**Bureau International des Poids et Mesures**

# Consultative Committee for Photometry and Radiometry (CCPR)

Report of the 24th meeting
(19-20 September 2019)
to the International Committee for Weights and Measures


Comité international des poids et mesures

**LIST OF MEMBERS OF THE**
**CONSULTATIVE COMMITTEE FOR PHOTOMETRY AND RADIOMETRY**
as of 19 September 2019

### President

Dr M. L. Rastello, member of the International Committee for Weights and Measures, Istituto Nazionale di Ricerca Metrologica [INRIM], Turin.

### Executive Secretary

Dr J. Viallon, International Bureau of Weights and Measures [BIPM], Sèvres.

### Members

Agency for Science, Technology and Research [NMC, A*STAR], Singapore.

All Russian Research Institute for Optical and Physical Measurements, Rosstandart [VNIIOFI], Moscow.

Centro Nacional de Metrología [CENAM], Querétaro.

Czech Metrology Institute [CMI], Brno

Federal Institute of Metrology [METAS], Bern-Wabern.

Instituto de Optica “Daza de Valdés” [IO-CSIC], Madrid.

Istituto Nazionale di Ricerca Metrologica [INRIM], Turin.

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

Laboratoire National de Métrologie et d’Essais [LNE], Paris.

Measurement Standards Laboratory of New Zealand [MSL], Lower Hutt.

National Institute of Metrology [NIM], Beijing.

National Institute of Standards and Technology [NIST], Gaithersburg.

National Measurement Institute of Australia [NMIA], Lindfield.

National Metrology Institute of Japan, AIST [NMIJ/AIST], Tsukuba.

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

National Metrology Institute of Turkey [UME], Gebze-Kocaeli.

National Physical Laboratory [NPL], Teddington.

National Research Council of Canada [NRC], Ottawa.

Physikalisch-Meteorologisches Observatorium Davos and World Radiation Center [PMOD/WRC], Davos Dorf.

Physikalisch-Technische Bundesanstalt [PTB], Braunschweig.

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

VSL B.V., [VSL], Delft.

VTT Technical Research Centre of Finland Ltd, Centre for Metrology / Mittatekniikan keskus [MIKES], Espoo.

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

## Observers

Industrial Technology Research Institute/Center for Measurement Standards [CMS/ITRI], Hsinchu.
Instituto Nacional de Metrologia, Qualidade e Tecnologia [INMETRO], Rio de Janeiro.
Standards and Calibration Laboratory [SCL], Wanchai.

## Liaisons

International Commission on Illumination [CIE], Vienna.
World Meteorological Organization [WMO], Geneva.

## 1. OPENING OF THE MEETING, MEMBERS AND OBSERVERS PRESENT, INTRODUCTIONS

The Consultative Committee for Photometry and Radiometry (CCPR) held its 24th meeting at the International Bureau of Weights and Measures (BIPM) headquarters at Sèvres, France, on Thursday 19 September and Friday 20 September 2019.

The meeting was chaired by the CCPR President, Dr. M.L. Rastello (CIPM member).

The following delegates from member institutes were present: Ö. Bazkir (UME), P. Blattner (METAS), V. Bormashov (VNIIOFI), G. Brida (INRIM), J. Campos Acosta (IO-CSIC), H.A. Castillo (CENAM), J. Dubard (LNE), N. Fox (NPL), H. Gan (NIM), J. Gröbner (PMOD/WRC), B. Hay (LNE), E. Ikonen (MIKES), B. Khlevnoy (VNIIOFI), A. Koo (MSL), M. Krempasky (SMU), S. Kück (PTB), D.-H. Lee (KRISS and CIE), J. Lehman (NIST), S.-D. Lim (KRISS) Y. Lin (NIM), P. Manson (NMIA), A. Meda (INRIM), M. Milton (Director of the BIPM), M. Nadal (NIST), G. Obein (LNE-Cnam), Y. Ohno (NIST), M. Richter (PTB), V. Sapritsky (VNIIOFI), H. Shitomi (NMIJ/AIST), R. Sieberhagen (NMISA), M. Smid (CMI), A. Sperling (PTB), L.-L. Tay (NRC), A. Todd (NRC), S. van den Berg (VSL), E. Woolliams (NPL), J. Zhang (NMC, A*STAR).

Observers: T. Menegotto (INMETRO), C.M. Tsui (SCL), K.-N. Wu (CMS/ITRI).

Liaison: I. Ruedi (WMO)

Representatives of Institutes from Member States invited to attend as Observers: M. Huriev (NSC IM), D. Matkowska (GUM).

Invited: M. AlFohaid (SASO), A. Bescupschii, (NMI (MD)), C. Cooksey (NIST).

Also attending the meeting: S. Picard (KCDB Coordinator, BIPM), J. Viallon (Executive Secretary of the CCPR, BIPM).

Dr Rastello opened the meeting by welcoming everyone to the BIPM. She thanked Dr Usuda, the previous President of the CCPR, for his work whilst leading the CCPR. Dr Milton added his welcome as Director of the BIPM, after which all those present briefly introduced themselves.

## 2. APPOINTMENT OF THE RAPPORTEUR

Dr Manson was appointed rapporteur for the meeting.

## 3. APPROVAL OF THE AGENDA

Dr Rastello showed a version of the agenda with some small changes after the working group meetings earlier in the week. She asked for approval of the modified agenda and all members agreed without proposing any additional changes.

## 4. ACTIONS FROM THE 23RD MEETING

Dr Rastello asked Dr Viallon to review the action points from the previous CCPR meeting in 2016.

AP1: Missing progress reports to be supplied to Dr Viallon by the end of the year, together with any revisions to those reports already submitted. All reports will be published in the open access area of the BIPM website at the start of 2017 unless a specific request not to do so is received.

*Done. Dr Viallon asked that members who had not yet submitted their reports for this meeting send them to her. She noted that it is useful to have replies to the questionnaire in advance so speakers for scientific talks can be selected.*

AP2: All NMIs with entries under 1.1.2 should update their CMC tables with the new number. The relevant RMO TC Chair will report this CMC tables update at the next CMC-WG meeting.

*Done.*

AP3: The rules governing membership of WG-CMC will be revised as agreed, with immediate effect. A new sheet, for Task Groups, in the WG-CMC section of the CCPR website, will be added.

*Done.*

AP4: Dr Ohno to send a letter on behalf of CCPR WG-KC to Dr Gran (EURAMET TC-PR Chair) highlighting the conflict between the EURAMET and CCPR guidelines, for discussion at the forthcoming meeting of EURAMET TC Chairs.

