**Bureau International des Poids et Mesures**

# Consultative Committee for Length (CCL)

Report of the 14th meeting
(10 – 11 June 2009)
to the International Committee for Weights and Measures

**Comité international des poids et mesures**

Note:

Following a decision of the International Committee for Weights and Measures at its 92nd meeting (October 2003), reports of meetings of the Consultative Committees are now published only on the BIPM website and in the form presented here.

Full bilingual versions in French and English are no longer published.

A.J. Wallard,
Director BIPM

## LIST OF MEMBERS OF THE CONSULTATIVE COMMITTEE FOR LENGTH
AS OF 10 JUNE 2009

### President

Dr A. Sacconi, Member of the International Committee for Weights and Measures, Istituto Nazionale di Ricerca Metrologica, Turin.

### Executive Secretary

Mr Raymond Felder, International Bureau of Weights and Measures [BIPM], Sèvres.

### Members

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Bundesamt für Eich- und Vermessungswesen [BEV], Vienna.

Centre for Metrology and Accreditation/Mittatekniikan Keskus [MIKES], Espoo.

Centro Español de Metrología [CEM], Madrid.

Centro Nacional de Metrología [CENAM], Querétaro.

Conservatoire National des Arts et Métiers/Institut National de Métrologie [LNE-INM/CNAM], La Plaine-Saint-Denis.

Czech Metrology Institute/Český Metrologický Institut [CMI], Brno.

D.I. Mendeleyev Institute for Metrology, Rostekhregulirovaniye of Russia [VNIIM], St Petersburg.

Federal Office of Metrology/Office Fédéral de Métrologie [METAS], Bern-Wabern.

Istituto Nazionale di Ricerca Metrologica [INRIM], Turin.

Korea Research Institute of Standards and Science [KRISS], Daejeon.

National Institute of Metrology [NIM], Beijing.

National Institute of Standards and Technology [NIST], Gaithersburg/Joint Institute for Laboratory Astrophysics [JILA], Boulder.

National Measurement Institute, Australia [NMIA], Lindfield.

National Metrology Institute of Japan, Advanced Institute of Science and Technology [NMIJ/AIST], Tsukuba.

National Metrology Institute of South Africa [NMISA], Pretoria.

National Metrology Institute of Turkey/Ulusal Metroloji Enstitüsü [UME], Gebze-Kocaeli.

National Physical Laboratory [NPL], Teddington.

National Research Council of Canada, Institute for Measurement Standards [NRC-INMS], Ottawa.

Physikalisch-Technische Bundesanstalt [PTB], Braunschweig.

Slovak Institute of Metrology/Slovenský Metrologický Ústav [SMU], Bratislava.

VSL, Delft.

The Director of the International Bureau of Weights and Measures [BIPM], Sèvres.

# 1 OPENING OF THE MEETING; APPOINTMENT OF RAPPORTEURS; APPROVAL OF THE AGENDA

The Consultative Committee for Length (CCL)* held its 14th meeting at the International Bureau of Weights and Measures (BIPM) headquarters, Sèvres, on Wednesday 10 and Thursday 11 June 2009. Four sessions were held.

The following delegates were present:

A. Baker (NMIA), P. Balling (CMI), A. Balsamo (INRIM), R.H. Bergmans (VSL), H. Bosse (PTB), R. Dixson (NIST), R. Fira (SMU), S. Gao (NIM), W. Giardini (NMIA), P. Gill (NPL), F.-L. Hong (NMIJ/AIST), P. Juncar (LNE-INM), J.-W. Kim (KRISS), O. Kruger (NMISA), A. Lassila (MIKES), A. Lewis (NPL), M. Matus (BEV), J. Pekelsky (NRC-INMS), E. Prieto (CEM), F. Riehle (PTB), A. Sacconi (INRIM), G. Santarelli (LNE), J. Stone (NIST), T. Takatsuji (NMIJ/AIST), S.-L. Tan (A*STAR), R. Thalmann (METAS), G.-P. Vailleau (LNE), M. Viliesid (CENAM), A.J. Wallard (Director of the BIPM), T. Yandayan (UME) and M. Zucco (INRIM).

Guests: J.C. de Oliveira (INMETRO), G.-S. Peng (CMS/ITRI)

Also present: E.F. Arias (BIPM), R. Felder (Executive Secretary of the CCL), J.R. Miles (BIPM), L. Mussio (Executive Secretary of the JCRB), T.J. Quinn (Director Emeritus BIPM), L. Robertsson (BIPM), C. Thomas (Coordinator of the KCDB), L.F. Vitushkin (BIPM).

Apologies: K. Chekirda (VNIIM)

Dr Sacconi welcomed the participants to the 14th meeting of the CCL. He asked those who were attending for the first time to introduce themselves. He apologized that a detailed agenda with item timings was not prepared but stated that a more detailed agenda will be prepared for the next meeting.

Dr Sacconi thanked Dr Lewis for his work as *Rapporteur* for the 13th meeting and invited him to act as *Rapporteur* for the 14th meeting. The agenda was tabled and approved.

# 2 REPORT ON ACTIONS ARISING FROM THE SEPTEMBER 2007 MEETING

Dr Sacconi examined the actions list from the previous meeting of the CCL.

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* For the list of acronyms, click here.

A.1 WGDM to request advice from FSWG regarding the new categories to be added to the DimVIM concerning comb based frequency calibrations. **Completed. To be reported at this meeting.**

A.2 WGDM to review the proposed FSWG single frequency list and suggest any additions to the list required for satisfying the needs of dimensional metrology. **Open. The frequency standards list was being revised at the time of the meeting.**

A.3 WGDM to ensure that document WGDM-07-06 '*WGDM responses to CIPM*' is placed on the WGDM website and forwarded to CCL President and BIPM Director. **Completed.**

A.4 WGDM task force and BIPM to co-author a paper, based on document WGDM-07-01 '*CCL comparison scheme*' and ensure that the paper is ready before the 2008 meeting of the CIPM. **Completed. To be reported at this meeting.**

A.5 WGDM chairman to ensure the WGDM report to CCL is made available on the CCL and WGDM document servers. **Completed**.

A.6 BIPM to approach CIPM to propose the eventual co-location of the future meetings of the CCL and CCTF, to enable a FSWG meeting to take place immediately before the meetings of the two CCs. The suggested date for the first of these co-located meetings was June-July 2009. **Completed. Dr Sacconi asked for opinions on the scheduling. Delegates from NMIs a long way from BIPM welcomed the co-location of the CCTF and CCL meetings, as this will make travelling arrangements more efficient.**

A.7 Dr Robertsson and the CCL-K11 pilot and node laboratories to refine the protocol for the CCL-K11 comparison. **Completed. To be reported at this meeting. The comparison was already under way.**

A.8 WGDM to prepare a document, under authority of the CCL, to contain the values from Appendix 2 of the FSWG frequency list, the approved text relating to the use of unstabilized lasers in dimensional metrology and the proposed new standards for nanometrology. **Open. The text for unstabilized lasers has been published. The nanometrology text had not been prepared at the time of the meeting.**

A.9 BIPM Director to prepare a summary of the discussion on the organization of the CCL and its working groups, and a proposal on a possible restructuring, for submission to the next CCL meeting. The **BIPM had prepared a summary for the previous CCL President. An alternative document was prepared during the WGDM meeting held immediately before the CCL meeting. The CCL meeting will cover this work under several agenda items.**

A.10 KCDB coordinator to note the decision regarding the conclusion of comparison BIPM.L-K11 and to mark the comparison in the KCDB as ended. **Completed.**

A.11 Dr Stone, and the *ad hoc* group on the use of 633 nm unstabilized lasers, to prepare a paper on their work for publication in *Metrologia*. **Completed.**

A.12 BIPM to bring to the attention of the CIPM, at its meeting in 2007, the two new Terms of Reference (numbers 3 and 4) proposed for, and by, the FSWG, and to ask the CCL and CCTF Presidents for their approval. **Completed - terms of reference were expanded and discussed at the FSWG meeting held the week before the CCL**

**meeting and these new terms of reference will be presented for discussion during the CCL meeting.**

A.13 BIPM to consider if the Terms of Reference for the FSWG should include an item relating to interaction between the FSWG and the CCTF working group on comparison of high accuracy clocks. **Completed. Now included in the updated Terms of Reference of the FSWG.**

A.14 WGDM Chairman to request the FSWG to include details of the acetylene stabilized 1.5 μm radiation in the FSWG frequency list. **Completed. The data was included in the list and was confirmed as being current.**

A.15 BIPM to take forward, via discussion with Philipe Tuckey, the possibility of a joint workshop between the CCL and the CCTF. **Open.**

Open items were carried forward to the action list for the CCL meeting. This list is included as Appendix L3.

## 3 LINKS BETWEEN THE CIPM MRA AND CONSULTATIVE COMMITTEES – REPORT BY THE DIRECTOR OF THE BIPM

Prof. Wallard asked Dr Arias to give the presentation, which had been shown on the previous day at the WGDM meeting [CCL/WGDM/09-51]. Dr Sacconi requested that this document should be made available on the CCL server as an open document.

## 4 REPORT FROM THE WORKING GROUP IN DIMENSIONAL METROLOGY

Dr Thalmann, the chairman of the CCL Working Group on Dimensional Metrology (WGDM), presented the report [CCL/WGDM/09-91]. The WGDM meeting in September 2008 was held at INRIM in Torino, Italy, and the 2009 meeting was held at the BIPM headquarters on the two days before the CCL meeting. The two *Rapporteurs*, Dr Meli (METAS) and Dr Lewis (NPL), were thanked for their detailed minutes. No additional reports had been prepared as the information was available directly from the minutes.

