Bureau International des Poids et Mesures

Consultative Committee for Acoustics, Ultrasound and Vibration (CCAUV)

Report of the 11th meeting
(20-22 September 2017)
to the International Committee for Weights and Measures

Comité international des poids et mesures

LIST OF MEMBERS OF THE
CONSULTATIVE COMMITTEE FOR ACOUSTICS, ULTRASOUND AND VIBRATION
as of 20 September 2017

President

Dr T. Usuda, Director, Metrology Management Center, CIPM Member, National Metrology Institute of Japan, AIST.

Executive Secretary

Dr G. Panfilo, International Bureau of Weights and Measures [BIPM], Sèvres.

Members

Central Office of Measures/Główny Urzad Miar [GUM], Warsaw.

Centro Nacional de Metrología [CENAM], Querétaro.

All-Russian D.I. Mendeleyev Research Institute for Metrology, Rosstandart [VNIIM], St Petersburg.

Danish Fundamental Metrology Ltd [DFM], Lyngby.

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

Instituto Nacional de Metrologia, Normalizacao e Qualidade Industrial [INMETRO], Rio de Janeiro.

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.

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, National Institute of Advanced Industrial Science and Technology [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-Technische Bundesanstalt [PTB], Braunschweig.

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

Observers

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

Institute for Physical-Technical and Radiotechnical Measurements, Rosstandart [VNIIFTRI], Moscow.

Bulgarian Institute of Metrology [BIM], Sofia.

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

Centro Español de Metrología [CEM], Madrid.

Czech Metrology Institute [CMI], Brno.

Industrial Technology Research Institute/Center for Measurement Standards [CMS/ITRI], Hsinchu.

Instituto Português da Qualidade [IPQ], Caparica.

Institutul National de Metrologie [INM], Bucharest.

Kenya Bureau of Standards [KEBS], Nairobi.

National Physical Laboratory of India [NPLI], New Delhi.

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

Liaisons

International Electrotechnical Commission [IEC], Geneva.

International Organization for Standardization [ISO], Geneva.

OPENING OF THE MEETING

The eleventh meeting of the Consultative Committee for Acoustics, Ultrasound and Vibration (CCAUV) took place at the International Bureau of Weights and Measures (BIPM), Pavillon de Breteuil, Sèvres, from 20 to 22 September 2017.

The following were present:

S. Barrera-Figueroa (DFM), C. Bartoli (LNE), T. Bruns (PTB), I. Calzado Guijorro (CEM), W.H. Cho (KRISS), S. Crocker (NIST), S. Cui (NMC/A*STAR), L. Dickinson (NMIA), D. Dobrowolska (GUM), G. Durando (INRIM), J.S. Echeverría-Villagómez (CENAM), A. Enyakov (VNIIFTRI), M. Gaitan (NIST), C. Hof (METAS), R. Horiuchi (NMIJ/AIST), A.E. Isaev (VNIIFTRI), C. Koch (PTB), J. Kolasa (GUM), T. LeBrun (NIST), T.R. Licht (DFM), A. Maina (KEBS), M.J.T. Milton (Director of the BIPM), R. Nel (NMISA), M. Nieves Medina (CEM), A. Nikolaenko (VNIIFTRI), E. Sandermann Olsen (BKSV-DPLA), A. Ota (NMIJ/AIST), A. Pérez Matzumoto (CENAM), L. Ribeiro (IPQ), G. Ripper (INMETRO), S. Robinson (NPL), D. Rodrigues (LNE), P. Rosenkranz (BEV), E. Sadikoglu (UME), A. Schiavi (INRIM), Q. Sun (NIM), T. Usuda (CIPM and NMIJ/AIST), C. Veldman (NMISA), L. Wu (NRC), P. Yang (NIM), A. Yankovsky (VNIIM), S. Rajagopal (NPL) and B. Zeqiri (NPL).

Guests: Y.C. Huang (CMS/ITRI and APMP), A. Biber (MRC MI-UAL), F. N. Alsubaey (SASO NMCC).

Also present: E. de Mirandes (BIPM), G. Panfilo (Executive Secretary of the CCAUV), S. Picard (Coordinator of the BIPM KCDB), N. Zviagin (Executive Secretary of the JCRB).

Excused: M. Blabla (CMI)

1. WELCOME / INTRODUCTION OF TOPICS AND PRESENTATION OF SPEAKERS BY THE CCAUV PRESIDENT

The President, Dr Takashi Usuda, welcomed the members to the meeting.

A special workshop on “Measurement of imperceptive matters” was held at the start of the 11th CCAUV meeting. This technical session took place before commencing with the agenda, and included a series of short presentations with selected topical themes. A copy of each presentation is available on the CCAUV website. The presentations were as follows:

- *Introduction: Aim of the workshop*
  Takashi Usuda, CCAUV President, NMIJ (Japan). Document CCAUV-17/37
- *The IMS network: Overview, measurement systems and calibration*
  Julien Marty, CTBTO (Austria). Document CCAUV-17/36
- *Report on CCAUV.V-K3 comparison*
  Qiao Sun, NIM (China). Document CCAUV-17/10

- *Hearing below the low-frequency-limit: Measurement, perception and impact of infrasound noise*
  Christian Koch, PTB (Germany). Document CCAUV-17/41
- *Realization of acoustic primary standards for airborne ultrasound and applications*
  Ryuzo Horiuchi, NMIJ (Japan). Document CCAUV-17/43
- *A Primary Method for the Complex Calibration of a Hydrophone from 1 Hz to 2 kHz*
  S.E. Crocker, NIST-USRD (United States). Document CCAUV-17/14
- *Metrology issues with long-term monitoring of very low frequency deep-water ocean noise*
  Stephen Robinson, NPL (United Kingdom). Document CCAUV-17/39
- *Free-field calibration of underwater sound receiver in a laboratory water tank at very low frequencies*
  A.E. Isaev, A.S. Nikolaenko, FSUE VNIIFTRI (Russia). Document CCAUV-17/38
- *A 6DOF micro-vibration measurement and generation test facility*
  Charlie Jarvis, NPL (United Kingdom). Document CCAUV-17/40

2. WELCOME BY THE DIRECTOR OF THE BIPM

The Director of the BIPM, Dr Martin Milton, welcomed the delegates to the 11th meeting of the CCAUV. He noted that it is the eighth meeting of a CIPM Consultative Committees in 2017. This increased frequency of meetings is due to the upcoming revision of the SI in 2018, with many Consultative Committees taking this opportunity to review their work and update their strategy beforehand. He emphasized the importance of the work carried out by Consultative Committees. The CCAUV has to update its strategy and identify opportunities to work with its stakeholders in order to make its work more efficient and effective.

Dr Milton updated the meeting on new developments within the CIPM and BIPM. He mentioned that more detailed information about important issues will be provided during the meeting under the different agenda items.

3. INTRODUCTION BY THE PRESIDENT OF THE CCAUV

Dr Usuda welcomed the delegates to the 11th meeting of the CCAUV. He noted that the CCAUV community had already held a very successful workshop on “Measurement of imperceptive matters” the day before the commencement of the formal CCAUV meeting.

All participants introduced themselves.

4. APPOINTMENT OF THE RAPPORTEUR

Dr Sadikoglu from UME and Dr Barrera-Figueroa from DFM were proposed as the Rapporteurs. This was approved by the meeting.

5. APPROVAL OF THE AGENDA

Dr Usuda introduced the agenda and asked participants if any changes or modifications are required. As no proposals were made the agenda was approved as is.

6. REPORT OF THE 10TH MEETING OF THE CCAUV 2015, INCLUDING ACTIONS AND DECISIONS

The essential actions and decisions arising from the 10th meeting of the CCAUV 2015 are summarized below. Dr Panfilo went through these for the benefit of the meeting. All actions and decisions had been completed with the exception of CCAUV10/A5 and partially CCAUV10/A6. CCAUV10/A5 was not completed because the NPL had withdrawn from activities in sound in air during 2016. However, a free-filed comparison will be discussed under item 12. As for action A6, definitions of AUV units given on the BIPM website were updated for the field of vibration, while an update in the acoustics field is pending.