*Done. The conflict between CCPR and EURAMET guidelines was resolved within a year of the CCPR meeting.*

AP5: Dr Zwinkels to send points of clarification and correction relating to the candela to CCU immediately, for incorporation in the next draft of the 9th SI brochure.

*Done.*

AP6: CCPR President to inform CCU that CCPR requests that Appendix 3 is reinstated in the 9th SI brochure.

*Done.*

AP7: A call for nominations for the position of WG-CMC Chair will be issued by 30 September 2016, with a deadline of 30 October 2016.

*Done.*

## 5. NEWS FROM THE CIPM AND CGPM

Dr Rastello presented a report. She noted that four CIPM meetings had been held since the last CCPR meeting in 2016 and that a lot has been done during that time. The 26th meeting of the CGPM had also occurred during that period. She summarized a selection of recommendations from those meetings.

105th CIPM Meeting (October 2016)

CIPM requested that CCs prepare updated *mises en pratique* by 31 July 2017. The CCPR *mise en pratique* was updated by the due date.

Some CCs have joined as new members of the Task Group for the Promotion of the SI, and the International Commission on Illumination (CIE) has joined as an Observer. The CIPM requested that the CCs prepare a statement to stakeholders regarding the changes expected under the revised SI, to be completed by the end of July 2017.

The Rules of Membership of the CCs related to observer status for national laboratories were revised. The CIPM decided that international organizations that attend CC meetings will be referred to as "liaisons" and not offered membership. All CCs will review whether their members and observers meet the relevant criteria. SCL (Hong Kong (China)) has been added as an observer to CCPR.

106th CIPM Meeting (October 2017)

The CIPM welcomed recommendations regarding the redefinition of the SI from CCs. It decided to submit a draft resolution to the CGPM since the conditions for the redefinition have been met.

The CIPM decided that *mises en pratique* prepared by the CCs should be presented in a common format. The *mise en pratique* for the candela has been updated accordingly.

The CIPM agreed that the document CIPM-D-01 which covers the operations of the CCs would be revised by adding three objectives.

Following the decision of the previous meeting regarding liaisons, the CIPM decided that the status of liaisons within CCs will be decided in each case by CIPM, using specified criteria.

Further changes to CIPM-D-01 were agreed to remove reference to votes taking place in CCs to emphasize the consensus-based decision-making process.

The CIPM decided to update the criteria and processes related to Associate State membership of the CGPM.

The CIPM decided to invite each Regional Metrology Organization (RMO) to send one or two representatives to the next meeting of CC Presidents (June 2018) to address the recommendations of the review of the CIPM MRA.

107th CIPM Meeting (June 2018)

The CIPM decided to review the purpose and agenda of the meeting of CC Presidents at its next meeting.

The practice of inviting the Chairs of RMO TCs to CC meetings was confirmed.

The use of a definition of "consensus" originating form ISO/IEC Directives was agreed. The document CIPM-D-01 will be updated.

26th CGPM Meeting (November 2018)

Dr Rastello displayed Resolution 1 for the meeting, related to the revision of SI, and noted the presence of $K_{cd}$. She drew attention to appendix 3 of the SI brochure entitled "Units for photochemical and photobiological quantities", specifically its mention of the candela.

She presented the poster prepared by the Working Group on Strategic Planning and thanked Dr Ohno for a complementary presentation representing CIE.

108th CIPM Meeting (March 2019)

Dr Louw was elected as CIPM President and Dr Usuda was elected as Secretary. Elections were also held for the CIPM Vice-Presidents.

The CIPM supported the formation of a task group to improve cooperation between the BIPM and International Organization of Legal Metrology (OIML) after a proposal from the President of the International Committee of Legal Metrology (CIML).

Presidents of the CCQM and CCTF were appointed. All incumbent CC Presidents were reappointed for four-year terms.

The CIPM welcomed progress on rationalization of the suite of MRA guidance documents, prompted largely by the launch of KCDB 2.0.

## 6. UPDATE ON THE BIPM KCDB 2.0

Dr Picard, KCDB Coordinator, gave a presentation on the implementation of KCDB 2.0.

She pointed out that new system will be merged with the existing JCRB web-based process, and includes a platform for submission, review and processing of CMCs, extended search facilities and generation of statistics including some customization. Intra-RMO review of CMCs is included.

Dr Picard summarized the sequence followed when processing a CMC claim. The claim is drafted by the NMI and then made accessible to TC Chairs for review (or for sending out to reviewers). It then goes to the JCRB, i.e., other RMO TC Chairs, for review and approval. A vote on approval is only required if revisions are requested. Following approval, the claim is made available via the KCDB website.

The system will cover CMCs, comparisons and statistics, although the statistics module will not be available initially.

Realization of KCDB 2.0 has involved parallel development of CMC facilities, migration of the existing database into the new system, comparison facilities and the statistics capability. Alpha testing has been carried out by BIPM staff and beta testing by CC experts is under way. Dr Picard expressed her thanks to WG-CMC for input. She noted that the system will be available on PCs, and that some facilities will be compatible with tablets and other mobile devices.

Meetings with the CCT, CCRI, CCQM and CCPR have occurred and meetings with other CCs are planned. The feedback and questions arising at these meetings helps when preparing the documentation.

Several sources of information on the new system are being prepared, including a “Getting Started” document, help on the search facilities and some YouTube videos. The system is expected to become operational at the end of October 2019.

Dr Picard’s presentation included a slide showing the planned implementation timetable. She emphasized that there will be a clear transfer, i.e. no overlap period where both the old and new systems are in operation is planned. A short time after the system becomes operational, adding new CMCs to the new database will start. Submission using the existing JCRB website will be available until the new system comes online, but will not be possible after that, although review of CMCs already submitted will continue using the old system. The new web-based submission platform will not open for all CCs simultaneously. There will be a sequential introduction, with steps of approximately one week for each CC.

Dr Picard presented several web pages from the new system, including the start page at www.bipm.org/kcdb.

Users wishing to apply for a user account start by logging in as a guest. The credentials will be made available by TC Chairs and BIPM staff. Once logged in as a guest, requests for a writer and reviewer profile can be submitted.

Users can login separately as writer, reviewer or TC Chair, although the writer and reviewer profiles can be combined. Logging in as a writer includes the possibility of creating a CMC claim using a web-based form. The claim can be saved as a draft or submitted to the review process.

TC Chairs have access to “spaces” for intra- and inter-RMO review, which include mechanisms for sending CMCs to reviewers.

The new system was discussed following the presentation.