The WGDM meetings discussed RMO reports, key comparison reports, CIPM MRA activities (including CMCs and the DimVIM), linking of key comparisons, WGDM and CCL structure, and nanometrology. The procedure for the review of CMCs after key comparison reports were available has been updated and this showed that the periodic review of CMCs was being undertaken. Between the meetings, the key and supplementary comparisons were being progressed, and there had been discussions on linking issues, CMC reviews, CMC corrective actions (performed in RMOs, coordinated by a WGDM Taskforce), and technical discussions in the WGDM discussion groups. During the last two years, final reports on comparisons CCL-K3 (angle), CCL-K6 (ball plate), EUROMET.L-S16 (gauge blocks), and Nano5 (2D-grids) were

published in the KCDB. Draft B report of APMP.L-K1.1 (gauge blocks) was approved at the WGDM and the final report will be sent for publication on the KCDB.

The WGDM will retain the option to use both 'classical' and CCL-RMO styles of key comparisons. The new CCL-RMO scheme is essentially equivalent to the classical scheme. It allows the participants to set up a 'virtual' key comparison. The CCL-RMO comparisons are linked. The document 'The CCL-RMO comparison scheme' [CCL/WGDM/09-22] will be maintained and will be further developed to address the issue of linking.

The WGDM Chairman presented several recommendations to the CCL and there was detailed discussion of the first item.

> *Regarding the operation of the new CCL-K11 comparison, WGDM asks the CCL to recommend to the CIPM that the expertise of the BIPM headquarters staff in laser standards (and the portable fs-comb) could be made available during the transition to the operation of the new comparison.*

Dr Arias welcomed this recommendation but suggested that the formal recommendation to the CIPM should be precisely worded in terms of the background rationale and the specific details of what was being requested. Dr Sacconi responded that this was a request for immediate actions rather than a submission for the future programme of work of the BIPM. Dr Gill responded that the FSWG had discussed this during the previous week, and the discussion included proposals for the BIPM programme of work 2013-2016. The requirements were different at the different node laboratories, some of which would not require this service. Prof. Wallard responded that the CIPM decision to close the length section and the forthcoming retirement of some former length section staff meant that it was unlikely that the proposal to the CIPM would be viewed favourably. Dr Arias reiterated that such a request would need very careful and specific wording. Dr Matus said that at least two of the node laboratories would benefit from such a service, especially from an independent entity such as the BIPM. The NMIs were funding the BIPM comb through their national dotation and extension of the work of the BIPM comb, from internal to external services, would improve the cost effectiveness and value for money. The internal uses of the comb, for example in gravimetry, could be served by iodine stabilized lasers. Dr Gill cautioned that the BIPM comb was not as transportable as other combs. He suggested that a compromise might be to limit travelling to the two node laboratories which had the greatest requirement for access to the BIPM comb. The costs were not insignificant. The BIPM would need to examine the costs of ongoing provision but Dr Sacconi wanted to make the most efficient use of staff experience while it was still available. A complication was voiced by Dr Arias that during the current programme, the budget was fixed and resources were already fully committed.

The use of transfer lasers, such as those used for BIPM.L-K11, may satisfy the requirements in terms of validation at the accuracy level that is required. Dr Giardini supported the suggestion for using a travelling laser, as the purpose was to support the services for calibrating lasers for dimensional metrology work. Dr Hong welcomed the contribution of the BIPM staff to the laser comparisons and enquired if Dr Robertsson could come to the node laboratories during the first round of measurements. Dr Bergmans suggested not distinguishing between node laboratories and non-node laboratories which have their own combs. At VSL, the comb is internally validated and the node laboratories could work similarly.

Dr Thalmann continued with the presentation of the WGDM recommendations.

> *Regarding the operation of the new CCL-K11 comparison, WGDM **recommends** the use of the current CCL-K11 protocol for the calibration of stabilized lasers such as lasers belonging to the (former) mise en pratique document.*
>
> *Regarding the participation in the new CCL-K11 comparison, WGDM **recommends** node laboratories to be aware that they should accept participation by any NMI of a Member State, but also be aware that Associate Members require special arrangements to be made.*
>
> *Regarding the validation of fs-combs, the WGDM **recommends** that this should not be part of comparison CCL-K11, but subject to a different comparison exercise, to be discussed by the FSWG, and that separate CMC categories be created for these new calibration services.*
>
> *Regarding the operation of the nodes in CCL-K11, the WGDM **recommends** that the node laboratories check the performance of their own lasers, but that this be performed as part of the NMI's internal quality system rather than as a separate, 'blind' exercise.*
>
> *Regarding the DimVIM CMC categorization list, WGDM **recommends** that the categories 1.1.1 and 1.1.2 be left un-edited at this time, but requests the FSWG to inform the relevant CCL working group (currently WGDM) of any additional parameters that need to be added to the existing wording, for example 'frequency linewidth'.*
>
> *Regarding the operation of comparisons, the WGDM **recommends** that the future planning of key comparisons include more strict rules, especially regarding the transmission of the results in a timely fashion to the pilot.*
>
> *The WGDM **recommends** that comparison pilots issue the draft A report in a simplified form, as soon as possible and only contact NMIs for corrections if potential errors are noticed, and not as a general rule.*

Dr Sacconi thanked the WGDM Chairman for the presentation and mentioned that some of these recommendations would require discussion with the FSWG before formal submission under agenda point 16. He welcomed and supported the recommendation to operate comparisons with enforcement of stricter reporting timescales. Prof. Wallard strongly supported this initiative as the JCRB was aware of many laboratories which were not able to utilize the results of comparisons for the validation of their CMCs in a timely fashion. He added that Dr Thomas scrutinized all final comparison reports that had been submitted and many errors were detected at this stage. He recommended that the pilots should be more careful when writing the reports. Dr Sacconi regarded key comparison reports as being of equal, if not higher, importance than journal papers and recommended independent refereeing of the final reports. Dr Thomas commented that errors included incorrect signs for numbers, transposed NMI names, and differences between numbers in spreadsheets and text files. Dr Thomas added that delays were observed not only in the final report submission, but also in the calculation of the linking. Dr Thalmann commented on the refereeing process by saying that firstly, all the participants and

then all the CCL-WGDM members, are sent the report for comments. In most cases, no comments or corrections are received. He suggested assigning responsibility to one or more persons for checking the quality of the publication. Dr Viliesid was, however, concerned that an additional step for reviewing may further delay publication of the report. He also welcomed stricter rules for key comparisons. Dr Stone asked if one or two of the participants (other than the pilot) could perform the detailed review. Prof. Wallard commented that this was a standing arrangement in another Consultative Committees. Dr Giardini strongly supported the use of a named reviewer for all reports.

Dr Sacconi returned to this agenda point on the second day of the meeting as there was one item omitted on the first day. The first key comparison of the second cycle was about to start and the WGDM had discussed the protocol for this new comparison. The WGDM was satisfied with the overall structure and contents and asked for approval from the CCL. The CCL approved the protocol for the new CCL-K1.2009 comparison.

## 5 NEW ORGANIZATION OF THE CCL AND ITS WORKING GROUPS

Dr Sacconi reflected on the structure of the CCL and its Working Groups. He has direct experience of the efficiency of the work regarding operation of the CIPM MRA through his participation in the WGDM. The WGDM was one the first of the Consultative Committee working groups to submit CMCs to the KCDB and to progress the CIPM MRA work through publications such as the DimVIM CMC categorization list. He was aware that the WGDM, which was created originally to address technical issues of dimensional metrology, had taken on the entire workload of the CIPM MRA on behalf of the CCL. This was not an ideal situation. When the former WGMeP joined with the CCTF to create the FSWG, it seemed logical that the CCL should to be restructured.

Dr Sacconi had taken all of these issues into account, as well as the recent concerns of the CIPM, and had considered the formulation of a new structure. The first new working group that he considered to be necessary was a Working Group (WG) on the CIPM MRA and CMCs (WG-MRA). The second WG should cover Strategic Planning (WG-S). He also wanted to ensure that the important topic of nanometrology was addressed by having a specific working group for this topic (WG-N). Dr Sacconi stated that there should be more technical discussions at the CCL and requested that the existing Discussion Groups (DGs) should be maintained in some form.

Dr Arias stated that it is usually the work of a WG-Strategic Planning to propose changes to the structure of the Consultative Committee and asked if such a Working Group would be set up during the meeting and then take on the task of proposing the new structure. Dr Sacconi replied that he had interpreted the CCL meeting agenda as requiring decisions on setting up all the new Working Groups at this meeting. He asked Dr Thalmann to produce a diagrammatic form of the structure proposed by Dr Sacconi. He added that he hoped that the decisions on forming the new working groups would be taken during this meeting as there was much work to be done before the next CCL meeting and if the groups were not set up until then, nobody would be responsible for the ongoing work and it was likely that it would cease for two years.

Dr Thalmann described the proposed new structure and the possible lines of reporting and responsibility. WG-MRA, WG-S and WG-N as well as the FSWG would report directly to the CCL. The discussion groups would interact with WG-S and WG-MRA as necessary. The WG-

MRA would have three task areas: key comparisons; CMCs; and linking. These could be operated by three taskforces to be set up within the WG-MRA.

