# Minutes of The CCL-CCTF Frequency Standards Working Group Meeting

($10^{th}$ –$11^{th}$ September 2007)

Agenda:

Monday, $10^{th}$ September

1. Welcome to existing and invited members.
2. Appointment of rapporteur(s).
3. Review of working group changes in light of single frequency list adoption and associated single working group.
4. Coordination between CCL and CCTF.
5. Terms of Reference of the CCL-CCTF Frequency Standards WG.
6. Consideration of returns from NMIs to WG questionnaire.
7. Consideration of additions/updates to the revised list, recognising that no proposal of recommendation for secondary representations of the second will be made until the WG meeting just prior to the next CCTF.
8. Presentation of the new organization for key comparison CCL.L-K11 and consideration of responsibility for it (ie within new WG? and not within JWG?).
9. Presentation by WG chairmen of a draft structure for the revised list of recommended radiations (hard copy version) to be published in Metrologia.

Tuesday, $11^{th}$ September

10. Detailed discussion on the draft of the list of recommended radiations to be published in Metrologia, including structure and contents.
11. Preparation of WG recommendations to CCL on the structure and contents of the list of recommended radiations for publication in Metrologia.
12. Preparation of WG recommendation(s) to CCL on CCL.L-K11 key comparison responsibility.
13. AOB

The following were present: P. Balling (CMI), F. Bertinetto (I.N.RI.M), N. Brown (NMIA), M. S. Chung (KRISS), A. Clairon (LNE-SYRTE), L. Erard (LNE), W. Giardini (NMIA), F.-L. Hong (NMIJ/AIST), P. Juncar (LNE-INM), J.-W. Kim (KRISS), P. Lemonde (LNE-SYRTE), A. Lewis (NPL), J. M. López-Romero (CENAM), A. Madej (NRC-INMS), M. Merimaa (MIKES), L. Mostert (NMISA), J. Pekelsky (NRC-INMS), R. Thalmann (METAS), M. Viliesid (CENAM)

M. Matus (BEV) and S. L. Tan (SPRING Singapore) were invited by the co-chairs

Also present: F. Arias (BIPM), R. Felder (BIPM and Executive Secretary of the CCL), J. R. Miles (BIPM publications), G. Petit (BIPM), L. Robertsson (BIPM), A. J. Wallard (Director of the BIPM),

The co-chairs were F. Riehle (PTB) and P. Gill (NPL)

1. Dr Gill welcomed the delegates, the guests and the BIPM representatives to the meeting and in particular the presidents of the CCTF (Dr Erard) and the CCL (Dr Chung).

   Dr Gill presented the proposed agenda for the meeting (CCL-CCTF/07-01).

   Dr Thalmann suggested to move agenda item 8 to follow item 4. The agenda was accepted with this change made. This re-ordering of agenda items is maintained in this document with the original item numbers retained.

   Dr Wallard added that he was pleased to welcome the Frequency Standards Working Group (FSWG) to the BIPM and pointed at that it was the first meeting to be held in the new meeting facilities of the BIPM located in the former mechanical workshop, recently renovated. He also made some security announcement and excused himself for not being able to take part in the whole meeting due to time issues related to the upcoming CGPM.

2. Dr Robertsson was appointed as rapporteur for the meeting.

3. Dr Gill re-iterated the recommendations of the CCTF (CCTF-C1-2006), later also accepted by the CCL, concerning a common list of frequency standards. He stressed that the dual aspect of the list, ie to provide for both CCTF recommended frequencies and CCL relevant frequencies, calls for synchronization between the FSWG, the CCL and the CCTF.

4. Dr Gill raised the question of how best to co-ordinate and synchronise the reporting of the FSWG proposals to both the CCTF and CCL.

   Dr Madej pointed out that there is a cost factor to be included in the coordination of the work since frequent and partly overlapping meetings subjects weight heavily on certain NMIs travel budget. There was consensus that a synchronization of the FSWG, the CCL and CCTF meetings would be preferable, for instance every other year.

   Dr Erard remarked that there should not be any particular periodicity on these meetings but rather should they be scheduled according to need.