Dr Smid thanked Dr Picard for the opportunity for training on the new system at the WG-CMC meeting. He asked if there will be any other training such as workshops, etc. Mr Henson replied that there are several opportunities, including a CBKT workshop in November 2019. The BIPM is offering to help each RMO run a course, depending on when travel can be timetabled. The training material will be made available. Help is also available by contacting the KCDB office. He said that a consolidation of JCRB documentation is under way so there will be one document covering CMCs and one on comparisons. They will be released later in 2019.

Dr Picard commented that the data migration appears to have worked well and samples have been checked. However, not all transfers have been checked so users need to check their own CMCs. Old versions of CMCs will be available for comparison. She said that the system will not be made operational unless the KCDB office is confident of the system's operation. Mr Henson added that testing shows that the system appears to be working well.

Dr Picard noted that 'de-batching' is now preferred, i.e., each CMC has a unique identity. This means that one CMC will not delay all CMCs in a batch. A constant stream of CMCs in review is possible because NMIs can submit a claim at any time. However, TCs and CCs can agree on the allowed timing.

Dr Rastello asked whether changes will be highlighted if submissions are modified and Dr Picard replied that they will not.

Dr Rastello invited questions and comments from TC Chairs. Mr Bescupschi said that some COOMET CMC claims are currently in inter-RMO review and will be finished soon, asking when they will be added to the new database. Dr Picard replied that it will happen as soon as the new database is available. Uploads using Excel files will be possible but submission using the new platform is preferred. Mr Henson said that adding data has stopped at the moment but will recommence as soon as possible after the system starts full operation. The old platform is still in use and will continue that way for some time. At any time there are many CMCs that are part way through the process and they will continue until they are approved at which point they will be queued for adding to the new system.

Dr Menegotto said that the short course during the WG-CMC meeting was very helpful, and Dr Picard replied that it is important that TC Chairs are familiar with the operation of the new system.

With no further discussion, Dr Rastello thanked Dr Picard for her presentation.

## 7. REPORT OF THE WORKING GROUP ON CALIBRATION AND MEASUREMENT CAPABILITIES (WG-CMC)

Dr Smid, Chair of the Working Group on Calibration and Measurement Capabilities, presented his report on the activities of the Working Group.

He described the new structure of WG-CMC that has been implemented since the 23rd CCPR meeting (2016). Members of the Working Group are Chairs of the RMO technical committees for radiometry and photometry, with each Chair able to appoint one additional expert as a member. The Chair rotates between the RMOs, with a term that is normally four years.

Dr Smid described the work of three Task Groups that have been established by WG-CMC since the previous CCPR meeting.

TG1 *Use of comparison results in assessment of CMC claims.*
The principles were discussed and accepted at an earlier WG meeting and a draft document was

agreed by WG-CMC in July 2018. It was submitted to the CCPR for comments and then published on the BIPM website in February 2019. The objective has been achieved.

TG2 *Update the Excel CCPR CMC supporting evidence file*.
First drafts of the updated documents were presented in June 2017 and new versions of both the evidence requirements spreadsheet and the service categories document were published on the BIPM website in May 2018. Some new service categories were added and the compatibility of the spreadsheet with the service categories file was improved. Dr Smid presented the improvements to the background information and descriptions of the evidence rules that have been made in the spreadsheet. He informed the meeting that the Chair of the Task Group, Dr Nadal, was stepping down due to commitment as Chair of WG-SP and that Dr Cooksey had agreed to take the role of Chair. The Task Group will continue into the future, initially because the work of TG3 may initiate some further changes.

TG3 *Clarify and harmonize the CMC review process.*
The aims of this Task Group are to reduce the burden associated with reviewing CMCs, while maintaining the quality of the database and supporting the establishment of CMCs by emerging NMIs. The first discussion on formulating the principles of the new approach occurred in June 2017 and, after the first decisions about the new approach in July 2018, the first draft of the TG3's guidelines was discussed in the WG-CMC meeting earlier in the week.
The terminology and details of the rules and process are yet to be agreed, but the general philosophy of classifying quantities as 'core' or 'linked' (or alternative terms to be agreed) with levels of review set appropriately was agreed. Work on how to classify the quantities and to set the appropriate levels of review remains to be done. The use of key comparisons to support a broader range of CMCs was agreed and there is general support for reducing the reliance on comparison evidence. Developing the details remains to be done.

Dr Smid expressed his thanks to all the Task Group Chairs and welcomed Dr Cooksey as the new Chair of TG2.

Dr Manson commented that awareness of TG1 guidelines needs to be raised among CMC reviewers. Dr Smid noted that the guideline has been used in some reviews already and discussed the possibility of holding a workshop on CMC review, adding that if an RMO would like support with reviewing, that can be discussed.

Dr Smid presented changes to the service categories since the previous CCPR meeting. Four categories were added at the WG-CMC meeting in June 2017, and Dr Smid indicated which RMO had submitted each category and summarized the motivation for the addition. Most were approved, but 7.7 chromatic dispersion needs further discussion. Dr Smid said that a Task Group, TG4, had been created to look at the fibre optic service category structure, and he summarized its work to date.

TG4 *Recommending a CMC structure for fibre optics*.
This Task Group was seeded by a METAS proposal regarding the service category structure in fibre optics. The decision was taken to create a Task Group, with terms of reference to recommend an updated service category structure, and to liaise with TG6 "Discussion Forum on Fibre Optics" of WG-SP.

Prof. Dr Kück pointed out that Dr Morel will be the new Chair, but that he (Prof. Dr Kück) will continue as a member.

Dr Smid closed his report by remarking that WG-CMC gives opportunity for discussion amongst TC Chairs, e.g., agreeing to 'de-batch' CMCs and submit smaller batches more frequently.

Dr Rastello asked for confirmation that TG1 is closed and Dr Smid replied in the affirmative, saying that its work is completed. Dr Rastello thanked Dr Koo and Dr Nadal for their contributions, and welcomed Dr Cooksey as the new Chair of TG2.

## 8. REPORT OF THE WORKING GROUP ON KEY COMPARISONS (WG-KC)

Dr Lee, Chair of the Working Group on Key Comparisons, presented his report on the activities of the Working Group.

He started by summarizing the status of the Working Group, noting that he had been Chair since the meeting in 2018. He expressed his thanks to Dr Ohno for his work as Chair for many years, saying that WG-KC is in a good state so continuing as the new Chair will be easy.

MSL (New Zealand) has joined the Working Group as a new member after having been a temporary member while piloting the K6 comparison. No other changes to the membership have been proposed.