Dr Mussio asked if the DGs will report directly to the CCL. Prof. Wallard expected that future CCL meetings will include agenda items on reports from the DGs, so this was anticipated. Dr Sacconi invited further discussion and comments.

Dr Bergmans supported the new structure and saw a clear need for the previous DG on nanometrology to become a separate WG in its own right as this group actually held regular meetings and were concerned with items in addition to the usual discussions on key comparisons that occur within the other DGs. Dr Pekelsky stated that he would like to see the CCL meeting become a discussion forum, rather than just a meeting where reports form the WGs were approved. He hoped to see CCL meetings operate similarly to the previous meetings of the WGDM and this would be better served by having the DGs report directly to the CCL, perhaps also having the WG-MRA task forces report directly to the CCL. In this way, the structure would be horizontal and similar to the proposed structure tabled by the NRC at the CCL meeting in 2007. Dr Pekelsky was mindful of the CIPM MRA workload and therefore hoped to have meetings of the WGs in the years between the CCL meetings in order to make progress with the CIPM MRA work.

Prof. Wallard cautioned against repetition of items at different meetings, especially where attendees at higher level meetings were not so interested in all the items coming from the discussions at the sub-group level. Dr Arias suggested trying a structure where fewer people participated in working groups, especially the working groups concerned with administrative functions. Dr Giardini wanted to see WGs that were small enough to operate efficiently. This may mean that they meet in parallel and people may not be able to attend all working groups. They would have to choose which to attend and have confidence that the WGs would do the work properly and report to the CCL in a way that could be examined and scrutinized if necessary.

Dr Pekelsky expressed concern with the proposed WG-MRA being a single entity. He stated that he would prefer to see the WG-MRA not as one working group but instead having two WGs, one on key comparisons and one on CMCs. The task group on linking, which had a less permanent role, could be a separate part of one of these WGs. These two working groups (WG-KC) and (WG-CMCs) would report directly to the CCL. Dr Kruger also supported separating these two working groups. Dr Balsamo was aware that one or both of the new proposed structures would require much discussion to take place within future CCL meetings. The CCL would not be meeting simply to approve reports from the WGs. He reminded the meeting that the workload of running the CIPM MRA, which was currently within the WGDM, would thus transfer to the CCL, which would become the necessary discussion forum. Biennial meetings of the CCL may then not be frequent enough to allow for this discussion, the CIPM MRA workload is currently undertaken in the WGDM and this requires annual meetings.

Dr Thalmann wished to see more discussion at CCL meetings and therefore only a minimum of reporting from WG-MRA should occur, to allow more time for the DGs to hold discussions during the CCL meeting. He foresaw the operation of WG-MRA as working mostly offline. Prof. Wallard stated that both options (one MRA WG or two) required the CCL to take back much of the workload from the WGDM. In this way, meetings of the CCL would be similar to the meetings of the former CCDM, where agenda items would include reports from RMOs and NMIs.

Dr Bergmans envisaged efficiencies in keeping the two WGs together as their work was interlinked. They would interact directly with each other on CIPM MRA issues rather than bringing the issues to CCL. Dr Sacconi wanted to see the WGs elaborate on the documents but the final decisions needed to be made during CCL meetings. He suggested that, to keep things moving, it may be necessary to test the proposed scheme for a year but also to hold the next CCL meeting in one year's time. Dr Arias added that whatever the working group structure, the decisions would need approval by the CCL so annual meetings of the CCL may be needed whatever structure is chosen and perhaps this would help with the final decision on the structure.

Dr Balsamo examined the practicalities of the proposed structure. He anticipated that all the possible reporting structures would need sufficient time and this may need very careful planning for the timetable of CCL meetings to occur every year. Dr Bosse strongly supported having a CCL meeting which would include technical discussions. He had experience of the work of the WGDM and wanted to see continuity of the work which was undertaken very efficiently. He supported the proposed structure for a single WG-MRA. Dr Bergmans clarified his earlier point about not splitting the two MRA task groups. If the split occurred, there would need to be a means of allowing these two WGs to meet and interact. This may need a meeting of the two WGs before reporting directly to the CCL.

Dr Lewis stated that if the CCL met every year, the meetings would have to be at the BIPM, according to the rules presented by Dr Arias. There would be no opportunity during the 'in between' years for the WGs to meet away from the BIPM, as happens at the moment for the WGDM, unless they happened to coincide with a conference. It was likely that every time the WGs met, this would always be at the BIPM. This could have an impact on the travel arrangements for some delegates. Dr Thomas and Dr Thalmann commented that having two separate meetings of the KC and CMC working groups/taskforces, and then a joint meeting where they could discuss their findings, before presenting to CCL, was a good compromise. This system already operated within WGDM where small groups had met in the evenings to perform work before speaking together at the WGDM meeting. This would operate within the structure originally proposed, namely with one WG-MRA. Dr Viliesid added that previous WGDM meetings had profited from co-locating with conferences and symposia.

Dr Pekelsky was concerned at the proposed increase in the frequency of the CCL meetings, and the necessary formalities that each CCL meeting involved. He suggested that a compromise may be to have the CCL President attend the non-CCL meetings.

After discussions during the lunch break, Dr Sacconi added that there was a concern that splitting the two Working Groups for the CIPM MRA work would result in the RMO TC-L representatives not being able to attend both Working Group meetings in parallel and these persons needed to interact directly with both Working Groups. This would require at least serial, rather than parallel meetings and this fitted well with having a single WG-MRA. Dr Sacconi thought, however that WG-N could generally meet separately, as the people that were active in key comparisons and CMCs were rarely the same.

Dr Sacconi considered and took opinions on the likely format of the meetings and the outcome was that it was considered useful to have a plenary session after the individual WG meetings so that they could interact. Dr Sacconi revisited the historical situation of the CCL. When it was originally set up, the CCL was concerned mostly with dimensional metrology. Then, the work on lasers became the dominant subject and CCDM focused its efforts on this. Now, the lasers

have become frequency standards and the former WGMeP has transformed into the FSWG. It was therefore a good time to revisit the terms of reference for the CCL as a whole.

Dr Kruger considered the options and suggested that the single WG-MRA structure was probably the best. He stressed that the key comparisons are not just supporting the CMCs but also test the most important techniques and developments at the NMIs. He enquired if the WG-N needed to be a joint WG with other CCs. Prof. Wallard stated that nanometrology impacted almost all CCs and the forthcoming BIPM workshop on nanometrology might show the way forward in this respect. Dr Bergmans added that in the past, DG Nano often met at technical conferences and he hoped that this would continue to be the case for WG-N. He expressed concern that a separate delegate would need to be sent at the same time to enable attendance at WG-MRA. Dr Sacconi added that having the WG-S meeting later than the others allowed participation of the other WG chairpersons. Prof. Wallard responded that the challenge was to avoid everybody having to go to all the meetings.

Dr Viliesid asked what form of reporting was envisaged. Prof. Wallard responded that in the years when a CCL meeting was held, formal reporting would be required. In non-CCL years, no formal reporting was to be expected, only the plenary session needed to be informed of major items. Dr Giardini reiterated he preferred to have parallel sessions of the WGs, however Dr Sacconi responded that this would not allow the RMO chairpersons to attend both WG meetings (CMCs, KCs). The WG-N meeting would be in parallel however. Dr Giardini wanted to ensure that non-attendance at the WGs did not disadvantage people from contributing, they could do so during the plenary or CCL sessions.

Dr Lewis enquired how the TC-L chairpersons could attend both the CMC and KC Working Group meetings if they were run in parallel. The RMO TC-L chairpersons have all the information and responsibility from the regions with regard to CMCs, key comparisons and strategy, and if they cannot attend one of the parallel meetings their region is either not represented or they will have to have a second representative. Dr Giardini added that the discussions were focused on the current structure. If the work to be undertaken was such that certain persons or functions had to be present in several places, then the structure should be adjusted to allow for this and to attain a better use of the limited resources.

Example structures from the CCT were examined. In the CCT the RMO representatives attend one meeting on CMCs but the meeting on KC planning is attended instead by the KC pilots. Dr Matus countered that in the CCL the RMO TC-L chairpersons are often the same people as the KC pilots. Dr Pekelsky described the behind the scenes work that took place at the WGDM, where small groups met outside the main WGDM meeting and prepared documents and ideas and these were then taken to the WGDM and discussed by the whole community. He felt that this was how the proposed structure would operate – small groups working aside and then discussing their findings in a plenary session or at the CCL meeting.

Dr Thomas asked if TG-linking was simply part of TG-KC. Dr Matus replied that the work of TG-linking was wider than just linking existing length comparisons, it had to discuss processes, methods and formulate general solutions that may be of interest outside the CCL.

Prof. Wallard showed a draft diagram of how future meetings might be organized. The agenda for the CCL meeting would be much more detailed and extensive than that for the plenary meeting and could include presentations from the NMIs. WG-S would meet specifically only during CCL years, i.e. in the days just before the CCL meeting, to save travelling costs. It would be a small group meeting just after the WG Chairs had finished their own meetings. The

responsibilities of the various WG chairs with regard to preparing the overall meeting agenda was stressed as being very important.

A text representation of Prof. Wallard's diagram is given below, showing the idea of parallel meeting sessions.