Actions

CCAUV10/A1 Dr Usuda, President, to seek input from CCAUV members via a free form questionnaire, on raising awareness of the CIPM MRA and its instruments such as the CMC database with consumers of calibration services. CCAUV members to provide their feedback by January 2016.

CCAUV10/A2 The BIPM Director to re-iterate to NMI Directors that delegates nominated to attend the CCAUV meeting have ongoing executive responsibilities until the next meeting.

CCAUV10/A3 PTB to prepare the outline and register a new CCAUV KC on acceleration sensitivity of accelerometers (see also CCAUV10/D6).

CCAUV10/A4 NIM to prepare the outline and register a new CCAUV KC on low intensity shock calibration (see also CCAUV10/D7).

CCAUV10/A5 NPL to prepare an outline for a new pilot study on free-field calibration of microphones, considering both reciprocity and optical calibration techniques, and in a separate study, extended high frequency calibration (see also CCAUV10/D3).

CCAUV10/A6 NPL and PTB to review the definitions for AUV units given on the BIPM website, and suggest alternatives where necessary.

Decisions

CCAUV10/D1 SPWG should be tasked with identifying the needs of developing NMIs for participation in the CIPM MRA.

CCAUV10/D2 The final report on AFRIMETS.AUV.A-S1 was approved with editorial comments.

CCAUV10/D3 A new pilot study on free-field calibration of microphones was agreed and will be developed by NPL (UK) and DFM and NMIJ will participate. The project is intended to inform a future KC (repeat of CCAUV.A-K4 with extension of scope).

CCAUV10/D4 AFRIMETS.AUV.V-S2 will be upgraded to a KC with a new designation AFRIMETS.AUV.V-K3 to facilitate linking to the corresponding CCAUV KC.

CCAUV10/D5 A new KC on the pressure calibration of LS2P microphones (repeat of CCAUV.A-K3) was considered, but will be postponed until new developments in low-frequency calibration are better established. It is likely that a new proposal for this KC will be developed for the next meeting of the CCAUV.

CCAUV10/D6 A new KC on the acceleration sensitivity of accelerometers (a repeat of CCAUV.V-K2) was agreed. The following expressed interest in participation: NIM, VNIIM, PTB, INMETRO, CENAM, NMIJ, BKSV-DPLA, NMISA, LNE, METAS, GUM, CEM, IPQ, NIST, A-STAR. However, final participation will be decided by the pilot laboratory, considering the variety of facilities to be used and the geographic distribution of participants. Other laboratories interested in participating should make this known to the proposed pilot laboratory PTB (Germany).

CCAUV10/D7 A new KC for low-intensity shock calibration was agreed. The following expressed interest in participation: NIM, VNIIM, PTB, INMETRO, CENAM, NMIJ, BKSV-DPLA, CMS/ITRI, NMISA, KRISS, NRC and INRIM. However, final participation will be decided by the pilot laboratory, considering the variety in facilities to be used and the geographic distribution of participants. Other laboratories interested in participating should make this known to the proposed pilot laboratory NIM (China).

CCAUV10/D8 The CCAUV Delegates unanimously supported the applications for full member status of the CCAUV by METAS (Switzerland), and observer status of the CCAUV by CMS/ITRI (Chinese Taipei), and agreed to submit these recommendations for ratification by the CIPM.

Dr Panfilo noted that the report of the 10th meeting of the CCAUV, held in 2015, had been circulated to the CCAUV and few comments were raised. All of them were considered in the final version of the report, which has been updated accordingly. There being no further comments, the report was confirmed and Dr Panfilo thanked Dr Barham and Mr Robinson for their efforts as Rapporteurs for the last meeting.

7. CIPM MRA REVISION

7.1. Recommendations from the Working Group on the Implementation and Operation of the CIPM MRA

Dr Usuda gave an overview of the status of recommendations from the Working Group on the Implementation and Operation of the CIPM MRA. He began his presentation by reiterating the CCAUV objectives. Currently the CCAUV has three objectives: to progress the state of the art, to reach out to new and established stakeholders and to demonstrate the global comparability of measurements. Although all of the objectives of the CCAUV are of equal importance, it was noted that the CIPM encourages CCs to work closely with stakeholders. This could be done by planning and implementation of various dissemination activities, and exchange of information with stakeholders. In this respect, a newly revised CCAUV Strategy Document is to be used as a communication tool with stakeholders. It is expected that the CCAUV Strategy Document will be published shortly after the meeting, and monitoring of the implementation of actions described in the document will be done at the next meeting. The document will be updated accordingly, if required.

Regarding the current status of recommendations of the Working Group on the Implementation and Operation of the CIPM MRA, Dr Usuda stated that the review of the CIPM MRA had been triggered by the 25th CGPM (Resolution 5). A NMI directors' workshop had been organized to review the current status of the CIPM MRA implementation and operation, and to identify actions for improving its efficiency and effectiveness. A CIPM Working Group on the Implementation and Operation of the CIPM MRA analyzed the outcomes of the workshop and summarized their recommendations in a document, which is publicly available on the BIPM website. There were eight actions adopted by the WG described in the document; these will be addressed by the CIPM Consultative Committees. The CCAUV response to these actions will be discussed later under agenda item "CCAUV implications". CCAUV comments on these actions were submitted to the CIPM MRA Review WG in March 2017.

Dr Usuda also noted that a survey of CCAUV members to collect input on raising awareness of the CIPM MRA and its instruments, such as the KCDB, among consumers of calibration services was carried out shortly after the 10th CCAUV meeting. A summary of outcomes from the survey was given by the CCAUV President.

7.2. KCDB 2.0

Dr Susanne Picard, KCDB coordinator, reported progress on the revision of the KCDB 2.0. She stated that work on the revision of the KCDB was triggered by Resolution 5 of the 25th General Conference of Weights and Measures (CGPM) in 2014. Actual work started in August 2016. Currently, work on the KCDB 2.0 is being carried out by team comprising the KCDB office staff, the JCRB Executive Secretary and other colleagues from the BIPM. The general concept of a new web platform for calibration and measurement capabilities as well as comparisons is based on the following: it will integrate better search facilities, have user friendly web support, allow web-based CMC submission and review, as well as a facility to track the status of comparisons. The new KCBD 2.0, based on the "Writer-Reviewer-Finder" principle, will enable support of both intra- and inter-regional CMC review. CMCs will be submitted not in batches, but one by one. Access to KCDB 2.0 will be via user accounts. Risk-based evaluation of CMCs will be included in KCDB 2.0, for

example low uncertainty will require thorough intra- and inter-regional review. The final objective is to have KCDB 2.0 operational before the 26th CGPM in November 2018. Dr Picard emphasized that action on a few issues is required from the CCAUV: to revise three equations currently published on the KCDB; to provide support for the thesaurus; to provide feedback on units to be used for AUV services; and to decide on a timetable when there will be no CMC submissions to allow the switchover from KCDB 1.0 to 2.0. It was asked if new units could be added to the KCDB 2.0 and special characters could be used. Dr Picard replied that the system would allow this.

The presentation is available on the CCAUV webpage (CCAUV/17-34).

Following the presentation on KCDB 2.0 the CCAUV formulated an action on the establishment of an *ad hoc* group, composed of RMO TC Chairs, which will discuss and make decisions on the presentation of units used in the AUV field in the KCDB, and to provide feedback to the KCDB office by the end of October 2017.

Action: CCAUV11/A1 An *ad hoc* group composed of RMO TC Chairs will discuss and make a decision on the way units used in the AUV field are presented on the KCDB and will provide feedback to the BIPM KCDB office by the end of October 2017.