He went on to summarize the activities of the Working Group since the last CCPR meeting, including three meetings and the completion of the second-round comparison CCPR-K6-2010 *Spectral regular transmittance*. The final report of that comparison was published in March 2017.

Dr Lee summarized the status of the 2nd round key comparisons, which started with K6 in 2013. They range from 'Draft A in review' to 'Protocol in development'.

He described the two spreadsheets covering RMO comparison activities which are published on the CCPR page of the BIPM website; one showing the status of all registered comparisons and the other showing the list of planned comparisons (to support other RMOs by providing an opportunity for participation from other RMO members).

He presented the CCPR guidelines related to comparisons. These guidelines are intended to cover all comparison activates in the CCPR and the RMOs and are an important foundation for those activities.

Dr Lee summarized the activities of the Task Groups set up by WG-KC.

TG1 *Pilot comparison for spectral regular transmittance in the UV*
The aim of this Task Group is to investigate the possibility of extending the wavelength range of the spectral regular transmittance comparison (K6) to shorter wavelengths. Experimental tests of the candidate filters are in progress.

TG2 *RMO linkage*
The aim of this Task Group is to develop guidance on data analysis for RMO key comparisons in photometry and radiometry. Appendices to two CCPR guidelines have been developed and published, and the Task Group is now working to develop a matrix-based approach.

TG3 *Comparison analysis*
The aim of this Task Group is to develop guidance on data analysis for CCPR key comparisons. An appendix covering the general least-squares approach has been developed and published in one of the CCPR guidelines, and the Task Group is now working to find the optimal analysis model.

TG4 *Pilot study for the use of alternative standards for photometric comparisons*
The aim of this Task Group is to investigate the possibility of using LED-based sources in future photometric comparisons (K3 and K4). Candidate lamps have been developed and tested by three NMIs, and a comparison will be conducted after long-term stability tests have been completed.

Dr Lee pointed out that the work of TG4 is important because of the difficulty in finding artefacts

based on tungsten lamps, adding that LEDs are more important, in general, than tungsten lamps. The Task Group is therefore investigating possible technical issues around LED-based lamps.

He concluded his report by summarizing the tasks of the Working Group for the next few years. In addition to completing the second-round key comparisons and planning for the third round, these include development of better data analysis methods for both CCPR and RMO comparisons, based on the work of TG2 and TG3.

Following on from Dr Lee's slide mentioning the next WG-KC meeting planned for June 2020 in Boulder (USA), in association with the NEWRAD conference, Dr Rastello asked whether WG-CMC will hold a meeting associated with NEWRAD. Dr Smid replied that it would.

Dr Manson commented that the K3 comparison on luminous intensity was based on lamps instead of photometers, asking whether there is some appetite for reconsidering that decision after the current K3 comparison has completed. Dr Lee summarized the history of that comparison, agreeing that it could be reconsidered after the current comparison, adding that the lamp type could also be considered. Prof. Ikonen said that the reason for the change was that it made more sense to use lamps since intensity is a source quantity, adding that this has not changed, particularly with LEDs.

Dr Zhang noted that the K2.c comparison covers the wavelength 200 nm to 400 nm, asking whether an NMI can participate over only a smaller range. Dr Lee replied that it may be possible since there is a precedent in the K1.b comparison, particularly if there are not many participants. It should be discussed with the pilot and WG-KC during planning. Dr Fox pointed out that it may be possible to look at the overlap with the K2.b comparison.

## 9. REPORT OF THE WORKING GROUP ON STRATEGIC PLANNING (WG-SP)

Dr Nadal, Chair of the Working Group on Strategic Planning, presented her report on the activities of the Working Group. She expressed her thanks to Dr Zwinkels for chairing the Working Group for more than a decade, adding that Dr Zwinkels had participated remotely in the WG-SP meeting earlier in the week and had been able to provide a lot of history and context.

Dr Nadal's summarized the eleven task groups within WG-SP, including name of the task group, its title and chair. She noted that the list shows that WG-SP monitors future needs in several areas, and added that it keeps the CCPR Strategic Document up to date. She indicated a number of changes of task group chair, and thanked the previous chairs.

She went on to highlight the important points from the discussions of each task group.

TG7 *Discussion forum on few-photon metrology*
The chair and members of the Task Group will report to the next WG-SP meeting, giving a summary of the activities within the community discovered by attending single-photon workshops.

TG8 *Discussion forum on THz metrology*
The results of a survey on the measurement needs for THz metrology were presented.

TG9 *OTDR length comparison* and
TG6 *Discussion forum on fibre optics*
New CMC entries on OTDR (optical time-domain reflectrometry) have been added to the CCPR service categories, and future pilot studies were discussed.

TG11 *Single-photon radiometry*
Members include NMIs and experts from academia and industry. Updates on pilot studies were

presented.

TG12 *Discussion forum on the use of white LED sources for photometry*
There has been in a change in the Chair of the Task Group. A brief overview of a survey seeking information on stakeholders and future collaborations was presented to the meeting.

TG13 *Optical fibre power responsivity*
A pilot study proposal has been agreed.

TG10 *Ad-hoc on CCPR strategy*
The aim of this Task Group is to establish and maintain a strategic planning document in line with CIPM guidance for CCs. The latest version was posted on the BIPM website in July 2018, with the aim of producing a revised version for the next CGPM during the northern hemisphere summer of 2022.

Two task groups have been dissolved because they have completed their stated mission.

TG4 *Developments with respect to the future of the SI*
The aim of this Task Group was to monitor and respond to developments with respect to the future of the SI in the lead-up to the redefinition.

CIE JTC-2 *Joint CCPR/CIE task group on "Principles Governing Photometry"*
The aim of this Task Group was to prepare a comprehensive joint CIPM/CIE Technical Report, and later a CIE Standard, on 'Principles Governing Photometry'. The document was published as a CIE standard and a BIPM report on 20 May 2019.

Dr Nadal thanked the chairs and members of both task groups for their input.

She went on to describe three new groups formed by WG-SP.

TG14 *Discussion forum on radiometry to support gravitational wave detection*
This Task Group was formed at the meeting of WG-SP in July 2018 and was originally titled *Discussion forum on improved 1 W laser power responsivity*. It arose from questions from the LIGO gravitational radiation observatory about uncertainties and inconsistencies between participants' results in the EURAMET.PR.S2 supplementary comparison. The terms of reference of the Task Group are yet to be decided.