Non CCL years

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TRACK 1 MEETINGS:      MRA > KC > CMCs > STRATEGY > PLENARY
TRACK 2 MEETINGS:      NANO >>>>>>>>>>>>>>>>>>>>>>> PLENARY
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CCL years

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TRACK 1 MEETINGS:      MRA > KC > CMCs > STRATEGY > CCL
TRACK 2 MEETINGS:      NANO >>>>>>>>>>>>>>>>>>>>>>> CCL
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Dr Sacconi thanked the meeting for the discussions. He stressed the importance of continuing the work, without pausing for a year and wished to seek agreement to implement the new structure, at least for the next year, so that work could continue in the meantime. He proposed setting up WG-N, WG-S, WG-MRA and also the three TGs within the WG-MRA. The DGs would continue as they already exist, and they would either inform the plenary session (in years when the plenary meeting would take place) or report to the CCL (during years when the CCL meets). The next CCL meeting would be in 2011 but in 2010 there could be, instead, a plenary session involving the WGs, after their individual meetings.

### 5.1 Creation of a WG on Strategic Planning

Dr Sacconi followed tradition and chose to chair this working group himself. The composition would also include the WG-N and WG-MRA chairs as well as the TG-Linking, TG-KCs and TG-CMC chairs, and the RMO TC-L representatives. One of the co-chairs of the FSWG would also be included. The FSWG co-chairs suggested that they alternate their attendance and this was accepted by Dr Sacconi. Dr Sacconi stated that this was the minimum membership and maybe one or two more persons could be invited to attend. Dr Arias asked if, rather than the RMO TC-L chairpersons, alternative representatives from the RMOs might be selected. After consideration, Dr Sacconi agreed. It may be difficult in the case of the TC-L chairperson as they are not from a CCL member NMI. Also, strategy involves long term planning and the TC-L chairperson changes every few years. The conclusion was to include RMO representatives.

Dr Sacconi also invited Dr Giardini to be a member of this group and he accepted. Additional volunteers were invited. Dr Pekelsky and Dr Takatsuji volunteered and were accepted. The Executive Secretary of the CCL was invited to attend.

### 5.2 Creation of a WG on Nanometrology

Dr Sacconi proposed setting up a CCL Working Group on nanometrology. This was an important technical area, previously dealt with as a WGDM Discussion Group. He stated that the

importance of the topic was such that it should now be a CCL Working Group. The members of the CCL agreed.

### 5.3 Status on the creation of a WG on MRA (evolution from TF1 and TF3)

Dr Sacconi proposed that a Working Group should be created to cover all the work of the CCL on CIPM MRA matters. Within this WG-MRA, he proposed setting up three Task Groups: a Task Group on CMCs; a Task Group on KCs and a Task Group on KC linking.

Later in the discussion the names of the two Task Groups, TG-CMC and TG-KC were changed to be sub-Working Groups, i.e. sWG-CMC and sWG-KC. The Task Group on KC linking remained as a Task Group.

### 5.4 Discussion and approval

For the Terms of Reference of the new structures, Dr Sacconi circulated a document which had been edited from existing documents proposed at previous WGDM meetings by delegates from the NRC.

It was confirmed by Dr Sacconi that two of the sub groups of WG-MRA would be referred to as sub-working groups (sWG-KC, sWG-CMC). The Task Force on comparison linking would remain as a Task Force because this group had a specific task in progress. Prof. Wallard confirmed that the naming as sub-Working Groups had no impact on the membership. The membership of sub-Working Groups was open to non-CCL members, whereas Working Group Chairs and normally their members had to come from CCL member laboratories.

Dr Riehle requested that the FSWG should have direct links with the WG-MRA and with WG-S.

Dr Balsamo asked what reason delegates from NMIs of the CCL, who were not members of the new WGs and sWGs, would have to attend the plenary meeting. Potential delegates would only feel a need to attend if the plenary session had sufficient content. Dr Balsamo responded to a WG membership question from Ms Tan that the membership of the new working groups was closed. The previous WGDM had an open membership which is why the attendance was so high. Dr Thalmann added that the WG and sub-WG meetings have specific roles and are not for general membership. If people want to contribute outside these WGs they can contribute to the Discussion Groups. There was strong support for having more technical discussions and this could happen inside the DGs and perhaps in parallel with the other WG meetings.

Dr Pekelsky was concerned that the content of future plenary sessions was becoming very restricted and there was a risk that future CCL meetings would have restricted agendas. He preferred the WGs to carry out the administrative work and to bring the interesting discussions to the CCL or plenary session. An alternative, in order to allow delegates to have increased involvement in WGs, would be that the WGs could have an open membership. Dr Sacconi wished to keep the WG membership restricted. Dr Bergmans noted that in other CCs, there were sub groups for the technical subjects (e.g. mass, force, pressure) and these were the areas where there were technical discussions.

Dr Thomas reiterated a previous suggestion of having a specific WG on dimensional metrology to carry out the technical discussions.

Dr Giardini assured delegates that not being members of the WGs did not mean that they were being ‘left out’. The WGs had tasks to perform and a membership that would accomplish it. The

work would be visible and discussed at the CCL, where the work of the WG would be examined. It was not necessary to be a member of the WG to see the work it performed or to influence it.

Dr Sacconi summarized that the technical discussions could occur during the plenary session rather than needing a separate WG.

Dr Lewis expected the CCL meetings to be very similar to the previous meetings of the WGDM. He felt that delegates who previously wanted to take part in the policy and technical discussions of the WGDM meetings would see the same or better opportunities at the CCL meetings, because the administrative work on CIPM MRA issues was to be devolved to the new WGs, freeing up time in the CCL meetings for technical discussions. Recently, the WGDM had met every year, mostly because it had CIPM MRA work to perform and needed to do this annually. By removing this workload to the smaller WGs, the remaining work would consist of technical discussions. He wondered if there was sufficient technical work and developments to justify a plenary meeting in years when there was no CCL meeting, now the plenary meeting would not be discussing the standard administrative work of the CIPM MRA.

Dr Gill added that delegates at the co-located CCTF, CCL and FSWG meetings in 2009 had found it much more efficient and did not intend to go to many future meetings if they were not as efficiently timetabled. He was cautious of expanding the number of meetings. Dr Bergmans added that there were not so many international dimensional metrology meetings of a wide enough scope and the CCL or WG meetings were the only ones performing this function.

Dr Sacconi agreed that co-locating the CCTF and CCL meetings was useful. He drew the discussions to a conclusion by proposing that he will take on board the detailed discussions and propose a solution as to how the necessary WGs of the CCL could work.

Dr Sacconi returned to this item at the start of the second day, in order to reach a conclusion. A new version of the structural diagram was presented.

## 6 NOMINATION AND APPROVAL OF WG CHAIRPERSONS

These items were discussed in parallel with the setting up of the working groups under agenda item 5.

Dr Sacconi was pleased to see the detailed presentation given during the DG Nano meeting and he proposed Dr Dixson as chairman of WG-N. He asked him to broaden the remit of the presentations in future.

To chair the CMC sub-Working Group of WG-MRA, he took note of the work performed previously by Dr de Oliveira and proposed him as the chairman of this sub-Working Group. Prof. Wallard added that this would be conditional on INMETRO becoming a full member of the CCL.

For chairing the Key Comparisons sub-Working Group of WG-MRA, he proposed Dr Lewis who had already prepared several documents on procedure and had piloted several key comparisons.

For the KC linking Task Group, he proposed Dr Decker as the chairperson.

For overall chairing of WG-MRA, which necessitated the detailed preparations that had so far been performed by the WGDM chairman, he proposed Dr Thalmann. Dr Thalmann commented

that normally as WGDM chairman he would step down soon, but he was willing to continue as chairman of the WG-MRA, at least for a short time, to ensure continuity.

All nominated persons, who were present, accepted their nominations.

## 7 CCL MEMBERSHIP AND MEMBERSHIP OF WORKING GROUPS. TERMS OF REFERENCE OF WORKING GROUPS

Dr Sacconi took this agenda item at the start of the second day, during continuing discussions on several agenda items concerning the new structure. A document describing the new structure was shown and edited during the meeting.

**WG-S – Strategic planning**

Chair: Sacconi (vice chair: Pekelsky)

Members: WG chairs, sWG chairs, representative of FSWG, Giardini, Takatsuji, Bosse, BIPM representative, RMO representatives

Terms Of Reference:

- to collect and make available information giving evidence for the continuing importance of metrology in Length;
- to call for information from the member-NMIs of the CCL regarding long-term research and development activities in order to encourage collaboration and coordination;
- to propose long-term plans for future activities of the CCL over the next ten to fifteen years and review and update these plans on a regular basis;
- to continue collaboration with the FSWG to highlight and support optical frequency sources that are needed for dimensional metrology;
- to define a proposal for the agenda of the Meeting of the CCL WGs;
- to monitor the evolution of the structure of the CCL;
- to ensure that the composition of WG-S is representative of regions.

**WG-MRA**

Chair: Thalmann

*ex officio* members: sWG chairs, members of TGs

Terms Of Reference:

see document WGDM-09-10 TOR_WGDM, implicitly given by task descriptions of sWGs

Sub groups:

sWG-KC – Key comparisons; sWG-CMC – CMCs, DimVIM; TG-L – KC linking

**sWG-KC – Key comparisons**

Chair: Lewis

Members: DG Moderators, RMO TC-L chair persons, KC pilots

Task description:

- to coordinate, supervise and support the administrative process of the pilot laboratories in conducting key comparisons;
- to examine all relevant documents for each key comparison, starting with the protocol and ending with the draft B report;
- to advise the pilot laboratory in preparing the text of the entry to Appendix B of the CIPM MRA as required, including the calculation of Degrees of Equivalence and Linking, and to prepare a recommendation on these subjects for approval by the CCL;
- to prepare guidance documents on identifying significant deviations for use by the pilot laboratories; and
- to advise the pilot laboratory in preparing a comparison status document, and to prepare a recommendation for this summary for the CCL.