7.3. CCAUV implications

Dr Usuda reported on the CCAUV position with respect to eight recommended actions from the Working Group on the Implementation and Operation of the CIPM MRA to be addressed by the Consultative Committees. These are the implications of the CIPM MRA review to the work of the CCAUV. He noted that discussion about these actions was carried out also by the CCAUV WGs, and the CCAUV had reached a conclusion on each action. Regarding the recommended action on progress on CC strategy updates, particularly related to defining the long-term timetable for CC key comparisons, the CCAUV decided to define and present long-term timetables and repetition periods for key comparisons in the CCAUV Strategy document. This information will be reviewed every two years. As a response to the action related to limiting the number of participants in a key comparison, it was stated that this approach is already implemented by the CCAUV. Typically, CCAUV key comparisons involve 10 to 15 participants (two to three per RMO) with a purpose to limit the circulation period to around 1 year. Regarding the action about progress towards better consistency in the expression of CMCs, it was noted that the CCAUV does not suffer significantly from inconsistency in the expression of CMCs. Nevertheless, the expression of CMCs will be reviewed by the *ad hoc* WG and reported to the KCDB manager by the end of October 2017. To address the action concerned with identification of CMCs to be covered by key and supplementary comparisons, the CCAUV considers that it is relatively difficult to give a general indication on “how far the light shines”. Nevertheless, comparison pilots are requested to include a statement in the documents pertaining to the key and supplementary comparisons as proposals to be approved by the CCAUV KCWG. As for action related to constraining the proliferation of CMCs and expressing CMCs as concisely as practicable, Dr Usuda stated that the CCAUV and the RMO TC-AUVs have not experienced significant overload of work with respect to this task. Furthermore, for the action on adoption and implementation of a “risk-based” approach for CMC review, it was noted that the CCAUV had not use the “risk-based” approach up to now. Nevertheless, the approach to limit the workload related to CMC submissions was accepted by the CCAUV. As for action related to harmonization of CC approaches to identify evidence needed to support CMC claims when not

supported by comparison, based on the analysis of CCAUV practices, no general concept for a harmonized approach to CMC review without direct support by key and supplementary comparisons was found. And finally, regarding the action on availability for common use of CCs specific methodologies for carrying out comparisons, the CCAUV encouraged past pilot laboratories to submit their comparison evaluation tools (for example Excel files) as templates for evaluation of results of future comparisons.

Action: CCAUV11/A2 CCAUV President, Dr Usuda, to present the CCAUV positions regarding the CIPM MRA review and redefinition of the SI units to the CIPM.

8. REPORT FROM THE CCU ON THE REDEFINITION OF THE SI

Dr Estefania de Mirandés, Executive Secretary of the CCU, reported on progress towards the revision of the SI. In her presentation she focused on outcomes of the recent meetings of the Consultative Committee for Units (CCU) and Consultative Committee on Mass and Related Quantities (CCM). The CCU meeting had been held at the BIPM on 5-6 September 2017 and was attended by CCU members, representatives from most of the CCs and NMIs involved in primary realizations of the kilogram. An overview of the current status of the experimental results on the determination of the Planck and Boltzmann constants was given. It was mentioned that in 2017, CODATA made an adjustment of values of fundamental constants (k, h, e and N_A), based on recent experimental results. Recent experimental results were also discussed at the CCM meeting. The CCM held its meeting in May 2017 and prepared recommendation (G1:2017) about the revision of the SI. The recommendation is publicly available on the BIPM website. The CCM recommends that the CIPM undertakes the necessary steps to proceed with the planned revision of the SI at the 26th meeting of the CGPM, acknowledging the measures to be taken by the CCM to ensure integrity and continuity in the dissemination of the kilogram. It was emphasized that the final recommendation from the CCU is also in the same direction and the CCU recommended to the CIPM that it proceed with the revision of the SI in 2018 according to the previously proposed timescales. Finally, it is expected that decision about revision of the SI units will be made at the 26th CGPM in November 2018. Dr de Mirandés noted that CCU also discussed a roadmap for a possible redefinition of the second in the future.

Information about the revision of the SI Brochure was given during the presentation. The SI Brochure is currently at the stage of “close-to-final”. It was stated that a fully edited version will be produced by the BIPM and presented to the CCU and then the CIPM in October 2017 for final approval. It was noted that in parallel, ISO 80000-1 was being revised and relied on some of the content of the “close-to-final” draft 9th SI Brochure being available online. A few of the changes in the 9th draft of the SI Brochure were mentioned. These are: inclusion of a side note concerning the *var* and the *gal*, and rejection of all requests to include further non-SI units.

Finally, Dr de Mirandés informed the CCAUV about materials, for example documents and videos, for promotion of SI on the BIPM website.

The presentation is available on the CCAUV webpage (CCAUV/17-47).

Action: CCAUV11/A3 CCAUV President, Dr Usuda, to present the CCAUV position regarding the SI Brochure to the CIPM.

9. REPORT FROM THE WORKING GROUP ON STRATEGIC PLANNING (CCAUV-SPWG)

Dr Michael Gaitan, chair of the CCAUV Strategic Planning Working Group (CCAUV-SPWG), reported on its activities. He began the presentation with an overview of the working group, its structure, mission and current membership. It was stated that the main efforts within the WG over the past two years have been focused on updating of the CCAUV Strategy Document. The draft document was prepared by a core group from the SPWG and had been submitted for discussion at the SPWG meeting, which was held on 19 September 2017. The draft document has been slightly revised, based on outcomes of discussions at the meeting.

The updated Strategy Document consists of eleven chapters. The document includes all important information to be provided by the CCAUV community to its external audience. This explicitly concerns CCAUV stakeholders. Great emphasis has been placed on the "Future Scan" chapter to make it as detailed as possible for identification of drivers and research fields to be covered by the CCAUV. Fields such as inertial acceleration, digitization, challenges for development of new and improved methods and measurement protocols for hearing assessment, development of new sensors and new methodologies for underwater acoustics measurements are just a few of the subjects presented in the Strategy Document.

The Strategy Document includes a chapter on scheduling and planning for comparisons in all subject fields. This addresses one of the requests from the CIPM MRA Review Working Group. The typical cycle for comparisons is 8-10 years, however a periodic update of this part, as well as the whole document, will be made in the future. Dr Gaitan emphasized that if there are any future ideas for further improvements to the Strategy Document, he or the co-chairs of the SPWG should be contacted.

After short discussion, the CCAUV decided to publish the Strategy Document on the website after the meeting. In addition, an Executive summary of the Strategy Document will be submitted to the CIPM.

The presentation is available on the CCAUV webpage (CCAUV/17-46).

Decision: CCAUV11/D1 The CCAUV approved publication of the Strategy Document on the website shortly after the meeting.

10. REPORT FROM THE WORKING GROUP ON KEY COMPARISONS (CCAUV-KCWG)

Dr Gustavo Ripper, chair of the CCAUV Key Comparison Working Group (CCAUV-KCWG), reported the outcomes from the KCWG meeting held on 19 September 2017. The meeting was attended by eight members of the WG, the CCAUV President and Executive Secretary, and the KCDB Coordinator, as well as ten guests from all RMOs. The agenda of the meeting included 25 items. The statements of the mission and tasks of the KCWG were slightly revised to more accurately reflect the tasks dealt with by the WG. Dr Salvador Barrera-Figueroa joined the WG as an expert in sound in air. The status of all ongoing or planned comparisons was reported. In some cases, when comparison coordinators were present, they verbally presented their reports. Currently there

are three CCAUV and five RMO comparisons in progress. All of them, with the exception of COOMET.AUV.V-K1 are progressing well. The issue with the COOMET comparison was discussed and the KCWG decided that a statement be included in the Abstract and Conclusions section "that the comparison is not to be used for supporting CMCs because the results are very outdated (more than 10 years old)". After incorporation of this action and some revisions to the format, the Final report will be approved by the KCWG and submitted to the CCAUV for approval and publication. In addition to key and supplementary comparisons, two pilot studies have been published since the last CCAUV meeting and one is in progress. It was noted that work of the KCWG is efficient: a Technical Protocol takes two weeks for approval and a Draft B report takes four weeks. Some delays could occur due to late reporting and lack of uncertainty budgets. He reiterated that authorship of Draft B reports now includes representatives of all participants. The issue of uncertainties smaller than those in published CMCs and reported by participants in key comparisons was discussed at the WG meeting. It was concluded that submitted uncertainties associated with key comparison results are not restricted by already established CMCs; they are based on actual (new) estimations of measurement uncertainty. Any inconsistency as a consequence of the reported results must be dealt with by the participant and the NMI/DI's QM system, with inclusion of the RMO procedures and RMO TC-Quality. Finally, the pilot laboratory is supposed to analyse and report the KC based on the reported results, without consideration of former established CMCs.