Ad-hoc *CCPR poster for the 2018 CGPM meeting*
This Task Group prepared the poster on CCPR activities that was displayed during the 26th meeting of the CGPM (2018)

Ad-hoc *Group to support the CCPR President*
The Group was formed during the WG-SP meeting earlier in the week, with the proposed title *What is next for the candela?* The initial aim is to provide slides and discussion points including future applications, accomplishments, reductions in uncertainties, derived units, and industries supported.

Dr Nadal completed her report by showing possible dates for the next WG-SP meeting in conjunction with the NEWRAD conference in June 2020.

## 10. PLANNING FUTURE CCPR WORKSHOPS

Dr Rastello opened the discussion on this agenda item by explaining that on some previous occasions, workshops had been held in association with CCPR meetings and she would like to discuss the possibility of including workshops with future meetings. Two types of workshop are

possible: internal workshops covering important issues for the CCPR e.g. the redefinition, or workshops with invited external experts covering issues of interest. Another alternative is to continue the usual meetings without workshops. She invited questions and comments, adding that there are several places where scientific results in photometry and radiometry can be presented, so the CCPR needs to think carefully about whether there are "hot" topics to include in the workshops.

Dr Obein said that measurement of appearance could be interesting, or an update on applications of artificial intelligence or 'big data', to see how the link can be made between perception and physical measurements.

Dr Smid pointed out that NEWRAD provides a good possibility for interactions between the CCPR and outside groups, asking whether it would be possible to postpone the decision until after NEWRAD.

Dr Gröbner provided an update on the topics to be covered at NEWRAD, noting that they will be similar to those of previous conferences, with photon momentum and gravitational radiation added.

Dr Fox asked whether meetings in 2021 were being discussed and Dr Rastello confirmed May or September 2021.

Dr Blattner pointed out that the BIPM had organized a workshop on physiological quantities, with the outcome that a follow-up would be worthwhile. This topic could be considered for a CCPR workshop.

Dr Rastello agreed on the need for meeting with the photobiological community. She asked whether that topic is covered by CIE and Dr Blattner replied that it is e.g., horticultural lighting. The CIE plans to run a workshop on how to measure photobiological quantities. He suggested that the CCPR could organize a workshop with a wider scope than that suggested by the CIE.

Dr Milton asked whether there would be more topics if the next CCPR meeting was held during 2022, adding that it is not necessary to meet every two years.

Dr Nadal agreed with Dr Obein. Artificial intelligence and 'big data' are the way of the future so the CCPR should start by understanding future needs. Dr Rastello pointed out that CIPM has created an *ad hoc* working group on a similar topic, but at the level of all metrology fields. She agreed that there is a need for a workshop on artificial intelligence for photometry in the near future. Prof. Dr Kück said that he would also support this topic since it covers a lot of different fields. For example, how to manage complicated models?

Dr Rastello asked Dr Milton to inform the meeting about possible CIPM workshops. Dr Milton replied that many different topics were being considered such as digitalization, the reproducibility crisis and metrology contributions, artificial intelligence as a technology for assimilating datasets, and metrologically validated data to support big data applications. All are very large tasks.

Dr Obein said that when considering digitalization, one of the problems is that we use a lot of digital data but that the end target is a human system that is analogue. We spend a lot of time transforming from the analogue domain to the digital domain without covering the reverse. He gave the example of sensations such as colour brightness where the detector is human i.e., analogue.

Dr Ohno turned the discussion to what is needed in the CCPR, suggesting that a recommendation on a model for comparison analysis is important. He suggested that it will be possible for the WG-KC to produce a recommendation but it may be difficult to understand. Sufficient time will be needed for a tutorial and discussion in order to develop widespread understanding. Dr Rastello agreed that it was necessary because the time for discussions is very short during the normal meetings. There could be

an internal workshop, possibly with the statistical community. Dr Koo agreed, saying that it could be the CCPR community possibly with external experts.

Dr Rastello summed up by saying that she proposed to agree to the workshop and that an *ad hoc* task group is needed to define a list of possible topics for the workshop. Possibilities already identified are: appearance and artificial intelligence, or statistics for comparison analysis.

Dr Lehman said that, although photon momentum is a special topic for NEWRAD, it is not yet clear if it is an important topic for the CCPR.

Dr Milton suggested that this discussion continue after the session on advancing the state of the art in measurement science.

## 11. REPORTS BY RMO TC CHAIRS

AFRIMETS

Mr Sieberhagen presented his report on the activities of AFRIMETS. He described the interactions between NMISA (South Africa) and NIS (Egypt) regarding mutual participation in proficiency testing schemes. NMISA is also planning to contact all African NMIs to determine the level of photometry and radiometry activity and to offer technical support with the hope of stimulating photometry and radiometry in Africa.

APMP

Dr Gan presented his report on the activities of APMP. He summarized the membership of APMP TCPR, noted the involvement of TCPR with several of APMP's focus groups, and outlined the topics of workshops and meetings held during 2018 and 2019. He showed results of two APMP pilot studies: APMP.PR-P3.1 *APMP pilot study on transmittance haze II* and APMP.PR-P2 *Total spectral radiant flux*. Finally he showed applications by APMP TCPR to the APMP Developing Economies Committee for projects targeted at raising the capabilities of several emerging NMIs in the region and based on topics closely related to their specific needs.

Prof. Dr Kück asked how the focus groups are formed and whether they meet regularly. Dr Gan replied that anybody can attend, but in practice attendance is limited by the number of people who can travel to the meetings. Focus groups often run workshops in conjunction with the General Assembly and TC meetings so attendees at TC meetings often attend the focus group meetings as well.

COOMET

Mr Bescupschi presented his report on the activities of COOMET. He summarized the membership of TCPR and showed a detailed view of the ongoing and completed key and supplementary comparisons. He covered a total of eleven comparisons with status ranging from 'measurement in progress' to 'approved and published'. Two pilot studies (*Spectral regular transmittance* and *Diffuse absorbance of transmitted samples*) are at the report drafting stage, and five supplementary comparisons or pilot studies are being planned. He highlighted the new CMCs that have been published. Mr Bescupschi concluded his report by describing three knowledge transfer activities covering important topics in metrology, such as the impact of the redefinition and the review of the CIPM MRA.

EURAMET

Prof. Dr Kück presented his report on the activities of EURAMET. He started by summarizing the

meetings that have occurred and the membership, and went on to show the objectives and results of three workshops that have been held by TCPR. The first, *Workshop on support, collaboration and coordination*, was followed up a year later by another workshop aimed at converting the results into concrete projects. In the first workshop, each NMI presented at most three issues it is facing and one strategic goal for the next five years. The third workshop was related to KCDB 2.0 and CMCs. He followed with a description of the European Metrology Networks, describing their goal as creating engagement between external communities and metrologists. He described the networks related to climate change and quantum technologies in more detail. The remainder of Prof. Dr Kück's report consisted of an analysis of the CMC activity, including a review of CMCs from other RMOs, and a detailed description of the comparison programme.