   Dr Thalmann raised the question about the individual responsibility of the CCL working groups and the CCL as a whole relative to the CCTF.

   Dr Riehle commented that one particular reason for the creation of the FSWG was to make frequency standards activity better defined to avoid both the possibility of different numerical values being adopted for *secondary representations of the second* (SRS) and *Mise-en-pratique* (MeP) listings and also repeated efforts.

Dr Wallard pointed out that while it seemed clear that responsibility for questions related to definition of the second and remote comparisons of high accuracy frequency standards naturally would come under the CCTF activity in other fields of strongly growing interest, like nano-metrology, would become very important for the CCL. The CCL authority would thus not be of reduced importance but rather focus on a different aspect.

Dr Juncar commented that the realization of the metre is not just a question of the value of the frequency of a particular radiation but that many other practical aspects need to be considered.

Dr Brown added that there is a distinction between a laser system and a frequency standard.

Dr Riehle agreed that there are different needs but reminded all of the advantages of a single list. This still could include standards of radiations considered necessary, e.g. lasers systems, spectral lamps etc. Then it is up to each CCL or CCTF community to recommend radiations for particular purposes (eg SRS or MeP).

Dr Wallard made the remark that the role of MePs in general will become an important issue in the light of possible redefinitions of several SI base units along the lines presently discussed in the CCU. He felt that the more common position was that the MeP should only consider high level representations of a particular unit and other and more practical considerations should be given in a Guidelines document.

Dr Madej pointed out that there is a lack of “terms of reference” for the selection of “other radiations” now included in the list.

Dr Thalmann added that it would not be good if both CCs needed to agree on the whole list if the responsibilities are clear and well separated.

Dr Arias explained that this has never been the case. The recommendation of values for adoption is done either by the CCL or by the CCTF.

Dr Gill explained that there are very well defined criteria for the recommendation of a radiation to be included in the SRS. It would also be possible for the CCL to choose a limited number of raditions particularly relevant for the length community. This would then automatically imply that there will be a third group of references, not included in the SRS or the CCL recommended ones.

Dr Madej raised the question, who will ratify the values for this third group?

Dr Riehle reminded the meeting that the FSWG cannot decide but only recommend to the CCL and CCTF, which in turn can propose to the CIPM to recommend these radiations.

Dr Madej took IR radiations at 1.5 microns as an example. Is this a time or length case?

Dr Riehle commented that there are many new developments, like X-rays, telecommunication etc, that can lead to new frequency standards. It will be up to the FSWG to make recommendations to the CCL or CCTF, whichever it considers most appropriate.

Dr Wallard added that there will always be a “grey area” and that, to some extent, such questions needs to be addressed once they appear.

Dr Erard asked if a new WG would be the appropriate solution to handle this issue.

Dr Viliesid mentioned that in the case of CENAM this was handled by the Radiometry and Photometry section.

Dr Riehle underlined that it is up to the FSWG to decide if a radiation is useful for the realization of the metre and should be included in the list, and again it is important to have a single list for practical realization of the metre.

After these discussions the meeting agreed that the FSWG should decide whether a particular radiation should be proposed to the CCL or the CCTF.

As for synchronization of the different meetings it was the consensus that the FSWG should be scheduled to be held just before the CCL and the CCTF meetings which, in turn, should be arranged in successive weeks. A preliminary time for these meetings in the spring of 2009 is foreseen.

8. Dr Robertsson gave a condensed report on the operation of the BIPM.L-K11 and a brief outline of the proposed CCL-K11. The CCL-K11 should in general follow the BIPM.L-K11 structure but the BIPM would be replaced by a group of 5 laboratories, BEV, NRC, NPL, MIKES and NMIJ, where BEV will be the pilot. The question of comb validation was discussed and which of the laboratories where absolute frequency measurements would take place needs to have validated comb measurement systems. Various validation mechanisms were outlined, such as comb measurement of a high-accuracy cold atom standard, direct comb-to-comb comparisons of the same stable laser, comb measurements of a number of MeP lasers, and some other methods.