**sWG-CMC**

Chair: Oliveira

Members: RMO TC-L chairpersons, Pekelsky, Prieto

Consultation from: JCRB Executive Secretary, CCL Executive Secretary and KCDB Manager

Task description:

- to establish and maintain lists of service categories (DimVIM) and, where necessary, rules for the preparation of CMC entries (DimVIM Guide);
- to agree on detailed technical review criteria;
- to coordinate inter-regional reviews of CMCs submitted by RMOs for posting in Appendix C of the CIPM MRA;
- to provide guidance on the range of CMCs supported by particular key comparisons;
- to identify areas, where additional key and supplementary comparisons are needed; and
- to coordinate the review of existing CMCs in the context of new results of key and supplementary comparisons.

**TG-L KC linking**

Chair: Decker

Members: Giardini, Viliesid, Bosse

Task description:

Work out appropriate ways on linking dimensional metrology key comparisons, support the DG moderators and KC pilots in linking the KC (see also document WGDM-09-21)

**WG-N – Dimensional nano metrology**

Chair: Dixson (vice chair: Bosse)

Members: specialists from member NMIs (former DG7)

Terms Of Reference: to be formulated

**DG1, DG2, DG3, DG4, DG5, DG7, DG8, DG11 – Discussion groups on KC topics**

| | |
|---|---|
| DG1 – gauge blocks | Lewis |
| DG2 – thermal expansion | Takatsuji |
| DG3 – angle | Kruger |
| DG4 – cylindrical diameter standards | Stone |
| DG5 – step gauges | Prieto |
| DG6 – coordinate metrology | (Balsamo) |
| DG7 – linescales | Bosse |
| DG8 – surface texture | Baker |
| DG11 – *mise en pratique* lasers and fs combs | Matus |

Chairs: DG moderators

Members: KC pilot, open to any expert

Task description (as an example for DG1):

- to advise the CCL on matters relating to end standards, including gauge blocks, length bars;
- to advise the CCL on matters related to interferometry with *mise en pratique* (laser) wavelengths, including the effects of the index of refraction of air;
- to produce a working document on principal uncertainty components in end standards metrology; and
- to harmonize the terms and definitions related to end standards metrology.

Dr Sacconi was aware that the FSWG featured on the new structure diagram but thought it was not the place to reiterate or re-state the terms of reference or membership of the FSWG.

Prof. Wallard asked for clarification on what was meant by an item in the draft ToR, concerning the coordination of the inter-RMO review. Dr Thalmann suggested that this was to ensure that

the processes in the different regions were aligned and transparent. Dr Mussio asked to whom the emails on the CMC reviews should be sent. Dr Thalmann responded that this would be the sWG-CMC and WG-MRA chairpersons.

Dr Sacconi requested that WG-S discuss the issue of refractive index and whether or not it required the formation of a new DG. Dr Balsamo mentioned comments from Dr Lewis that there are many more areas of dimensional metrology which have no relevant DG. Dr Thalmann added that it may be useful to add a DG6 on coordinate metrology. The formation of these and other potential discussion groups should be discussed by WG-S.

Ms Tan requested that anyone representing their regions should be responsible for disseminating the information gained from the WG meetings to their regions. This was approved by the delegates.

Dr Sacconi asked Dr Bosse and Dr Dixson to prepare and distribute the proposed terms of reference for WG-N via the CCL President.

Dr Sacconi asked the WG chairmen to consider which parts of the next CCL meeting agenda they can assume responsibility for.

## 8 PRESENT STATUS OF THE NEW ORGANIZATION FOR CCL-K11 – DISCUSSION AND CONCLUSION

This agenda item was discussed immediately before item 7.

Dr Matus presented a report which was shown earlier in the week to the WGDM meeting [CCL-09-08].

Dr Stone asked about comb service verification. Some NMIs can compare their comb with an optical clock and they consider this to be a verification. After this they are able to use the laser to calibrate lasers for customers. Dr Stone asked if, additionally, key comparison participation was necessary. This was necessary in order to support calibration of 'MeP' lasers if this service was to be covered by a CMC. Dr Gill enquired about the way forwards. Could the existing protocol be modified to support alternative ways of verifying the measurement claims?

The meeting agreed that the request to send the frequency value in advance of the measurement actually meant sending the value in advance of the analysis. This meant that the value could be of better quality, but still preserve the 'blind' nature of the comparison.

Dr Sacconi recommended discussions outside the meeting between the CCL-K11 pilot, node laboratories and the FSWG.

## 9 DISCUSSION ON NEW OPTICAL STANDARDS AND COMPARISON TECHNIQUES

Dr Gill gave a presentation which had previously been given to the CCU, on a new definition of the second. [CCL/09-09]. Optical clocks are superior to the best primary Cs clocks with respect to stability and accuracy. It is presently not clear whether the best approach will be single trapped ions or neutral atoms in an optical lattice. The CCTF and CCL have established a

Working Group that recommends frequencies for secondary realizations of the second and practical realizations of the metre. One of these standard frequencies may lead to a new definition of the second. The CCU encourages the laboratories to work on optical frequency standards for a possible new definition of the second in 2019. However, further developments in time and frequency transfer are needed first. The CCU encourages the FSWG to list optical frequency ratios. New definitions of the SI base units kg, A, mol, and K will also lead to a new phrasing of the definitions of the metre and the second.

e.g. The metre as the base unit of length is defined such that the speed of light is 299 792 458 $ms^{-1}$;

e.g. The second as the base unit of time is defined such that the hyperfine transition in $^{133}Cs$ is 9 192 631 770 Hz.

Feedback from committees, such as the CCL on the proposed new definition of the metre, was welcomed.

## 10 PROPOSALS FOR NEW KEY COMPARISONS

No proposals for new comparisons were made.

## 11 IMPLICATIONS OF THE CIPM REPORT ON MATERIALS METROLOGY FOR CCL

Prof. Wallard gave some background information, mentioning the report of the Materials Metrology working group, written by the CIPM member, Dr Bennett (NPL, UK). The concept of a Memorandum of Understanding with VAMAS had been explored and a MoU had been signed recently by both VAMAS and the BIPM. VAMAS was asked to report annually to the CIPM on proposed actions and VAMAS was likely to suggest topics for pilot studies. VAMAS has 15 working groups, some of which were of interest to the CCL: Nano-mechanical measurements on SPMs; creep and cracking in welds; working group on modulus measurements.

The MoU and the CIPM Report on Materials metrology were both available from the BIPM website. There would be a special issue of *Metrologia* on materials measurements edited by Dr Bennett. Dr Bergmans informed the meeting that VSL had started some fundamental national projects in materials, and he hoped that these may provide outputs of use in topics such as understanding the drifts observed in several dimensional metrology key comparisons.

Prof. Wallard suggested waiting for the information expected from VAMAS and then discussing this further at the next meeting.

## 12 REPORT FROM THE CCL-CCTF WORKING GROUP ON FREQUENCY STANDARDS (FSWG)

Dr Gill presented the report of the FSWG. He gave an overview of the work of the FSWG since its inception. Work had been performed in a number of areas since the previous CCL meeting.

Different optical transitions are being investigated in different institutes and strategic co-operations. Novel concepts of time and frequency transfer suitable for optical clocks are being explored. The Cs definition of the second has served the needs of industry for some time, and the secondary representations serve the needs of the science community. It would only be correct to undertake a new definition of the second when progress with optical standards slows down and transfer problems have been solved.

There has been much discussion regarding the protocol for comparison CCL-K11. Possibilities for an amended protocol wider than current one have been discussed. These include: participation in CCL-K11 or bilateral with a laboratory operating high accuracy standards to validate capability of transfer laser uncertainty; transportation of comb systems to the BIPM or a CCL-K11 node laboratory; node laboratory/other to demonstrate methodologies for direct frequency determination from their primary realization of the second, or from secondary representations; node laboratory/other to show equivalence via 2-comb measurement of the same standard and methods to ensure comb operational functionalism.

In terms of the list of standard frequencies, there were new entries into the list ($^{40}Ca^{+}$, $^{171}Yb$, $^{88}Sr$), an update of a value already in the list ($^{171}Yb^{+}$), an update of the value and uncertainty of a secondary realization of the second ($^{87}Sr$), but no new secondary representations of the second and no new realizations of the definition of the metre.

Other actions and subgroup work included the setting up of guidelines on how to deal with new values, to develop a protocol for traceability of the metre directly from the Cs clock, to evaluate the implications of (optical) frequency ratios e.g. for inclusion in the list and to set up a questionnaire about possible new BIPM activity in supporting comb validations. In order to highlight the recent changes in moving to a single list of standard reference frequencies which serves the CCL requirements for the definition of the metre and the CCTF secondary representations of the second, and other applications, a draft paper for *Metrologia* was being prepared. The values in the paper would be introduced by historical rationale and perspective. There would be a single list with values and uncertainties (including the 2009 update), appendices for secondary representations and realization of the metre.

