM events. • New member recruited to the Editorial Board: Richard Brown, Kenichi Fujii, Stephan Schlamminger, Inseok Yang • Discussions held with most members of the Editorial Board and Board of Directors • Meetings held with Guest Editors of future Focus Issues • WEBSITE: The BIPM’s electronic archives were extended to include all past CC reports (in searchable format). New format introduced for the JCRB directory. New areas created concerning promotion of the SI. Major update of the BIPM gas chemistry pages. Routine maintenance. • Project under way to redesign the graphic style. First workshop held with chosen external supplier. 	<p>improve functionality and user-friendliness.</p> <p>METROLOGIA: Impact Factor (2017): 2.275.</p> <ul style="list-style-type: none"> • Accelerated publication introduced, so that an article can be made available online the same day it is accepted. • Two Deputy Editors named, to help cover editorial duties: Dr Richard S. Davis (BIPM) and Dr Giovanni Mana (INRIM). • 21 papers presenting new data or supplementary information to be considered in the CODATA-2017 special adjustment were published ahead of the 1 July 2017 deadline set by the CIPM . • Results of the CODATA-2017 special adjustment were published. • Focus Issues completed: Focus on Optical Metrology; Focus on Pressure and Vacuum Metrology; Focus on Realization, Maintenance and Dissemination of the Kilogram. • Open Focus Issues: Focus on the Quantum Revolution in Metrology; Focus on Advances in Metrology and Biology; Focus on Metrology in Electricity and Magnetism; Informal promotion of Metrologia during the majority of BIPM events. • New member recruited to the Editorial Board: Andreas Bauch (PTB), Luca Callengaro (INRIM), Ian Robison (NPL).

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					<ul style="list-style-type: none"> Discussions held with most members of the Editorial Board and Board of Directors. <p>WEBSITE:</p> <ul style="list-style-type: none"> New pages introduced, showing the BIPM's: CBKT interactions per Member State/Associate. Major update of the pages on the BIPM's organic chemistry programme. Graphic design project completed, with models developed for the new graphic design on table top and small-screen browsers. Contract placed to develop website on a new CMS: Liferay Initial meetings held with contractor.
4.	Workshops on key topics identified by the CIPM and support to a combined metrology school	-	"X Grand challenge CIPM workshops plus Metrology school delivered collaboratively with Verona"	<ul style="list-style-type: none"> BIPM Symposium: The Fundamental Constants of Physics organized at BIPM (September 2017) BIPM Workshop: The Quantum Revolution in Metrology held at BIPM (September 2017) CC Presidents meeting hosted at BIPM (June, 2017) 	<ul style="list-style-type: none"> <i>Metrology school delivered collaboratively at Varenna (with SIF/INRIM) will be held in 2019 and two events during the period of the 2020-2023 Work Programme of the BIPM.</i>
5.	CBKT	-	<p>Agreed BIPM CBKT courses:</p> <ul style="list-style-type: none"> NIST funded: "Leaders of Tomorrow", 2016. "Metrology: from physics fundamentals to quality of life" METAS sponsorship and placement. "Metrology for Safe Food and Feed in Developing Economies" project. 	<ul style="list-style-type: none"> 2016 "Leaders of Tomorrow" course, 18 participants from 15 countries (11 day training, November 2016, BIPM). Sponsor NIST. 2016 "BIPM-GULFMET TC Workshop", 44 participants from 6 countries (3 day training, November 2016, UAE). GULFMET support. 	<p>Cumulative overview of the CBKT:</p> <ul style="list-style-type: none"> 16 CBKT initiatives were organized: 12 completed and 4 ongoing. Placements/workshops/courses have been heavily oversubscribed. Already, over 75 % of Member States and Associates have participated in the CBKT Programme (as trainees, lecturers and sponsors).

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V International Liaison and Coordination					
#	Name of the project	Project Code	Deliverables	Work performed in the period (30 Sept. 2016 – 30 Sept. 2017)	Work performed in the period (1 Oct. 2017 – 30 Sept. 2018)
			<p>NIST: Sound beginning in the CIPM MRA”, 2017.</p> <p>Courses under development:</p> <ul style="list-style-type: none"> - "BIPM-EURAMET TC leadership Course" - GULFMET workshop "Interlaboratory Comparison (ILCs)" 	<ul style="list-style-type: none"> • 2017 BIPM-EURAMET TC leadership course 18 participants from 12 countries (4 day training, February 2017). EURAMET Support. • The content of the 2017 "Sound beginning in the CIPM MRA" course (13-24 Nov 2017) identified. 24 participants have registered. • Content of the 2017 APMP-DEC "Leadership training" course and dates (4-8 December 2017, at NIMT, Thailand) identified. • 2018 & 2019 "BIPM - TÜBİTAK UME project placements" – laboratory based trainings are scheduled in two cycles (2018 -2019), with durations ranging from 1 to 3 months at TÜBİTAK UME depending on the participant’s research interests and preferences. The first placement cycles will begin on 1 April 2018. Contract was signed. Call for application has started. • BIPM-METAS CB&KT course “Effective participation in Universal Coordinated Time (UTC)” is planned (Beginning of the next year). Contract with METAS was signed. 	<ul style="list-style-type: none"> • Overall, 308 participants (124 at the BIPM) from 83 countries participated in various training courses; • 14 new RMO TC/WG Chairs were trained and 12 existing RMO TC/WG Chairs benefited from the CBKT programme. • First ever CMC publication: 7 CMCs in mass metrology of Namibia (joined in 2012) and 13 CMCs in thermometry of Zimbabwe (joined in 2012) and 1 CMC in Viscosity of Azerbaijan (joined in 2015) have been published in the KCDB, 12 CMCs in Thermometry of Zambia (joined in 2010) at the final approval of JCRB. <p>Beneficiaries of the courses organized during the reporting period:</p> <ul style="list-style-type: none"> • 24 trainees from 20 countries at 2017 “Sound beginning in the CIPM MRA” course; • 24 trainees from 17 countries & 2 RMOs at 2018 “Effective participation in Universal Coordinated Time (UTC)”; • 18 trainees from 12 countries at 2018 BIPM – COOMET “Sound beginning in the CIPM MRA” Workshop; • 23 trainees from 12 countries at 2018 AFRIMETS – BIPM “Sound beginning in the CIPM MRA” Workshop; • 10 young metrologists from 10 countries at 2018 - BIPM- TÜBİTAK UME project placements. The application for the second – 2019 cycle has been launched.

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