   Dr Brown made a presentation titled “Traceabilty issues in Length”. A discussion around KC reference value, validation of combs and node labs followed.

   Dr Matus reminded the meeting that the objective with BIPM.L-K10 was to demonstrate competence.

   Dr Brown stressed the importance of having a KCRV for the CCL-K11. However, there were some different views concerning the relevance of a KCRV for comb-based measurements. The comment was made that K11 should test measurement capability, and not strive for achievement of a particular reference value as the comb systems were capable of accurately monitoring frequencies relevant to particular operating conditions both within and outside the MeP specified conditions. For MeP lasers, the value of the recommended frequency component could serve as a useful operating target, but it was not the “right answer”.

   Dr Gill reiterated the question raised in Dr Brown’s presentation “who should take on the responsibility for the CCL-K11”?

   Dr Riehle expressed that he saw it important to keep the operation of the CCL-K11 under the supervision of the FSWG.

   Dr Thalmann asked for clarification, does this include coordination, comb validation as well as CMC reviewing? He proposed that the WGDM could continue to coordinate the CMC reviewing.

   The meeting agreed that the FSWG should take responsibility for the operation of the CCL-K11 and the WGDM should continue to coordinate the CMC reviews.

5. Dr Gill reminded the meeting about the terms of reference (ToR) drawn up by the CCL in its 12$^{th}$ meeting and asked if any additions were needed, particularly in the light of the just-decided responsibility for the operation of the CCL-K11.

Dr Arias commented that the CCTF made no changes to these ToR in its 17th meeting.

Additions to the ToR were drafted to be presented to the 13th CCL meeting and agreed upon by the meeting.

Dr Arias pointed out that any change to the ToR has to be ratified by the CCTF and Dr Erard proposed this to be made by correspondence.

6. Mr Felder presented a compilation of the answers to the questionnaire (CCL-CCTF/07-02). 11 NMIs had answered. In general the answers did not include much work on the former MeP wavelengths. On the other hand, several experiments and developments related to time applications and to SRS were reported.

   - NRC proposed the addition of new measurements for the $C_2HD$ and $^{12}C_2H_2$ molecules.
   - NMIJ proposed to add the frequencies of 3 new lines for the Nd:YAg laser stabilized to iodine.

   Dr Riehle pointed out that a new value in the list that cannot be rapidly ratified by the CCTF might lead to confusion having one value proposed to the list and a different value recommended in the existing SRS. This underlines the need to synchronize the FSWG meeting to those of the CCL and CCTF.

   Dr Gill raised the question, who should ratify the 3rd group of frequencies, CCL or CCTF?

   Dr Riehle responded that it is always the CIPM that recommends after proposal from CCL or CCTF. It is the task of the FSWG to direct each specific frequency to the appropriate CC.

7. Additions and updates to the revised list were discussed.

   - Dr Madej proposed changes to the acetylene frequencies, in particular for the isotopes; $C_2HD$ and $^2C_2H_2$ molecules, since the results for these cases are comparable to values of $C_2H_2$ already listed and would increase the range of available frequencies in this region.
   - Dr Hong proposed to include new measurements for radiations in the vicinity of 532 nm. This could support the development of Nd:Vanadate lasers which have a wide gain curve and can reach additional lines compared to the Nd:YAG laser. This is a new source and the inclusion of these frequencies would support its use and further development. The working conditions should be the same as for the already recommended 532 nm wavelength.

   Dr Robertsson asked if, in the case of a laser system operating at some other parameter setting, it is still considered to be a realization of the metre if appropriate corrections are applied.

   Dr Riehle confirmed that this is the case.

   Dr Gill raised the question as to whether the operating conditions for the 543 nm wavelength are too restrictive? Could this recommended frequency also apply to lasers

systems stabilized by high-frequency modulation methods like FM side band or modulation transfer spectroscopy? Considering the small frequency change induced by 3f modulation techniques, relative to the stated uncertainty, it was proposed to change the sentence “frequency modulation width, peak-to-peak, (2.0 ± 0.5) MHz. ” to “frequency modulation width, peak-to-peak, (2.0 ± 0.5) MHz when using the 3f technique. ”

Dr Juncar pointed out that some of the recommended radiations are linked to specific laser sources and wondered if it would be possible to enlarge the recommendations to allow the use of new laser technologies to be used as well.