This agenda point was returned to later in the meeting, when Dr Gill presented a proposal from the FSWG for a recommendation regarding the single list of recommended frequencies.

The Consultative Committee for Length,

**considering** that

- a common list of “Recommended values of standard frequencies for applications including the practical realization of the metre and secondary representations of the second” has been established,
- the CCL-CCTF Frequency Standards Working Group (FSWG) have reviewed several promising candidates for inclusion into the list,

- the CCTF at its session in June 2009 has already recommended new values for the same reference frequencies;

**recommends** that the following transition frequencies shall be included or updated in the list of recommended standard frequencies

- the unperturbed optical transition $5s^2\ ^1S_0 - 5s\ 5p\ ^3P_0$ of the $^{87}Sr$ neutral atom with a frequency of
  429 228 004 229 873.65 Hz and a relative standard uncertainty of $1 \times 10^{-15}$.

  This radiation is already endorsed by the CIPM as a secondary representation of the second.
- the unperturbed optical transition $5s^2\ ^1S_0 - 5s\ 5p\ ^3P_0$ of the $^{88}Sr$ neutral atom with a frequency of
  429 228 066 418 012 Hz and a relative standard uncertainty of $1 \times 10^{-14}$.
- the unperturbed optical transition $4s\ ^2S_{1/2} - 3d\ ^2D_{5/2}$ of the $^{40}Ca^+$ ion with a frequency of
  411 042 129 776 393 Hz and a relative standard uncertainty of $4 \times 10^{-14}$.
- the unperturbed optical transition $^2S_{1/2}$ ($F$=0) – $^2F_{7/2}$ ($F$=3, $m_F$=0) of the $^{171}Yb^+$ ion with a frequency of
  642 121 496 772 657 Hz and a relative standard uncertainty of $6 \times 10^{-14}$.
- the unperturbed optical transition $6s^2\ ^1S_0$ ($F$=1/2) – $6s\ 6p\ ^3P_0$ ($F$=1/2) of the $^{171}Yb$ neutral atom with a frequency of
  518 295 836 590 864 Hz and a relative standard uncertainty of $1.6 \times 10^{-13}$.

The CCL approved the text of the recommendation.

## 13 UPDATE OF THE INTER-RELATIONSHIP BETWEEN CCL AND CCTF – DISCUSSION AND CONCLUSIONS

A new draft of the FSWG terms of reference was tabled in the format of a decision from the CCTF.

Dr Thalmann and Dr Matus queried exactly what responsibilities were being assumed by the FSWG with regard to comparisons such as CCL-K11. Previously it had been decided that this had been limited to technical issues, with the administrative items being the responsibility of the WGDM (now to be transferred to WG-MRA).

CCL supported the recommendation but asked that the bullet point number 3 on responsibilities be clarified so that it is limited to technical issues only.

Also, the CCL requested that this item needed to be amended to include preparation of a suitable protocol in order that CMCs could be supported.

Dr Pekelsky asked for the official name of the joint working group. Dr Arias replied that it was now called the CCL-CCTF Frequency Standards Working Group (CCL-CCTF FSWG). Up until now WGDM had referred to it as JFSWG. It would now be referred to as FSWG.

After discussing several other agenda items, Dr Riehle and Dr Gill amended the text for the decision and it was re-tabled for discussion:

**Decision CCL (2009)**
The Consultative Committee for Length,

**considering** that:

- the terms of reference of the Frequency Standards Working Group (FSWG) have been amended by the CCTF 2009
- the CIPM requested to have a well defined procedure for the appointment of the chairperson of each working group to be defined in the terms of reference
- the CCL-K11 protocol refers only to the validation of CMC entries by participating in the CCL-K11 key comparison of stabilized laser standards

**Agrees** to the new Terms of Reference for the FSWG as given below:

1. To maintain and update a list of recommended frequency standard values and wavelength values for the realization of the definition of the metre and for secondary representations of the second, and for other applications;
2. To make recommendations to:
   - CCL for radiations to be used for the realization of the definition of the metre,
   - CCTF for radiations to be used as secondary representations of the second.
3. To take responsibility for key comparisons of standard frequencies such as CCL-K11.
4. To respond to future needs of both the CCL and CCTF concerning standard frequencies relevant to the respective communities.
5. The chairperson is appointed jointly by the CCL and CCTF chairpersons for a period of four years (or at least two consecutive committee meetings) with the possibility of a second term.

**Confirms**

that the responsibility of the FSWG in respect of CCL-K11 refers to the technical issues only

and **Decides**

that the FSWG draw up procedures for an extended CCL-K11 protocol that will allow the traceability of the realization of the definition of the metre directly from the primary standard of frequency, thereby underpinning comb-based CMCs.

Dr Thalmann enquired whether or not this was in contravention of the rules demanding participation in a key comparison where one exists in the relevant area. The conclusion was that the only length key comparison in this area was CCL-K11 and therefore some way of participating in this comparison was necessary for those wishing to submit CMCs for measurements based on their fs-combs. If the protocol could be altered to allow alternative demonstrations of traceability, then such CMCs could be supported by participation in and according to the rules of CCL-K11.

The revised text was accepted and the CCL agreed on the decision.

Dr Thalmann asked how the sWG-CMCs would review these CMCs. Dr Sacconi asked that this be added as an action for the sWG to address.

Dr Sacconi asked how well the co-location of CCTF and CCL had been received. Dr Gill responded that on this occasion it had worked well because the short period between the CC meetings had allowed both meetings to approve recommendations. Prof. Wallard enquired about the terms of office of the two joint chairmen. They responded that the terms were not yet complete and the terms of reference allowed for a second term. Both chairmen were happy to continue or step down as necessary.

## 14 REPORT AND DISCUSSION ON THE PRESENT WORK AT THE BIPM

Mr Felder presented the report, revisiting the timetable of the closure of the BIPM's length section. Since the previous meeting of the CCL, the budget, as voted by the meeting of the CGPM and the response by the CIPM, had required the iodine cell service to be closed. A letter was sent to existing customers of the service in September 2008. Last orders from the customers were requested in October 2008. In July 2009, the service will be closed definitively.

Mr Felder described all the features and organization of the iodine cell service. This had involved several BIPM staff including R. Felder, J. Labot and L. Robertsson and the service required considerable background services. Approximately 15 cells per year were supplied, split equally between 633 nm He-Ne standard cells and specially designed cells. Strong demand existed for other molecules or atoms but these had never been taken up by the BIPM.

Potential future suppliers included INRIM, LNE-INM/CNAM, NPL, NMIJ, Neoark (Japan), and Institute for Scientific Instrumentation (Brno, Czech Republic). Dr Matus asked if an application note would be published in a journal containing the knowledge of the staff involved. The BIPM planned to share a reasonable amount of information from its iodine service. Prof. Wallard wanted to ensure that the NMIs were the primary recipients of the information. The existing quality procedures would be available, but he thought that the main knowledge was embodied in the experience of the staff involved. Dr Zucco asked what would happen to the existing materials and equipment. The difficulty was that there was more than one laboratory interested in taking on the activity. There was also a legal issue that consultation should be wider than the laboratories which had already responded. Prof. Wallard requested any NMIs with a genuine interest to correspond directly with the BIPM.

Dr Sacconi requested that the previous discussion on requesting assistance or use of the BIPM fs-comb and the operation of CCL-K11 should be revisited. Dr Matus responded that a new wording of the request was available for submission. Regarding the questionnaire on CCL-K11, this was not yet ready and nothing additional could be tabled.

Dr Robertsson reported on the work on interferometric measurement of the calculable capacitor electrode position and a subtle correction required to compensate for diffraction effects in laser systems used in gravimetry [*Metrologia* 44 35-39]. The correction for the gravimeter required accurate determination of the beam waist and this required measurement of the wavefront curvature using a Shack-Hartman sensor. Dr Stone asked what size the Abbe offset was and

whether or not it was measurable. He suspected that it could represent a surprisingly big problem.

Dr Vitushkin presented the recent work on gravimetry, a subject which is reported to a working group in the CCM. However the work is performed within the Time, Frequency and Gravimetry section at the BIPM, and therefore is of interest to the CCL. Typically 640,000 fringes are recorded in the 0.2 s drop time in the BIPM gravimeter. Uncertainties of $10^{-9}$ in distance and $5\times10^{-10}$ in time measurement are required – this is not easy in a 0.2 s period. The 2009 key comparison of gravimeters (ICAG) will include measurement of 27 absolute gravimeters. The best typical expanded uncertainties obtained are around 5 μGal. The results over time indicate that the gravity field at the BIPM is stable in time. However, there was a possibility that the gravimetry work at the BIPM might cease.

Dr Giardini asked about Dr Vitushkin's statement that the length unit is not realized in the absolute gravimeter by only the laser, but by the interferometer. Dr Vitushkin responded that for the realization of the length unit it needs to "mark" two points in space between which there is the length unit or its part. To do this one must place there two material bodies or "material points" with the non-zero rest mass (see, for example, the book by V. Fock "The theory of space, time and gravitation"). The laser alone generates only an infinite travelling electromagnetic wave which does not "mark" in space any selected points. It is possible only with the help of material bodies (for example, the mirrors, the rods (rails) where the mirrors are fixed, *etc*.). Thus not only the laser but the laser displacement interferometer of the absolute gravimeter realizes the length unit. Dr Sacconi asked the CCL to recommend that the work on gravimetry continue at the BIPM.