Recommended actions from the CIPM MRA Review Working Group were discussed at the meeting and the following decisions were made. Technical Protocols for future key and supplementary comparisons shall explicitly state the services that are intended to be supported by the results of the comparison. A repetition period for key comparisons of 10 years was considered as an appropriate compromise between workload, time for proliferation to the RMOs and requirements for validation of QM systems, especially considering the need for RMOs to conduct KCs in sequence.

The presentation is available on the CCAUV webpage (CCAUV/17-45).

11. REPORT FROM THE WORKING GROUP FOR RMO COORDINATION (CCAUV-RMOWG)

Dr Qiao Sun, chair of the CCAUV Working Group for RMO Coordination (CCAUV-RMOWG), reported on the activities of the WG. The report focused on discussion and outcomes form the WG meeting held on 20 September 2017. The meeting was attended by WG members, the CCAUV President and Executive Secretary, the KCDB Coordinator, the JCRB Executive Secretary, as well as nine guests from all of the RMOs. The agenda included 12 items, the most important of which were: a review of service categories; a proposal for a new unified structure for service category; and the issue of adding a service item using the electrostatic actuator method. The proposal for a new unified structure for 'service category' was discussed and approved. The service categories were reviewed resulting in categories for the sound in air, vibration and auxiliary devices areas being approved. However, further modifications are required for services in the sound in water area. A discussion on the service category for the determination of microphone response by electrostatic actuator concluded with the decision to 'grey out' this service in the service category to prevent its use in the future. A final decision was made about the approach for limiting the number of participants in key comparisons. The approach was accepted and supported, leading to the decision that number of participants in key comparisons has to vary from 10 to 15 with balanced

representation from all RMOs. This will enable the circulation time within a comparison to be maintained at around one year.

Dr Sun's presentation is available on the CCAUV webpage (CCAUV/17-48).

Dr Barrera-Figueroa commented that further investigation is required for revisiting the decision about the service related to electrostatic actuators.

Dr Usuda noted that CCM WGs have to be consulted about services in dynamic force and pressure.

Action: CCAUV11/A4 CCAUV RMOWG to finalize the work on service categories and CCAUV President, Dr Usuda, to consult with relevant CCM WGs about services in dynamic force and pressure.

12. CCAUV KEY COMPARISONS

Status of all AUV comparisons registered on the BIPM KCDB is presented in the CCAUV-17/20 document prepared by the CCAUV Executive Secretary prior to the meeting. Coordinators provided updates on ongoing comparisons during the meeting.

12.1. Comparisons and reports: published/in progress/proposed

12.1.1. CCAUV.W-K2

Mr Stephen Robinson reported on progress with the key comparison on hydrophone free-field calibration. There are seven participants in the comparison: NPL (pilot), INMETRO, KRISS, NIM-HAARI, NIST (USRD), TUBITAK-MAM and VNIIFTRI. Measurements within comparisons started in the beginning of 2016. However, there were some delays due to customs. This is why measurements by one of the participants were moved from the middle of circulation period to the end. Measurements are expected to be completed by the end of 2017 and Draft A of the comparison report will be submitted in spring 2018. Mr Robinson noted that an institute from India had expressed a wish to participate; the institute is neither a NMI nor DI. He asked if there are any regulations for such a situation.

Dr Milton replied that CIPM MRA rules allow the participation of expert laboratories in key and supplementary comparisons.

12.1.2. CCAUV.V-K4

Dr Sun presented progress with CCAUV.V-K4, a comparison on accelerometer shock calibration. The comparison has nine participants: NIM (pilot), NMIJ/AIST (co-pilot), KRISS, CENAM, PTB, INMETRO, NMIA, NMISA, VNIIM. The Technical Protocol for the comparison has been approved by the CCAUV and circulation of accelerometers will start in 2018.

12.1.3. CCAUV.V-K5

Dr Thomas Bruns reported on the status of CCAUV.V-K5, a comparison of calibrations of accelerometers in the frequency range from 10 Hz to 20 kHz. Three accelerometers, Brüel & Kjaer (B&K) type 8305, type 8305-001 and type 4371 are used as transfer standards in the comparison. Participants of the comparison are: PTB (pilot), BKSV-DPLA, CEM, METAS, NIST, CENAM, INMETRO, NIM, NMIJ, NMIA, NMC/A*STAR, NMISA, UkrMet and VNIIM. Measurements within the comparison started in spring 2016. The comparison was running smoothly, but recently some delays had occurred due to custom problems and the time schedule for the comparison has been updated. Some technical problems were detected for the B&K type 4371 accelerometer. It is expected that measurements will finish early in 2019.

Dr Bruns emphasized the fact that participants have to take care when collecting the transducers from PTB. To overcome custom problems he asked participants to inform the pilot in advance about any specific issues to be taken into account, to ensure the process of circulating the transfer standards is as fast and easy as possible.

12.1.4. Future comparisons

Dr Enver Sadikoglu raised an issue about repeating comparisons on pressure and free-field calibrations of LS2p microphones, CCAUV.A-K3 and CCAUV.A-K4, as the previous comparisons was completed a long time ago. After discussion the CCAUV came to conclusions for both comparisons. New comparisons, CCAUV.A-K6 and CCAUV.A-K7 as a repeat of CCAUV.A-K3 and CCAUV.A-K4 respectively will be organized in the nearest future.

LNE (France) will pilot the key comparison CCAUV.A-K6 on calibration of LS2p microphones in the frequency range from 20 Hz to 25 kHz with an option to make calibrations down to 2 Hz.

Decision: CCAUV11/D2 LNE (France) will pilot the key comparison CCAUV.A-K6 on calibration of LS2p microphones in the frequency range from 20 Hz to 25 kHz with an option to make calibrations down to 2 Hz.

DFM (Denmark) will pilot the key comparison CCAUV.A-K7 on free–field calibration of LS2p microphones in the frequency range from 1 kHz to 40 kHz, which will start in 2020.

Decision: CCAUV11/D3 DFM (Denmark) will pilot the key comparison CCAUV.A-K7 on free–field calibration of LS2p microphones in the frequency range from 1 kHz to 40 kHz, which will start in 2020.

12.2. CCAUV supplementary comparisons: published/in progress/proposal

The single CCAUV supplementary comparison, CCAUV.V-S1 (Primary angular vibration calibration), was completed some time ago. A final report of the comparison was published on the BIPM KCDB in 2014. No further supplementary comparisons were proposed at the meeting.

13. REGIONAL METROLOGY ORGANIZATIONS

13.1. JCRB Matters

The update was provided by Mr Nikita Zviagin, the JCRB Executive Secretary. Since the previous meeting of the CCAUV (2015), the JCRB has held five meetings: September 2015, March 2016, September 2016, March 2017 and September 2017. The next meeting of the JCRB is scheduled for March 2018. He noted that outcomes of the JCRB meetings are available on the BIPM website.

Mr Zviagin gave an overview of BIPM Capacity Building and Knowledge Transfer (CBKT) initiatives and emphasized that currently four have been completed, three are ongoing and there are two planned initiatives. Information about updated CIPM MRA documents since the last CCAUV meeting was given. This concerned the revision of documents CIPM MRA-D-04 and CIPM MRA-D-01. In document CIPM MRA-D-04, the template for CMCs with uncertainty matrices was changed, text in section 5.3 about the possibility of changing the date for review submission was modified, and some minor changes in terminology and structure of the document were made. There were few modifications in section 9 about debates and section 11 about minutes in the "Rules of procedure for the JCRB" (CIPM MRA-D-01) document. In addition, reference to the ISO Guide 34 was changed to the ISO 17034 standard in all CIPM MRA documents.

A new, web-based JCRB directory is available on the BIPM website. It lists chair persons by RMOs and by metrological areas. Statistical information about CMCs in AUV fields indicates that 47 CMC sets comprise 1193 CMCs currently published on the BIPM KCDB. Since the last CCAUV meeting in 2015, five new CMC sets have been published (one by AFRIMETS, three by APMP and one by SIM). It was noted that the average review time is 357 days. The JCRB is monitoring the status of comparisons which are more than 5 years old. There are two key and single supplementary comparisons which have not been completed after a period in excess of 5 years. These are all RMO comparisons.

The presentation is available on the CCAUV webpage (CCAUV/17-35).