Dr Gill reminded the meeting that in earlier MeP deliberations, frequency values of “uncommon” light sources or light sources of limited use were not included.

Dr Juncar was invited to consider a proposal how such an extended formulation of the recommendations could be made to leave the possibility open to use alternative light sources.

Dr Riehle pointed out that the recommended frequencies in the list are evaluated and reviewed only for specific case conditions given. The influence of any modification to these conditions needs to be re-evaluated in each specific case.

The meeting agreed that, bearing in mind that any change in the SRS list can not be ratified before the next CCTF and that the FSWG will have a meeting just before, it should not make any updates of the $^{87}$Sr frequencies even though new results from the LNE-SYRTE and NIST/JILA were available. This would avoid possible confusion. By the same reason it was also proposed to wait with the up date of the frequency for the $^{+}$Hg.

9. Dr Riehle informed the meeting that a new publication of the list of recommended frequencies had been proposed. Drs Gill and Riehle had been asked to make a first outline. The new list would appear in hard copy form in its totality in Metrologia and augmented also on the BIPM web site, www.BIPM.org. A first version was presented and issues like sub-lists (ie active and inactive parts), and ways to identify the time-related and length-related frequencies were discussed.

   Dr Viliesid stressed the fact that, for many laboratories, even though the most recent instrumentation is not used, there still is a need to be traceable to the SI metre. It is therefore important to try to include both present but also “past” ways to obtain the traceability from the list.

   Dr Madej commented that the present list will possibly serve as a test-bed for the MeP of other units in the future. As Dr Wallard mentioned earlier, there is a reluctance to include too many and less important standards since this would entail a large additional work, not only for the metre, but also for other base units.

   Dr Riehle agreed that it would be helpful to the length community to somehow account for low accuracy standards associated with a proper uncertainty and asked what could be a suitable form of support for this, and what sort of document would be appropriate. It was decided to ask Dr Wallard for his view on the question.

   Dr Gill asked the opinion of the meeting if it was considered that it would be useful to keep a part of the list as “in-active” and still keep some standards there which could be of some importance but not necessarily reviewed at each meeting of the FSWG. This proposal was accepted by the meeting.

Dr Riehle raised the question of which frequencies should be selected to be listed as "commonly used" wavelengths for the realization of the metre? A list of iodine stabilized laser systems were considered but in a first place only the 633 nm, the 543 nm and the 532 nm wavelengths were retained. It was considered important that the WGDM should be consulted and invited to take part in this selection during the CCL meeting.

10-12. Dr Riehle presented a revised version of the new list. The use of the expression "Mise en pratique" was questioned.

Dr Miles exposed some of the discussions that had taken place over the years concerning the use of "Mise en Pratique" versus "The practical realization".

Dr Erard proposed that the meeting should seek advice from the CIPM. The meeting agreed to avoid the use of the expression "Mise en pratique", until further information becomes available.

Dr Miles asked about the form of the hard copy list relative to the web based version. Issues like page charges to *Metrologia* and language, English/French, were discussed.

The meeting refined the wording and the form of the list and discussed again the selection of wavelengths to be listed as commonly used.

- Methane was considered to still be supported and active in some laboratories and, for the time being, it was proposed to keep the value of the hyperfine resolved frequency in the active list.
- $OsO_4$ was considered not to be much used and it was decided to move this frequency to the inactive list.
- 633 nm, 543 nm and 532 nm were at this stage chosen as commonly used wavelengths but the meeting agreed to seek advice from the WGDM on this selection.
- 515 nm should stay on the inactive list even though it has a low uncertainty.

Dr Gill presented and summarized the modified terms of reference for the FSWG.

13. Next meeting is planned for the Spring of 2009. The exact date will be determined in discussions with the CCL and the CCTF. If there would be need for a meeting earlier to that date it should be held in conjunction with an upcoming conferences.