## 15 BIPM FUTURE ACTIVITIES (2009-2012 AND 2013-2016) IN RESPONSE TO THE NEEDS OF THE NMIS

Dr Arias made the presentation. The programme of work 2009-2012 is under way. The programme of work was modified after prioritization of programmes at the BIPM following the CGPM meeting in 2007. A CIPM workshop in November 2008 discussed the future work of the BIPM in preparation for the CGPM meeting in 2011.

What the NMIs should expect from the BIPM in the future included items such as: maintaining the highest technical competence in metrology; availability of trained staff; well equipped laboratories; awareness of new trends in metrology; and promotion of the benefits of having access to an organized structure for metrology. NMIs would see the Metre Convention and the CIPM MRA as the vehicle for accessing international equivalence in measurements. The BIPM would provide support to NMIs in key activities in metrology, including support for Consultative Committees and NMI directors meetings, coordination of actions initiated in the scientific sections, and having a voice in international organizations.

However, there were major challenges ahead in terms of funding and available staff resources.

Prof. Wallard hoped that the BIPM would be successful in attracting additional Members before the next meeting of the CGPM and in this case additional funding may become available. The timetable would be that the CGPM would meet in Oct 2011 and the Convocation for the meeting will be sent to Members a few months beforehand. This will be accompanied by a draft programme of work for 2013-2016. This will require approval by CIPM in October 2010. The

next CCL meeting would be too late to influence the agenda for the next meeting of the CGPM as the preparation of proposals was already under way and would be concluded by then. Watt Balance and mass dissemination will be a high priority. This is closely followed by TAI and UTC operations. Next will come work in electricity (quantum Hall effect, Josephson junctions, increased interest in resistance measurement, calculable capacitor), chemistry, ionizing radiation (including a proposal for a linear accelerator at the BIPM, costing ~2.5 million euros), and nanometrology.

Dr Sacconi thanked Prof. Wallard for the interesting insight into the process. Dr Pekelsky asked what parts of nanometrology were to be addressed and if it was limited to non-length based nanometrology. Prof. Wallard responded that the BIPM workshop in February 2010 and the work programme were open across all technical fields.

## 16 RECOMMENDATIONS TO THE CIPM

A prepared version of the recommendation on key comparison CCL-K11 was tabled and edited.

### RECOMMENDATION CCL (2009)

### Supporting key comparison CCL-K11 in national metrology laboratories

The Consultative Committee for Length,

**considering** that

- the key comparison of stabilized lasers has been defined by the CCL as a BIPM key comparison under the name BIPM.L-K11 in 2003,
- the BIPM organized BIPM.L-K11, started the first measurements in 2004, and ran successful comparisons of more than thirty frequency standards until the end of 2006,
- the CIPM recommended to re-organize it as a CCL key comparison under the name CCL-K11 with one pilot laboratory and several node laboratories distributed in the regions;

**aware** that

- CCL-K11 has started under the new structure, with one pilot and four other node laboratories,
- these laboratories call for technical expertise from the BIPM,
- the CCL WGDM had recognized this need;

**recommends** that

the BIPM provide support to the development of CCL-K11 during a transition period by allowing one of its experts on laser frequency metrology to assist the node laboratories.

The edited text was accepted by the meeting. The text of the other recommendation had already been edited and approved in an earlier agenda item.

Another recommendation proposed by the FSWG (see section 12) was accepted by the meeting.

## 17 ANY OTHER BUSINESS

Ms Tan requested the CCL membership list on the BIPM website to be updated to include A*STAR rather than SPRING, as a member of CCL.

Ms Tan enquired which person or persons were to be the contact persons for arranging the various working group meetings. Dr Thalmann volunteered and Dr Sacconi agreed.

Ms Tan requested action to determine the optimum meetings dates for the Meeting of the CCL Working Groups in Singapore in 2010.

## 18 NEXT MEETING OF THE CCL

The next meeting of the CCL will be in 2011. It should be arranged so that it will be co-located at a similar time to the CCTF meeting.

Dr Sacconi thanked all of the participants for the excellent discussions and Dr Lewis for the minutes of this and previous CCL meetings which Dr Sacconi had found very useful.

Prof. Wallard reminded the meeting of the forthcoming retirement of several BIPM staff who had worked in the length section: Leonid Vitushkin, Raymond Felder and Jacques Labot. The meeting showed its appreciation for their work.

Mr Felder thanked Dr Gill, Dr Juncar, Dr Arias and all of the colleagues he had worked with over the years.

The staff of the BIPM were thanked for their help during the meeting and behind the scenes.

The meeting was closed.

**RECOMMENDATIONS OF**
**CONSULTATIVE COMMITTEE FOR LENGTH**

**SUBMITTED TO THE**
**INTERNATIONAL COMMITTEE FOR WEIGHTS AND MEASURES**

## RECOMMENDATION CCL1 (2009)

## Supporting key comparison CCL-K11 in national metrology laboratories

The Consultative Committee for Length,

**considering** that

- the key comparison of stabilized lasers has been defined by the CCL as a BIPM key comparison under the name BIPM.L-K11 in 2003,
- the BIPM organized BIPM.L-K11, started the first measurements in 2004, and ran successful comparisons of more than thirty frequency standards until the end of 2006,
- the CIPM recommended to re-organize it as a CCL key comparison under the name CCL-K11 with one pilot laboratory and several node laboratories distributed in the regions;

and **aware** that

- CCL-K11 has started under the new structure, with one pilot and four other node laboratories,
- these laboratories call for technical expertise from the BIPM,
- the CCL WGDM had recognized this need;

**recommends** that

- the BIPM provide support to the development of CCL-K11 during a transition period by allowing one of its experts on laser frequency metrology to assist the node laboratories.

## RECOMMENDATION CCL2 (2009)

## Updates to the list of standard frequencies

The Consultative Committee for Length,

**considering** that

- a common list of "Recommended values of standard frequencies for applications including the practical realization of the metre and secondary representations of the second" has been established,
- the CCL-CCTF Frequency Standards Working Group (FSWG) has reviewed several promising candidates for inclusion into the list,
- the CCTF at its session in June 2009 has already recommended new values for the same reference frequencies;

**recommends**

that the following transition frequencies shall be included or updated in the list of recommended standard frequencies:

- the unperturbed optical transition $5s^2\ ^1S_0 - 5s\ 5p\ ^3P_0$ of the $^{87}Sr$ neutral atom with a frequency of
  429 228 004 229 873.65 Hz and a relative standard uncertainty of $1 \times 10^{-15}$.

  This radiation is already endorsed by the CIPM as a secondary representation of the second.
- the unperturbed optical transition $5s^2\ ^1S_0 - 5s\ 5p\ ^3P_0$ of the $^{88}Sr$ neutral atom with a frequency of
  429 228 066 418 012 Hz and a relative standard uncertainty of $1 \times 10^{-14}$.
- the unperturbed optical transition $4s\ ^2S_{1/2} - 3d\ ^2D_{5/2}$ of the $^{40}Ca^+$ ion with a frequency of
  411 042 129 776 393 Hz and a relative standard uncertainty of $4 \times 10^{-14}$.
- the unperturbed optical transition $^2S_{1/2}$ ($F$=0) – $^2F_{7/2}$ ($F$=3, $m_F$=0) of the $^{171}Yb^+$ ion with a frequency of
  642 121 496 772 657 Hz and a relative standard uncertainty of $6 \times 10^{-14}$.
- the unperturbed optical transition $6s^2\ ^1S_0$ ($F$=1/2) – $6s\ 6p\ ^3P_0$ ($F$=1/2) of the $^{171}Yb$ neutral atom with a frequency of
  518 295 836 590 864 Hz and a relative standard uncertainty of $1.6 \times 10^{-13}$.

## APPENDIX L 1.

### Working documents submitted to the CCL at its 14th meeting

Open working documents of the CCL can be obtained from the BIPM in their original version, or can be accessed on the BIPM website:

http://www.bipm.org.cc/AllowedDocuments.jsp?cc=CCL

Documents restricted to Committee Members can be accessed at the restricted website.

| Document | |
|---|---|
| CCL/09-00 | BIPM. – Agenda (access restricted), 1 p. |
| CCL/09-01 | BIPM/CCL. – Report of the 13th Meeting of the CCL, 46 pp. |
| CCL/09-ref | CCL. - Advice from the CCL on the use of unstabilized lasers as standards of wavelength: the helium-neon laser at 633 nm (*Metrologia, 2009, 46, 11-18*). |
| CCL/09-03 | BIPM. – Links between the CIPM MRA and CCs. |
| CCL/09-08 | BEV. – CCL-K11 presentation (access restricted), 17 pp. |
| CCL/09-09 | CCU/09-P2. – On a new definition of the second, 15pp |
| CCL/09-10 | Report of the 2009 meeting of the CCL/CCTF FSWG, 9pp |
| CCL/09-11 | Minutes of the 14th WGDM meeting (2009), 23pp |
| CCL/09-12 | WGDM report to the CCL, 6pp |

## APPENDIX L 2.
## List of decisions made by the CCL at its 14th meeting

This list is a summary of the decisions made by the CCL at its 14th meeting.