13.2. Reports from Regional Organizations

13.2.1. SIM

Dr Ripper, chair of the SIM MWG-9, reported on the activities of SIM, which is active in all fields of AUV. Currently, SIM has nine NMIs with interest in AUV. Five of them have CMCs published in the BIPM KCDB. However, four SIM members, NMIs from Bolivia, Colombia, Costa Rica and Peru do not yet have CMCs in AUV field. SIM members are currently involved in four ongoing CIPM or RMO key and supplementary comparisons.

Cooperative activities have been developed by SIM members to disseminate technical knowledge and exchange experiences during the last two years. Informal bilateral comparisons in the fields of acoustics and vibration, as well as technical visits and training of INMETRO staff at CENAM are examples of such cooperation. SIM MWG-9 considers development and realization of further activities for increasing the participation of SIM countries in AUV metrology. This will involve development of joint activities to increase the level of technical exchange in the near future and the

provision of technical support to newcomers to assist in the publication of their first CMCs in AUV field.

The written report and the presentation are available on the CCAUV webpage (CCAUV/17-16 and CCAUV/17-44).

13.2.2. AFRIMETS

Mr Riaan Nel, chair of AFRIMETS's TC-AUV Working Group presented progress within AFRIMETS. Three NMIs are active in AUV field: KEBS, Kenya (acoustics and vibration), NIS, Egypt (acoustics), and NMISA, South Africa (acoustics and vibration). Recently the NMIs of Nigeria and Ethiopia have expressed their intention to develop capabilities in the acoustics and vibration field. Rwanda is also considering the potential establishment of AUV capabilities.

Currently members of AFRIMET TC-AUV Working Group are involved in four ongoing CIPM or RMO key and supplementary comparisons. An additional two AFRIMETS supplementary comparisons are planned for the future. AFRIMETS has had CMCs published by two NMIs (NMISA, KEBS) in the fields of sound in air and vibration. There are no CMCs in the fields of ultrasound and underwater acoustics so far. New calibration capabilities are under development in AFRIMETS. These include calibration of artificial ears and mastoids, low-frequency calibrations of microphones and monitoring devices, primary shock calibrations and both primary and secondary calibration of accelerometers at high frequencies up to 20 kHz. All these activities are carried out by NMISA. Mr Nel noted in his presentation that there is a need for training in the various AUV subjects as well as in the organization of inter-laboratory comparisons.

The presentation is available on the CCAUV webpage (CCAUV/17-49).

13.2.3. APMP

Mr Huang, chairperson of the APMP TC-AUV, reported on the APMP, highlighting activities in a variety of key comparisons. A total of 12 countries are active in AUV field: NMIA (Australia), NIM (China), CMS (Chinese Taipei), Hong Kong (SCL), India (NPLI), Indonesia (KIM-LIPI), Japan (NMIJ), Republic of Korea (KRISS), Malaysia (NML-SIRIM), Thailand (NIMT), Singapore (NMC/A*STAR), Nepal (NBSM), Fiji (NML) and Viet Nam (VMI). In addition, Egypt (NIS) and NMISA (South Africa) have the status of associate members in APMP TC-AUV. Currently, ten APMP TC-AUV members have a total of 306 CMCs published in the BIPM KCDB. There is a single APMP comparison, APMP.AUV.A-P2, in progress. Draft A of the comparison report is being prepared. However, APMP is planning to start a new key comparison on ultrasonic power measurement. The technical protocol for the comparison is under preparation. Mr Huang reported that four peer reviews in the AUV field were organized between 2016 and 2017, and an additional one will be performed in October 2017.

The APMP TC-AUV anticipates several major challenges in AUV: in health for diagnostics, therapy and hearing assessment (acoustics and ultrasound); in industry for the automotive, aerospace and manufacturing sectors (vibration and acoustics); and environment in the areas of airborne noise, marine noise pollution and earthquake monitoring (acoustics, underwater and vibration).

The APMP TC-AUV held a workshop from 31 May to 3 June 2016 in Thailand on the application of acoustics, ultrasound and vibration metrology in the transportation industry. Fourteen papers related to the topics of high speed trains, railways, metro systems and automobile were presented during the workshop. The second workshop on applying acoustics, ultrasound and vibration metrology to intelligent machines for Industry 4.0 was held in Hsinchu City on 2-4 May 2017. The workshop was attended by 50 participants. The next workshop, to be hosted by NPLI (India) in New Delhi, is scheduled for November 2017.

The presentation is available on the CCAUV webpage (CCAUV/17-22).

13.2.4. COOMET

Dr Alexander Enyakov, COOMET TC-AUV vice chair, presented progress within COOMET TC-AUV. The NMIs from 15 COOMET member countries are represented in AUV. There are eight NMIs, (Azerbaijan, Armenia, Belarus, Georgia, Cuba, Russia, Uzbekistan and Ukraine) that submit their AUV CMCs via COOMET, and seven NMIs (Bulgaria, Germany, Lithuania, Slovakia, Romania, Turkey and KDPR) that do this through other RMOs. Only three countries: Belarus, Russia and Ukraine have published their CMCs in AUV until now. COOMET NMIs have participated in 13 CCAUV key comparisons. Three COOMET key/supplementary comparisons have been completed and results have been published on the BIPM KCDB since the last CCAUV meeting. In addition, two pilot studies are currently ongoing. The subjects of pilot studies are: comparisons of underwater particle velocity receiver in the frequency range from 5 Hz to 4.0 kHz and comparison in the field of velocity of longitudinal ultrasound wave's propagation in solid media.

Two COOMET TC-AUV meetings have been held since the 10th CCAUV meeting. The 11th TC-AUV meeting was held in Minsk in September 2016 and 12th meeting in Vilnius in September 2017.

The written report and the presentation are available on the CCAUV webpage (CCAUV/17-23 and CCAUV/17-51).

13.2.5. EURAMET

The report was presented by Mr Robinson, Chair of EURAMET TC-AUV. Three Sub-Committees (SCs) are organized under the EURAMET TC covering three technical areas: SC-A "Sound in Air", SC-U "Ultrasound and Underwater Acoustics", and SC-V "Vibration and Acceleration". There are 24 members of EURAMET TC-AUV, and 21 NMIs and DIs have a total of 525 CMC entries approved and published on the BIPM KCDB. There was slight decrease in the number of published CMCs as the NPL withdrew from metrology in the field of sound in air in 2016. EURAMET TC-AUV members are involved in six CIPM or RMO key and supplementary comparisons. Recent EURAMET projects include "Reference data for pressure reciprocity calibration according to the standard IEC 61094-2:2009" (EURAMET project No: 1281) and "Calibration of accelerometers at middle and high frequencies" (EURAMET project No: 1281).

TC-AUV participates in the European Metrology Programme for Innovation and Research (EMPIR). There are two ongoing projects, involving TC-AUV members: "Metrology for modern hearing assessment and protecting public health from emerging noise sources" (EARS II) and "Underwater acoustic calibration standards for frequencies below 1 kHz" (UNAC-LOW). The first project coordinated by the PTB (Germany) and involving 11 partners was elected under the 2015 Call

focused on Health, while the second project with five partners was evaluated and elected under the Research Potential Call of the same year. Both projects were started in May 2016 and will be finished in 2019.

The TC-AUV and the three Sub-Committees meet typically on a yearly basis. The 2017 meetings were held at MIKES (Finland) on 2-3 February 2017, and the 2018 meetings will take place at the NPL (United Kingdom) on 14-15 May.

The written report and the presentation are available on the CCAUV website (CCAUV/17-09 and CCAUV/17-52).

13.2.6. GULFMET

Dr Enver Sadikoglu (UME) presented brief information about the Gulf Association for Metrology (GULFMET), which was officially established in June 2010. Currently the organization comprises seven members: United Arab Emirates, Kingdom of Bahrain, Kingdom of Saudi Arabia, Sultanate of Oman, State of Qatar, State of Kuwait, and Republic of Yemen. In addition, the National Metrology Institutes of Turkey (UME), Bosnia and Herzegovina (IMBIH), Republic of Korea (KRISS), Egypt (NIS) and Hong Kong (China) (SCL) have the status of associate members in GULFMET. Furthermore, GULFMET has invited NMIs from China and Australia to join the RMO as associate members. This will strengthen the technical committees of GULFMET. GULFMET applied for recognition as a RMO in February 2012. The application was evaluated by the JCRB, and as a result, and based on the recommendation of the JCRB, the CIPM granted provisional acceptance to GULFMET at its 104th meeting in October 2015.