Dr Koo referred to the workshop on support, collaboration and coordination, asking whether a summary document exists. Prof. Dr Kück replied in the affirmative and Dr Koo said that it would be interesting in the context of strategic planning for all NMIs. Prof. Dr Kück agreed to ask the workshop participants for permission to share the summary document with NMIs in other RMOs.

**AP1:** Prof. Dr Kück to ask EURAMET NMIs for permission to share documentation from the workshop on support, collaboration and coordination.

SIM

Dr Menegotto presented his report on the activities of SIM. He started by summarizing the member NMIs and DIs and went on to show new activities of SIM, including a new website. Dr Menegotto presented SIM's comparison activity, including four comparisons in planning and others ranging from protocol preparation to published report, as well as significant participation in comparisons run by the CCPR and by other RMOs. A survey of the needs of TCPR members for comparisons was conducted, with responses from two NMIs and one DI. It showed the need for a number of key and supplementary comparisons, some of which can be met by SIM planned comparisons or participation in comparisons run by other RMOs, but in some cases no comparison exists. Dr Megotto summarized SIM's CMC and quality system activities, including review of CMCs from other RMOs. He completed his report by outlining the NIST-SIM Engagement Opportunity and three projects aimed at strengthening the quality infrastructure in several economies in SIM.

GULFMET

Mr Al Fohaid presented his report on the activities of GULFMET. He showed the list of member economies, noting that only NMCC-SASO (Kingdom of Saudi Arabia) has activities in photometry and radiometry. NMCC-SASO is participating in a EURAMET comparison on spectral regular transmittance. Mr Al Fohaid finished by presenting the agenda of meetings of the TCPR during 2017, 2018 and 2019 (although the last one did not take place).

In closing the agenda item covering the activities of RMO technical committees, Dr Rastello said that she was impressed by the quality and range of the work in the regions. She expressed her thanks to TC Chairs for their presentations.

## 12. LIAISON WITH OTHER ORGANIZATIONS

WMO

Dr Ruedi reported on a major reform of the WMO structure to take place in 2020. Existing basic commissions, such as the Commission for Instruments and Methods of Observations (CIMO) covering activities of interest to CCPR members, will be phased out. Instead, Expert Teams will be

created with specific activities within a new Technical Commission on Infrastructure, including one on Methods of Observations, Measurements and Instrumentation.
Dr Ruedi reported that the World Radiometric Reference (WRR) is still considered as the most effective means to represent the solar irradiance scale for the meteorological community, even if it was found to provide irradiances with an offset of 0.3 % compared to the SI-traceable Cryogenic Solar Absolute Radiometer (CSAR). PMOD/WRC is building its own cryogenic radiometer which will be regularly compared to the WRR.

The traceability of terrestrial radiation measurements has been under investigation within the CIMO, including representatives of NMIs. The status of the World Infrared Standard Group (WISG) is under consideration, with further measurements being required to determine the value of its offset compared to SI-traceable measurements. A strong cooperation between the metrology and meteorology/climate communities is required to investigate alternative stable reference instruments. This should take place within the Task Team on Radiation References (TT-RadRef) which was re-established by CIMO-2017.

Dr Milton asked how the function of CIMO will be delivered in the new structure. Dr Ruedi explained that most of the major activities will be transferred to various groups within the Technical Commission on Infrastructure.

CIE

Dr Lee presented the report on the activities of the CIE on behalf of the Director of CIE Division 2. Dr Lee showed slides covering the objectives of the CIE and its board and division structure. A large number of technical reports or technical notes were published from 2017 to 2019, including "Calibration, Characterization and use of Array Spectroradiometers", "The Basis of Physical Photometry", 3rd edition and "Optical Measurements of High-Power LEDs". Several international standards were published or released in draft form, including three parts of the standard covering colorimetry. The CIE also released a position statement on blue light hazard. Several new technical committees and research fora were established and Dr Lee reported on the new activities in CIE Division 2.

Dr Blattner thanked Dr Lee for his report and noted that there might be a workshop on measurement of photobiological health effects. It will probably occur during the last week of August 2020 in Vienna.

CORM

Dr Nadal presented the report on the activities of the CORM (Council for Optical Radiation Measurements). She summarized the council's mission, membership and organizational structure. CORM runs an annual conference which is a multi-day event attracting attendees from government, industry and academia. It publishes a twice-yearly magazine called "Optical Radiation News" which is available on the website. From time to time, CORM publishes a document titled "CORM Report Pressing Problems and Projected National Needs in Optical Radiation Measurements", the most recent being published in May 2016.

Dr Smid asked what the typical size of a CORM conference is, and Dr Nadal replied that between 40 and 70 people attend.

## 13. ADVANCING THE STATE OF THE ART IN MEASUREMENT SCIENCE

Evolution of (High Power) Laser Measurements (John Lehman)

Dr Lehman showed the history of high power (1 kW – 100 kW) leading to the current state of the art, which has response times of tens of seconds, and is of order cubic metres in size. There is a need for small, portable power meters with sub-second response time. He then discussed how photon momentum can be used as the basis of power measurements, showing how systems can be designed for in-line measurement or calibration. Dr Lehman then proposed that the frequency range from RF to UV and power range from a few milliwatts to a few megawatts can be covered by the technique based on radiation pressure. He finished by showing the relative uncertainty of calibration based on laser power (radiation pressure) and based on mass, showing that they become equal at approximately 1 W or 1 µg.

Dr Lee thanked Dr Lehman for his presentation but noted that one concern is the reflectance of the mirror must be known. Dr Lehman agreed but pointed out that at 1070 nm reflectance can be 99.999 %. High quality mirrors at 10 µm is a problem, as is drift due to heating of the mirror.

Dr Milton asked for clarification of the comment on fundamental measurements on Dr Lehman's final slide. He replied that the Kibble balance measures mass using gravity but using optical power would mean that gravity is not needed. It can be thought of as a massless, non-mechanically coupled force. Dr Milton said that he thought that adding the uncertainties achievable based on laser power measurements to the plot of achievable mass uncertainties was very interesting

Dr Rastello asked for clarification of the comment regarding shipping calibrated masses to customers. Dr Lehman replied that it was referring to the use of a mass standard artefact to calibrate optical power meters.