### DECISION CCL 1 (2009) – creation of a working group on strategic planning

The Consultative Committee for Length (CCL),

**decides** to create a CCL Working Group on strategic planning (WG-S);

**decides** that the chair of this working group shall be the CCL President, with Dr Pekelsky (NRC-INMS) as vice-chair;

**decides** that the membership shall comprise: chairpersons of other CCL Working Groups and their sub-Working Groups, representatives of the CCL-CCTF FSWG, Dr Bosse (PTB), Dr Giardini (NMIA), Dr Takatsuji (NMIIJ/AIST), a BIPM representative, and additional RMO representative(s) as necessary to ensure that each RMO is represented;

**asks** that the draft terms of reference for WG-S, submitted during the 14th meeting of the CCL and recorded in document CCL-09-30, be elaborated by WG-S and submitted to CCL for future formal approval.

### DECISION CCL 2 (2009) – creation of a working group on the CIPM MRA

The Consultative Committee for Length (CCL),

**decides** to create a CCL Working Group on operation of the CIPM MRA (WG-MRA);

**decides** that the chair of this working group shall be Dr Thalmann (METAS);

**decides** that the working group shall be comprised of a sub-Working Group on key comparisons (sWG-KC), a sub-Working Group on CMCs (sWG-CMC) and a Task Group on key comparison linking (TG-L);

**decides** that the membership of WG-MRA shall be comprised of the members of the two sub-Working Groups and the Task Group;

**asks** that the draft terms of reference for WG-MRA submitted during the 14th meeting of the CCL and recorded in document CCL-09-30, be elaborated by WG-MRA and submitted to CCL for future formal approval.

### DECISION CCL 2a (2009) – creation of a sub-working group on key comparisons

The Consultative Committee for Length (CCL),

**decides** to create a sub-Working Group of WG-MRA on key comparisons (sWG-KC);

**decides** that the chair of this sub-working group shall be Dr Lewis (NPL);

**decides** that the membership of sWG-KC shall be comprised of the moderators of the Discussion Groups, the RMO TC-L chairpersons and the key comparison pilots;

**asks** that the draft terms of reference for sWG-KC submitted during the 14th meeting of the CCL and recorded in document CCL-09-30, be elaborated by sWG-KC and submitted to CCL for future formal approval.

### DECISION CCL 2b (2009) – creation of a sub-working group on CMCs

The Consultative Committee for Length (CCL),

**decides** to create a sub-Working Group of WG-MRA on CMCs (sWG-CMCs);

**decides** that the chair of this sub-working group shall be Dr de Oliveira (INMETRO);

**decides** that the membership of sWG-CMC shall be comprised of the RMO TC-L chairpersons, Dr Pekelsky (NRC-INMS) and Dr Prieto (CEM);

**asks** that the draft terms of reference for sWG-CMC submitted during the 14th meeting of the CCL and recorded in document CCL-09-30be elaborated by sWG-CMC and submitted to CCL for future formal approval.

### DECISION CCL 2c (2009) – creation of a task group on key comparison linking

The Consultative Committee for Length (CCL),

**decides** to create a Task Group of WG-MRA on key comparison linking (TG-L);

**decides** that the chair of this task group shall be Dr Decker (NRC-INMS);

**decides** that the membership of TG-L shall be comprised of Dr Bosse (PTB), Dr Giardini (NMIA) and Dr Viliesid (CENAM);

**asks** that the draft terms of reference for TG-L submitted during the 14th meeting of the CCL and recorded in document CCL-09-30 be elaborated by TG-L and submitted to CCL for future formal approval.

## DECISION CCL 3 (2009) – creation of a working group on dimensional nano- metrology

The Consultative Committee for Length (CCL),

**decides** to create a CCL Working Group on nano dimensional metrology (WG-N);

**decides** that the chair of this working group shall be the Dr Dixson (NIST);

**decides** that the membership shall comprise of experts from the NMIs;

**asks** that WG-N prepares an updated membership list;

**asks** that WG-N prepares a draft Terms of Reference and submits this to CCL for future formal approval.

## DECISION CCL 4 (2009) – terms of reference of the CCL-CCTF-FSWG

The Consultative Committee for Length (CCL),

**considering** that:

- the terms of reference of the Frequency Standards Working Group (FSWG) have been amended by the CCTF 2009,
- the CIPM requested to have a well defined procedure for the appointment of the chairperson of each working group to be defined in the terms of reference,
- the CCL-K11 protocol refers only to the validation of CMC entries by participating in the K11 key comparison of stabilized laser standards;

**agrees**

to the new Terms of Reference for the FSWG as given below:

1. To maintain and update a list of recommended frequency standard values and wavelength values for the realization of the definition of the metre and for secondary representations of the second, and for other applications;
2. To make recommendations to:
    - CCL for radiations to be used for the realization of the definition of the metre,
    - CCTF for radiations to be used as secondary representations of the second.
3. To take responsibility for key comparisons of standard frequencies such as CCL-K11.
4. To respond to future needs of both the CCL and CCTF concerning standard frequencies relevant to the respective communities.
5. The chairperson is appointed jointly by the CCL and CCTF chairpersons for a period of four years (or at least two consecutive committee meetings) with the possibility of a second term.

**confirms**

that the responsibility of the FSWG in respect of CCL-K11 refers to the technical issues only;

and **decides**

that the FSWG draw up procedures for an extended CCL-K11 protocol that will allow the traceability of the realization of the definition of the metre directly from the primary standard of frequency, thereby underpinning comb-based CMCs.

### DECISION CCL 5 (2009) – approval of the protocol for CCL-K1.2009

The Consultative Committee for Length (CCL),

**considering** that:

- the protocol [CCL/WGDM/09-31-1] for the second round CCL key comparison, CCL-K1.2009 had been discussed at the 2009 meeting of the WGDM;
- the WGDM had recommended approval of the protocol;

**approved** the protocol

provided that only minor changes were yet to be made, such as finalization of the timetable and list of participants.

### DECISION CCL 6 (2009) – improving the quality of key comparison final reports

The Consultative Committee for Length (CCL),

**considering** that:

- errors have been detected in key comparisons reports submitted to the KCDB from several consultative committees;
- the key comparison reports are a visible part of the operation of the MRA;

**asks**

pilots of key and supplementary comparisons in length metrology to arrange for independent review of the comparison final reports before they are submitted to the KCDB.

### DECISION CCL 7 (2009) – regional representation at CCL and WG meetings

The Consultative Committee for Length (CCL),

**considering** that:

- representatives from the RMOs are to be present at meetings of several CCL working groups;
- the RMO representatives are invited in their capacity to represent certain communities of the RMOs, such as the RMO TC-L committee,

**reminds** RMO representatives

that they have a duty to disseminate information received from the meetings that they attend, to the wider community within their RMO.

### DECISION CCL 8 (2009) – reducing the delay in reporting on key and supplementary comparisons

The Consultative Committee for Length (CCL),

**considering** that:

- the key comparison guidelines call for prompt reporting of results to the pilot, after measurement by a participant,
- several NMIs have expressed dissatisfaction at the time taken for comparison reports to be published and become openly referable,

**supports**

action by comparison pilots to enforce more strict guidelines concerning the late transmission of results to the pilot laboratory.

## APPENDIX L 3.
## List of actions resulting from the 14th meeting of the CCL

This is a list of the actions from the 14th meeting of the CCL, including those carried forward from the 13th meeting.

A.1 WGDM (now WG-MRA) to review the proposed FSWG single frequency list and suggest any additions to the list required for satisfying the needs of dimensional metrology.

A.2 BIPM to take forward, via discussion with Philipe Tuckey, the possibility of a joint workshop between the CCL and the CCTF.

A.3 WGDM (now WG-MRA) to prepare a document, under authority of the CCL, to contain the values from Appendix 2 of the FSWG frequency list, the approved text relating to the use of unstabilized lasers in dimensional metrology and the proposed new standards for nanometrology.

A.4 Dr Arias to make the presentation on the links between the CIPM MRA and consultative committees available on the CCL server as an open document.

A.5 RMO TC-L chairpersons to recommend to pilots of key comparisons that are currently running or are in the planning stage, to arrange for independent refereeing of the final reports, by one of the participants (other than the pilot), before submission to KCDB via CCL.

A.6 sWG-CMC to investigate how to perform the review of CMCs supported by participation in CCL-K11.

A.7 Dr Bosse and Dr Dixson to prepare and distribute via the CCL President the proposed terms of reference for WG-N.

A.8 Dr Bosse and Dr Dixson to update the membership list for WG-N and forward to the CCL for information.

A.9 WG-S, WG-MRA, sWG-CMC, sWG-KC and TG-L to elaborate their terms of reference, based on document CCL-09-30 and submit to the CCL for approval.

A.10 The WG chairs to correspond and determine which parts of the agenda of the next Meeting (of the CCL WGs) each WG would assume responsibility for.

A.11 The BIPM to update the CCL membership list on the BIPM website to include A*STAR rather than SPRING, as a member of the CCL.

A.12 Ms Tan to determine the optimum meeting dates for the Meeting of the CCL Working Groups in Singapore in 2010.

**APPENDIX L 4.**

**Report of the meeting of the Frequency Standards Working Group**
BIPM, Sèvres, 2-3 June 2009

See document http://www.bipm.org/wg/CCL/CCL-CCTF/Restricted/2009/Report_FSWG-June09.pdf

**APPENDIX L 5.**

**Report of the meetings of the Working Group on Dimensional Metrology**
INRIM, Torino, 24-25 September 2008
BIPM, Sèvres, 8-9 June 2009

See document http://www.bipm.org/wg/CCL/WGDM/Restricted/14/WGDM-09-91-Report_to_CCL.pdf