Currently, five technical committees are operational under the GULF Metrology Organization. They are Technical Committees for length (TC-L), mass and related quantities (TC-M), thermometry (TC-T), joint committee for electricity and magnetism, and time and frequency (TC-EMTF), technical committee for quality system (TC-QS). A decision on establishment of two new Technical Committees, namely, TC for photometry and radiometry (TC-PR) and for chemistry (TC-CH) was made. So far GULFMET does not have a technical committee for acoustics, ultrasound and vibration. The only NMI with comprehensive capabilities in the AUV field is the National Metrology and Calibration Center (NMCC) under the Saudi Organization for Standardization and Quality (SASO). It was noted that as a newly established RMO, GULFMET puts considerable efforts into the organization of various activities for capacity building and knowledge transfer, and support from other RMOs is welcomed.

The presentation is available on the CCAUV website (CCAUV/17-53).

13.3. Regional key comparisons and links to CCAUV comparisons: published/in progress/proposed

13.3.1. EURAMET.AUV.A-K5

Mr Robinson reported on the status of EURAMET key comparison on calibration of LS1p microphones. Participants in the comparisons are: NPL (pilot), LNE, CEM, PTB, INRIM, METAS, UME, BIM, DMDM, SP, BEV and NIS. Measurements were completed in 2015. Draft B report of the comparison has been agreed by participants and was submitted to the CCAUV KCWG for

review in September 2017. The report is currently under review by the KCWG. It is expected that the final report of the comparison will be published in the BIPM KCDB in the first half of 2018.

13.3.2. EURAMET.AUV.V-K5

Dr Claire Bartoli presented progress for the EURAMET.AUV.V-K5 key comparison. The technical protocol for the RMO key comparison on accelerometer calibration has been prepared, reviewed and approved by the CCAUV KCWG. The comparison involves 13 NMIs/DIs: LNE (pilot), BKSV-DPLA (co-pilot), PTB, INRIM, UME, MIKES, CMI, GUM, CEM, METAS, RISE, SASO NMCC. In addition, to EURAMET NMIs/DIs, the NMI from Saudi Arabia will participate in the comparison. Circulation of transfer standards will start in October 2017.

13.3.3. APMP.AUV.U-K3

Dr Wan-Ho Cho reported on the planned APMP key comparison on ultrasonic power calibrations. The comparisons involve four NMIs: KRISS, NMIJ, NMT and PTB. KRISS will act as pilot for the comparison. The technical protocol for the comparison will be the same as a protocol for the CCAUV.U-K3 comparison. Measurements will start early in 2018. It was noted that frequencies at which measurements have to be performed are slightly different from those of the CCAUV.U-K3.1 key comparison. Dr Cho questioned if this could be a problem for the linking process.

Dr Christian Koch replied that the difference could be compensated for by using appropriate corrections and experts in the evaluation of key comparisons will be consulted. In addition he emphasized that linking could be made at two stages; first to CCAUV.U-K3.1 and then to CCAUV.U-K3 through the PTB results.

The presentation is available on the CCAUV website (CCAUV/17-50).

13.4. Regional supplementary comparisons: published/in progress/proposed

As there were no supplementary ongoing comparisons up to date for the meeting, no information was reported under this item.

14. CCAUV MEMBERSHIP

14.1 Confirmation of the membership

The CCAUV president recalled the criteria for membership. Dr Usuda noted that the membership criteria are fully described in a document on the BIPM website: (http://www.bipm.org/en/committees/cc/cc-criteria.html). He also emphasized that each member of the CCAUV has to submit a report for the meeting about their recent activities. In addition, members and observers have to provide an update of their bibliography to the CCAUV Executive Secretary on a regular basis. He mentioned that there are no applications for membership or for receiving observer status this year. However, there are requests for presentations from two institutes: Underwater Acoustics Laboratory (UAL MI MRC), a Turkish Designated Institute, and National Metrology and Calibration Center of the Saudi Standards, Metrology and Quality Organization (SASO NMCC).

The CCAUV confirmed the current membership of the committee.

Decision: CCAUV11/D4 The CCAUV confirmed the current membership of the committee.

14.2 Update from members

Since time was limited, only guests and members who have made major developments and changes since the last meeting were invited to report their activities.

14.2.1. Underwater Acoustics Laboratory (UAL MI MRC, Turkey)

Dr Alper Biber made a presentation about the Underwater Acoustics Laboratory, the Turkish Designated Institute for underwater acoustics under the CIPM MRA. The Underwater Acoustics Laboratory (UAL MI MRC) is part of the Material Institute of Marmara Research Center. The Marmara Research Institute operates under the auspices of the Turkish Scientific and Technological Council of Turkey (TUBITAK). UAL MI MRC is located in TUBITAK's Gebze Campus, as well as Turkish National Metrology Institute (UME). Having been established in 2007, UAL MI MRC has the status of associate member (A-DI) in EURAMET. The laboratory has advanced infrastructure for underwater acoustics measurements. This includes an open test tank with dimensions of 15 m × 10 m × 7.5 m which is equipped with a positioning system with load capacity up to 3500 kg, hydrostatic pressure tanks, impedance tube, a Hydrophone Test and Calibration System operating in the frequency range from 2 kHz to 120 kHz, and a Hydrophone High Frequency Calibration System, operating in the frequency range from 20 kHz to 1 MHz. Currently UAL MI MRC has a wide range of calibration and measurement capabilities in the field of underwater acoustics such as free-field calibration of hydrophones, characterization of underwater receivers and transducers. All calibration and testing services of UAL MI MRC are covered by accreditation from the Turkish Accreditation Agency (TURKAK), which is a signatory of the ILAC MRA. The laboratory participates in the ongoing key comparison CCAUV.W-K2. In addition to providing calibration and testing services to customers, the laboratory is involved in various research projects on prototyping, characterization and calibration of electro-acoustic transducers for different underwater acoustic applications. An example is the EMPIR project "Underwater acoustic calibration standards for frequencies below 1 kHz" (UNAC-LOW) coordinated by UAL MI MRC. Brief summaries of other projects were given in the presentation.

The presentation is available on the CCAUV website (CCAUV/17-62).

14.2.2 NIST

Dr Thomas LeBrun reported on a novel self-calibrating optomechanical accelerometer designed and developed at NIST. Based on Fabry-Perot micro-cavity, the accelerometer is capable of measuring the test-mass displacement with high sensitivities. In addition to the high sensitivity of the accelerometer, its compact size and high mQ-product are advantages when compared to other sensors. Based on calculations, the accelerometer is expected to achieve a resolution better than 1 $\mu g/\sqrt{Hz}$ for a wide range of sensor resonant frequencies, making it highly competitive compared to conventional MEMS accelerometers. The fabricated microscale concave mirrors have been shown to have excellent surface quality (better than $\lambda/25$) and very low surface roughness (1 nm RMS), thereby meeting the requirements for high-finesse optical cavities. An assembled accelerometer was

found to have well-defined fundamental modes and an optical finesse around 2800. It was noted that using the dither locking technique, it was possible lock a tunable diode laser to the accelerometer.

14.2.3. National Metrology and Calibration Center of the Saudi Standards, Metrology and Quality Organization (SASO NMCC)

Mr Fheed Alsubaey gave a short presentation on the current status of activities at the National Metrology and Calibration Center of the Saudi Standards, Metrology and Quality Organization (SASO NMCC). SASO NMCC was established in 1986. Currently NMCC has more than 28 operational laboratories and total staff of 65 persons. Significant investments in metrology have been made from 2014 to 2017. These investments resulted in a remarkable extension of calibration and measurement capabilities of existing SASO NMCC laboratories such as mass, force, pressure and the establishment of new laboratories covering not just traditional metrology fields, but also chemistry. Establishment of new laboratories were made in cooperation with the Turkish National Metrology Institute (UME) in the framework of a three-year project.