Specular Gloss Measurements at NRC (Li-Lin Tay)

Dr Tay summarized the definition of gloss and its measurement, noting that it depends on the measurement geometry. She described the NRC Reference Glossmeter (RG) and the Reference Goniospectrophotometer (GSP), noting that they conform closely with the geometry specifications of a number of documentary standards and showing the results of comparisons between the two instruments. The NRC have a number of CMCs and services based on the instruments. Dr Tay described the requirements for a primary gloss standard and the design of the NRC primary standard. She finished her presentation by outlining current research on the impact of beam geometry on the measurements and BRDF measurement on pearlescent coatings.

Spectral Solar Irradiance Measurements (Julian Gröbner)

Dr Gröbner set the context by showing Earth's radiation budget and the increasing world photovoltaic capacity. He then discussed the uncertainties, noting that the uncertainties in the final product include radiometric uncertainties and uncertainties in the atmospheric model. After outlining the character of the solar spectrum and the associated measurement difficulties, Dr Gröbner discussed the Precision solar spectroradiometer that has been developed. He then gave a detailed uncertainty budget of the instrument and showed measurements of effects such as linearity and stray light and other work to characterize the instrument in detail. He concluded his presentation by showing some measurements of solar spectral irradiance and outlining the outlook for the work.

Dr Lehman asked whether there are components of the radiation budget that are not complete or need improvement. Dr Gröbner replied that the solar part is quite good but development of standards for the long-wave infra-red is still under way. Uncertainties in that region are not adequate.

Dr Lee referred to the use of a spectroradiometer outdoors, asking about the long-term stability. Dr Gröbner replied that they do not yet have an answer because there has been no time for a long-term study. A few instruments have been sold to other institutes and they are returned every few

years for recalibration. Differences of 1 % – 2 % are typical but it is not known how the instruments were handled. Three instruments are now kept at Davos so the stability could be monitored.

Dr Smid referred to the use of lasers instead of lamps as calibration sources, noting that using pulsed laser sources can lead to data acquisition issues.

Dr Rastello informed the meeting that Dr Corredera was unable to attend the meeting so his presentation will not be given.

Feasibility study towards comparison of the $g^2(0)$ measurement in the visible range (Giorgio Brida)

Dr Brida started by defining the second order intensity correlation function, $g^{(2)}(\tau)$, noting that it plays a fundamental role in characterizing and understanding single photon emission. At low flux, it can be determined from coincidence rates in a Hanbury Brown Twiss interferometer. Dr Brida showed some of the components of the experiment, including a single nitrogen-vacancy centre in a nano-diamond, single-photon avalanche detectors and the simultaneous operation of two measuring systems taken to INRIM by the participants. He showed some typical plots of coincidence rates against delay time between detector signals and explained how to calculate the required quantity taking into account background coincidences. He finished his presentation by showing experimental results from the measurements of $g^{(2)}(0)$ by all participants, as well as the lifetime of the emitter. The results were all found to be compatible to within the estimated uncertainty.

Dr Lehman asked for confirmation that the comparison consisted of one source with the evaluation systems brought together in the host laboratory. Dr Brida confirmed that was the case, agreeing with Dr Lehman's follow-up question about whether that meant that the coupling etc. was fixed. He added that moving emitters was not practical.

Dr Lee asked about the major uncertainty source. Dr Brida replied that there were a number of issues. Mechanical stability causing changes in the emitter was one. A second problem is to collect properly the data, overestimating the background is a problem since it is subtracted. These issues become part of the comparison. At the moment this is the most reliable hardware.

Equipment being developed for mid-IR spectral reflectance measurement in KRISS (Sun Do Lim)

Dr Lim set the context of the work by noting the importance of reflectance measurements in the mid-infrared for vicarious radiometric calibration of sensors on satellites. He presented the design of a reflectance measurement system based on an integrating sphere built into a FTIR spectrometer. A new, compact version of the comparator is being developed, and Dr Lim showed its use for absolute reflectance measurements. The reflectance values from the system are approximately 10 % lower than those measured by NIST, and Dr Lim showed some possible reasons for the discrepancy. He presented a detailed analysis of the effects of a number of properties of the integrating sphere and the system operation, including an analysis based on a ray-tracing technique. Based on this study, a new sphere has been developed and the discrepancy is substantially reduced. He finished his presentation by showing some standard diffuse reflectance plates being developed by KRISS.

Dr Fox commented that he did not see how the work relates to vicarious satellite calibration since different quantities are typically used in those spectral regions. Dr Lim replied by saying that emittance comes from reflectance but Dr Fox said that he did not see the achievable uncertainty from this route, adding that this is not the way the community has agreed. Dr Lim said that characterization of ground target is motivation for the work and reflectance is relevant up to 2.5 microns. Further discussion about the relevant technique and spectral regions ensued.

Development of broadband quadrant photodetector (Zhang Jing)

Dr Zhang reported that the aim of the work was to develop a monolithic broadband detector covering 400 nm – 1600 nm using a single chip, with a particular application to replace the silicon quadrant detector in a cryogenic radiometer. She then showed how extending the useable wavelength range of their cryogenic radiometer will allow NMC A*STAR to improve their measurement services, especially at the wavelengths used for optical communications. By combining a silicon layer and a germanium layer on the same device, a photodetector covering the desired wavelength range can be fabricated. Dr Zhang showed responsivity results and the effects of temperature. She illustrated the process of installing a quadrant detector fabricated in this way into a cryogenic radiometer, and some calibration results from the instrument after installation. She finished her presentation by saying that NMC would like to commercialize the new detector, and offering it to cryogenic radiometer developers and users.

Dr Krempasky asked about the typical thickness of the germanium and silicon layers and Dr Zhang replied that they both have a thickness of approximately 2 microns to 3 microns.

## 14. WHAT'S NEW FOR THE CANDELA IN THE NEXT DECADE?

Dr Rastello reminded members that she needs their help and slides for a presentation to the CIPM and she thanked Dr Obein for his slides sent to her the previous day.