The Acoustics and Vibration Laboratory was established as a result of this investment. The laboratory is well equipped with state of art equipment, and in the field of sound in air has calibration and measurement capabilities for primary and secondary calibration of microphones, calibration of sound level meters, sound calibrators and audiometers. SASO NMCC's capabilities in the field of vibration cover primary and secondary calibration of vibration pick-ups and vibration measuring instruments. To prove newly established calibration and measurement capabilities, SASO NMCC participated in bilateral comparisons with UME on primary calibration of LS1p and LS2p microphones by the reciprocity method and primary calibration of accelerometers by laser interferometry. The results of comparisons confirmed SASO NMCC's uncertainty claims for the above mentioned services. SASO NMCC also has registered for participation in the EURAMET.AUV.V-K5 key comparison. In addition, SASO NMCC staff attended EURAMET TC-AUV and SCs meetings in 2017, international conferences such as Internoise 2016, The 23rd International Congress on Sound and Vibration (2016) and IMEKO TC3, TC5 and TC22 Joint Conference (2017).

The presentation is available on the CCAUV website (CCAUV/17-56).

14.2.4 DFM (Denmark) and Brüel & Kjaer Sound and Vibration (BKSV-DPLA)

Dr Barrera-Figueroa reported on current research activities at DFM. He started with an overview of the Danish metrology system noting that in the AUV field it consists of Danish Fundamental Metrology (DFM) and Danish Primary Laboratory of Acoustics of Brüel & Kjaer Sound and Vibration (BKSV-DPLA). Research carried out in these organizations covers mostly microphone and accelerometer calibration over a wide frequency range. Dr Barrera-Figueroa focused his presentation on the investigation of free-field environmental corrections for microphone sensitivity due to the importance of determining the sensitivity under actual environmental conditions. The research has yielded the static pressure and temperature coefficients for measurement microphones of the type WS3 from 10 kHz and up to 150 kHz.

The presentation is available on the CCAUV webpage (CCAUV/17-63).

14.2.5. LNE (France)

Dr Dominique Rodrigues and Dr Bartoli gave a joint presentation on recent activities at LNE in the AUV field. Following a general overview about the LNE and its activities in AUV, the report highlighted research in the period 2015–2017. Research was focused on traceability for measurements within the International Monitoring System under CTBTO. This includes calibration of infrasound sensors at low frequencies down to 0.02 Hz and calibration of seismometers. Traceability for calibration of infrasound sensors would be possible if capability for primary calibration capability at very low frequencies is established. For calibration of microphones at low frequencies the reciprocity method was chosen. However, the main limitation for the method is the validity of the model currently used for heat conduction correction. To overcome the limitation, a new heat conduction model has been developed and experiments for validation of the model have been made.

They major issue with the calibration of seismometers is the fact that only electrical calibrations of the seismometer's internal coil were performed until now. However, seismometers have to be calibrated in real conditions by being exposed to mechanical vibrations. The set-up for calibration of seismometers has been developed at LNE. To validate newly established calibration capabilities an informal comparison between LNE, PTB and SPEKTRA (Germany) was initiated. The comparison is currently in progress.

The presentation is available on the CCAUV website (CCAUV/17-55).

14.2.6. NMC/A*STAR (Singapore)

Mrs Cui Shan reported on the current activities at the National Metrology Centre of Singapore (NMC/A*STAR) in the AUV field. She began the presentation with a general overview of the National Metrology Centre and stated that activities currently cover airborne acoustics, vibration, underwater acoustics and ultrasound fields. The calibration set-ups and current capabilities of the laboratory were explained in more detail. In the field of airborne acoustics this includes primary and secondary calibration of microphones, calibration of sound level meters and sound calibrators. Some specific services such as characterization of MEMS microphones are offered to customers. Calibration and measurement capabilities of NMC/A*STAR in the vibration field include primary calibration of reference and industrial accelerometers, seismic accelerometers, calibration of laser vibrometers, and characterization of MEMS-based vibration sensors. Set-ups for ultrasound power measurements and hydrophone calibrations by the vibrating column method have been developed and used by NMC/A*STAR for many years. Besides calibration and testing services the laboratory is also involved in research projects. A project on "Natural Gas Transmission Pipeline Leakage Detection" is one example and it was briefly presented by Mrs Shan.

Participants asked a number of questions related to calibration of laser vibrometers which were answered by Mrs Shan.

The presentation is available on the CCAUV website (CCAUV/17-24).

14.2.7. KRISS (Republic of Korea)

Dr Cho reported on recent activities at KRISS in the AUV field. The research activities of KRISS have been fully re-organized and currently activities in the field of acoustics, vibration and

ultrasound are carried out by laboratories at three different centres. Peer review covering all fields with experts from NIM (China) has been scheduled for October 2017. The main ongoing subjects for research at KRISS are: diffuse field calibration of microphones, measurement of sound pressure by optical method for the future realization of a primary standard, development of capabilities for ultrasonic high power measurements, and traceability for seismic monitoring systems.

The written report is available on the CCAUV website (CCAUV/17-29).

14.2.8. NPL (United Kingdom)

Dr Bajram Zeqiri gave a presentation on phase-insensitive ultrasonic computed tomography (UCT). In the framework of the joint project between NPL, University Hospitals Bristol, Precision Acoustics, Acoustic Polymers Ltd and Designworks a prototype clinical system for a new breast screening technique using ultrasound computed tomography (UCT) has been developed. Due to the nature of the detectors currently used in UCT, these are phase-sensitive. This negatively affects the final results of screening. A UCT system, based on phase-insensitive detector(s) that exploit the pyroelectric effect in a thin polymer has been developed within the project. He noted that initial scans using the new system completed on a CIRS phantom are encouraging. The technique shows promise as an operator-independent, non-ionizing, quantitative technique for assessing the pathology of soft tissue.

The presentation is available on the CCAUV website (CCAUV/17-54).

15. REPORTS FROM INTERNATIONAL OBSERVERS

15.1. IEC TC29

Mr Robinson on behalf of Susan Dowson, Chair of the IEC TC29, presented the update of activities in IEC TC29. The Technical Committee IEC TC29: Electroacoustic was established in 1953 and the current scope is: “To prepare International Standards related to instrumentation and methods of measurement in the field of electroacoustics”. IEC TC29 currently has the following Working Groups and Maintenance Teams: MT 4 Sound-level meters; WG 5 Measurement microphones; WG 10 Audiometric equipment; WG 13 Hearing aids; MT 17 Sound calibrators; MT 18 Amendments of relevant IEC TC29 standards with respect to developments on EMC; WG 21 Head and ear simulators; WG 22 Audio-frequency induction-loop systems and equipment for assisted hearing; MT 23 Revision of IEC 61265:1995 - Instruments for measurement of aircraft noise. WG24 Modular Instrumentation for acoustics measurements was established recently. It will address the use of computer-based modular systems and the lack of proving compliance with the sound level meter standard, IEC 61672, and produce a new document to ‘fill the gap’, specifically for user configurable, computerized, data acquisition and analysis systems.

IEC TC29 held its last plenary session, together with meetings of its Working Groups and Maintenance Teams at the Comitato Elettrotecnico Italiano (CEI) in Milan on 27-31 March 2017. Nine new or revised standards, as well as five amendments have been published since the last CCAUV meeting. They are mostly related to EMC testing of the various instruments. A further seven documents are expected to be published during 2018.

The presentation is available on the CCAUV website (CCAUV/17-32).

15.2. IEC TC87, ISO TC43 SC3 and ISO TC12

Mr Robinson reported recent activities within IEC TC87, ISO TC43 SC3 and ISO TC12.

IEC TC87 Ultrasonics was established in 1985. Chaired by Volker Wilkens (PTB), it has eight active Working Groups. They are: WG3: High power transducers, WG6: High Intensity Therapeutic Ultrasound (HITU) and Focusing transducers, WG7: Surgical and therapeutic devices, WG8: Ultrasonic field measurement, WG9: Pulse-echo diagnostic equipment, WG13: Terminology, WG 14: Determination of ultrasound exposure parameters and WG15: Underwater Acoustics. TC87 held its last plenary session, together with meetings of its Working Groups in Sendai (Japan) in September 2016. There was another interim meeting of the TC in Vienna (Austria) in June 2017 and the next plenary meeting is scheduled for June 2018. The meeting will be held in Olomouc (Czech Republic). It was reported that IEC 60500: Properties of hydrophones was published in April 2017. Another standard, IEC60050-8-1-32: International Electrotechnical Vocabulary - Part 32 reached the Committee Draft (CD) status. It was circulated in June 2017. Work on another Standard, IEC 60565-2: Pressure calibration of hydrophones at low frequencies, has continued. The CD stage for the standard passed in 2017.