## 15. MEMBERSHIP OF CCPR AND ITS WORKING GROUPS

Dr Rastello reported that the BIPM Director had received a request by InMetro (Brazil) on 13 September 2019 for full membership of the CCPR. There was not enough time to assess the application by InMetro but a decision was made to allow InMetro to make a presentation here. Dr Menegotto gave a presentation outlining the capabilities of InMetro. InMetro fulfils the roles of NMI, regulatory agency for conformity assessment and legal metrology, accreditation body in Brazil and acts as a point of enquiry for matters related to TBT/WTO. The Division of Optical Metrology is divided into three laboratories, the Laboratory of Radiometry and Photometry and the Laboratory of Optical Applications being relevant for this membership application. They provide a number of services in the fields of Properties of detectors/Radiometry, Photometry, Properties of Materials and Properties of Sources, and have eleven CMCs listed in the KCDB. The latest peer review was in 2014 and the next one will be held shortly after the CCPR meeting. InMetro has participated in a number of comparisons and contributes to SIM activities, including chairing TCPR since 2017. The last section of Dr Menegotto's presentation showed InMetro's research activates. He outlined a number of collaborative research projects on subjects including calibration of solar reference cells and optical coherence tomography for cancer detection, and showed InMetro's record of peer-reviewed research publications.

Dr Lee asked how many staff members were involved and Dr Menegotto replied that there were around 13 people, including five PhDs and two masters.

Dr Rastello said that formal approval will be postponed until the next CCPR meeting. She strongly suggests that NMIs send formal application letters at least one year in advance to allow time for preparation. Dr Milton added that the final decision rests with the CIPM.

## 16. REPORT TO THE CIPM AND RECOMMENDATIONS

Dr Rastello said that she did not believe that there were any clear or burning issues, and there was no

disagreement.

## 17. ANY OTHER BUSINESS

Dr Todd said that the presentations on the state of the art in measurement science had been particularly enjoyable and that talks and workshops should be incorporated into CCPR meetings in future.

Dr Rastello said she would like to continue the discussions regarding workshop(s) with the next CCPR meeting. She recalled that three possible topics had been raised in the earlier discussion: appearance and artificial intelligence, the use of statistics in comparison evaluation, and photobiology and photochemistry (possibly in relation to CIE). She raised the possibility of including a workshop on statistics in comparison evaluation with the working group meetings in Boulder (USA), adding that it is important that the WG-KC and WG-CMC understand all possible approaches. A second option is to include a workshop on artificial intelligence and appearance at the next full CCPR meeting, and a third option is to have joint workshop with the CIE.

Dr Fox commented that a workshop on comparison analysis in Boulder (USA) would add an extra day. He noted that he was not sure that the application of artificial intelligence was exclusive to appearance but inclusion of its wider impact in photometry and radiometry would be preferable. Dr Rastello agreed, saying that wider breadth to the topic would create higher levels of interest.

It was agreed that WG-SP should prepare proposals for a workshop at the next CCPR meeting.

**AP2:** WG-SP to prepare proposals for workshop(s) in conjunction with the next CCPR meeting.

## 18. NEXT MEETING DATE

Dr Rastello noted that the option of September 2021 for the next meeting has problems because it is close to vacations, so it could be changed to May 2022. She asked if there were any conflicting meetings and it was pointed out that the EURAMET GA is usually held in the last week of May.

Dr Rastello closed the meeting, thanking all participants for the discussions. She expressed thanks to the working groups and to the BIPM.

## APPENDIX 1
## WORKING DOCUMENTS SUBMITTED TO THE CCPR AT ITS 24TH MEETING

Documents listed below were submitted to the CCPR meeting and can be accessed on the CCPR website. Access to documents indicated with an asterisk is limited to attendees of the meeting.

| File | Title |
|---|---|
| CCPR/19-01 | Agenda of CCPR 2019 meeting |
| CCPR/19-02 | Schedule of CCPR 2019 and WG meetings |
| CCPR/19-03 | Questionnaire on activities in radiometry and photometry |
| CCPR/19-03-01 | GUM Progress Report |
| CCPR/19-03-02 | SCL Progress Report |
| CCPR/19-03-03 | IO-CSIC Progress Report |
| CCPR/19-03-04 | NMCC-SASO Progress Report |
| CCPR/19-03-05 | NRC Progress Report |
| CCPR/19-03-06 | PTB Progress Report |
| CCPR/19-03-07 | MSL Progress Report |
| CCPR/19-03-08 | PMOD Progress Report |
| CCPR/19-03-09 | UME Progress Report |
| CCPR/19-03-10 | KRISS Progress Report |
| CCPR/19-03-11 | INRIM Progress Report |
| CCPR/19-03-12 | INMETRO Progress Report |
| CCPR/19-03-13 | NIST Progress Report |
| CCPR/19-03-14 | NMIA Progress Report |
| CCPR/19-03-15 | METAS Progress Report |
| CCPR/19-03-16 | CMI Progress Report |
| CCPR/19-03-17 | LNE Progress Report |
| CCPR/19-03-18 | CENAM Progress Report |
| CCPR/19-03-19 | VSL Progress Report |
| CCPR/19-03-20 | NMIJ Progress Report |
| CCPR/19-03-21 | NIM Progress Report |
| CCPR/19-03-22 | VTT-MIKES Progress Report |

| File | Title |
|---|---|
| CCPR/19-03-23 | SMU Progress Report |
| CCPR/19-03-24 | CMS/ITRI Progress Report |
| CCPR/19-03-25 | NMISA Progress Report |
| CCPR/19-03-26 | VIINOFI Progress Report |
| CCPR/19-05* | KCDB v2.0 presentation to CCPR |
| CCPR/19-06* | WG-CMC Report |
| CCPR/19-07* | WG-KC Report |
| CCPR/19-08* | WG-SP Report |
| CCPR/19-09* | AFIRMETS Report |
| CCPR/19-10* | APMP Report |
| CCPR/19-11.3* | COOMET Report |
| CCPR/19-12* | EURAMET Report |
| CCPR/19-13* | SIM Report |
| CCPR/19-14* | GULFMET Report |
| CCPR/19-15* | WMO Report to CCPR |
| CCPR/19-16* | CIE Report to CCPR |
| CCPR/19-17* | CORM Report to CCPR |
| CCPR/19-18* | INMETRO capabilities in Photometry and Radiometry |
| CCPR/19-19* | CCPR science session speaker 1 |
| CCPR/19-20* | CCPR science session speaker 2 |
| CCPR/19-21* | CCPR science session speaker 3 |
| CCPR/19-22* | CCPR science session speaker 4 |
| CCPR/19-23* | CCPR science session speaker 5 |
| CCPR/19-24* | CCPR science session speaker 6 |

## APPENDIX 2
## SUMMARY OF ACTION POINTS

**AP1** (page 15) Prof. Dr Kück to ask EURAMET NMIs for permission to share documentation from the workshop on support, collaboration and coordination.

**AP2** (page 20) WG-SP to prepare proposals for workshop(s) in conjunction with the next CCPR meeting.