The written report is available on the CCAUV website (CCAUV/17-08).

ISO TC43 SC3 Underwater Acoustics consists of four Working Groups: WG1: Measurement of noise radiated by ships, WG2: Underwater acoustic terminology, WG3: Measurement of radiated noise from marine piling and WG4: Standard target of calibrating active sonar. ISO TC43 SC3 held its last meeting in Teddington (United Kingdom) in June 2016. The next meeting of the TC43 SC3 will be held in Woods Hole, MA (USA) in October 2017. The meeting will be hosted by Woods Hole Oceanographic Institute. Recently published ISO standards are: ISO 17208-1:2016. Underwater acoustics - Quantities and procedures for description and measurement of underwater sound from ships; Part 1: Requirements for precision measurements in deep water used for comparison purposes, SO 18405:2017. Underwater Acoustics - Terminology, and ISO 18406:2017. Underwater acoustics - Measurement of radiated underwater sound from percussive pile driving.

The written report is available on the CCAUV website (CCAUV/17-07).

ISO TC12 deals with the standardization of units and symbols for quantities and units (and mathematical symbols) used within the different fields of science and technology. It is chaired by Leslie Pendrill (RISE, Sweden). It was emphasized that the most important news from the TC is the revision of ISO 80000-8 Quantities and units - Part 8: Acoustics. One of the main changes in the standard is the re-definition of sound pressure level. In addition, the removal of the definition of “decibel” from ISO 80000-3 was considered and this has created concern, as it leaves no ISO definition. However ISO TC12 stated that they would rely on the IEC definition of the decibel.

15.3. ISO TC108

Mr Ian Veldmann reported on recent activities of ISO TC108 Mechanical vibration, shock and condition monitoring. The scope of activities of the ISO TC 108 covers standardization in the fields

of mechanical vibration and shock and the effects of vibration and shock on humans, machines, vehicles (air, sea, land and rail) and stationary structures, and of condition monitoring of machines and structures, using multidisciplinary approaches. The last plenary meeting of ISO/TC108 "Mechanical vibration, shock and condition monitoring" took place in Gaithersburg (USA) in September 2017. A number of ISO/TC108 sub-committees (SC) and working groups (WG) also met during this period. The meetings were hosted by NIST.

It was noted that the work programme of WG 34 "Use and calibration of vibration and shock measuring instruments" is the most relevant to the CCAUV. A number of standards have been published since the last CCAUV meeting. They are: ISO 16063-1:1998 Amendment 1, ISO 16063-17, ISO 16063-32, and ISO 16063-45. In addition ISO 16063-33 layout was sent to ISO for publication in July 2017.

Furthermore, a review of the ISO 16063-12, ISO 16063-13 and ISO 16063-41 standards has been made. It was noted that work on a number of other standards is currently in progress. They are: ISO 16063-44 (DIS stage), ISO 16063-34 (CD stage), ISO 5348, ISO 19665 and ISO 5347-8.

The written report and presentation are available on the CCAUV website (CCAUV/17-27 and CCAUV/17-59).

16. REPORTS FROM INTERNATIONAL MEETINGS

16.1. IMEKO TC3, TC5 and TC22 Joint Conference

Dr Bartoli, Scientific Secretary of TC22, reported on the IMEKO TC3, TC5 and TC22 joint conference held in Helsinki (Finland) from 30 May to 1 June 2017. She began the presentation with an overview of TC22, stating that it was founded in 2005. TC22 is composed of 29 experts from 25 countries. TC22 is chaired by Gustavo Ripper (INMETRO) and Akihiro Oota (NMIJ) is a deputy chair of the committee.

There were ten sessions organized under TC3: Force, torque and mass, three sessions under TC5: Hardness and seven sessions under TC22: Vibration. Twenty two papers were selected by the Scientific Committee for presentation at the conference under TC22. Twenty were presented orally and two as posters. Presentations and posters in TC22 sessions are generally concerned with the following subjects: 3D calibration and 3D sensors, primary calibration methods at very-low and very-high frequencies, data acquisition and analysis, temperature influence on accelerometer calibration. All papers are publicly available on the IMEKO website. At the end of the presentation Dr Bartoli recalled that the next IMEKO World Congress will be held in Belfast (United Kingdom) on 3-6 September 2018 and invited the CCAUV community to contribute to the congress. The IMEKO World Congress in 2021 will held in Yokohama (Japan) from 30 August to 3 September 2021. Dr Bartoli's presentation is available on the CCAUV webpage (CCAUV/17-33).

17. PUBLICATIONS

All reports issued for the 11th CCAUV meeting as well as presentations from the meeting and workshop will be made available on the CCAUV webpage. However, Dr Panfilo will contact authors for their confirmation as to whether documents can be made available as open access.

18. RECOMMENDATIONS to the INTERNATIONAL COMMITTEE for WEIGHTS and MEASURES (CIPM)

The CCAUV President provided an overview of the information to be submitted to the CIPM. This included a summary of CCAUV implications for the CIPM MRA review. The implications are related to strategy updates of KC cycles, an approach for limiting KC participants, progress towards better expression of CMCs, clarification of KC/SC coverage of CMCs, constraining the proliferation and concise expression of CMCs, and the implementation of a risk-based approach to CMC review. Other implications were concerned with a harmonized approach across CCs on the evidence needed to support CMCs that are not supported by comparisons, and sharing specific methodologies for carrying out comparisons, including tools for evaluation of comparison results.

In addition, the position of the CCAUV related to the revision of the SI units and SI Brochure will be reported to the CIPM. An executive summary of the Strategy Document will also be submitted to the CIPM.

The presentation by the CCAUV President is available on the CCAUV webpage (CCAUV/17-60).

19. OTHER ITEMS

The CCAUV President asked the CCAUV Working Group Chairs if they are willing to continue chairing the working groups. Chairs of all three working groups confirmed that they will continue chairing the WGs.

He also recalled that, as a pending action from the 10th CCAUV meeting, the NPL has to review the definitions of AUV units given on the BIPM website, and suggest alternatives where necessary.

20. DATE OF NEXT MEETING

It was proposed that 12th CCAUV meeting, workshop and meetings of the CCAUV Working Groups would be held in September 2019. The exact dates will be defined later. This was agreed by the participants.

Decision: CCAUV11/D5 The next meeting of the CCAUV and its Working Groups will be scheduled for September 2019.

Dr Usuda thanked the participants for their valuable contributions, the CCAUV Executive Secretary Dr Panfilo for the preparations before the meeting and assistance during the meeting, and the BIPM staff for their excellent organization of the meeting.

The meeting closed at 14:30 on 22 September 2017.

Enver Sadikoglu, *Rapporteur*

Salvador Barrera-Figueroa, *Rapporteur*

Appendix 1

Working documents submitted to the CCAUV at its 11th meeting

Below all the working documents submitted to the CCAUV at its 11th meeting are listed.

Document CCAUV/	
17-01	CCAUV Draft agenda 2017, T. Usuda
17-02	Information for users on the proposed redefinition of the SI, CCAUV
17-03	Actions and decisions of the 10th CCAUV meeting, CCAUV
17-04	Workshop Programme, T.Usuda
17-05	Status report of CENAM, A.E.Perez *et al.*
17-06	Status report of PTB, T. Bruns *et al.*
17-07	ISO TC43 SC3 report to the CCAUV, S. Robinson
17-08	ISO TC87 report to the CCAUV, B. Zeqiri, S. Robinson
17-09	RMO report: EURAMET, S. Robinson
17-10	Presentation on CCAUV.V-K3 comparison, S. Qiao
17-11	Status report of INRiM, G. Durando *et al.*
17-12	Status report of DFM and BKSV-DPLA, S. Barrera-Figueroa
17-13	Status report of USRD, S. Crocker *et al.*
17-14	Primary method for the complex calibration of a hydrophone from 1 Hz to 2 kHz, W.Slatter *et al.*
17-15	Status report of NPL, B. Zeqiri *et al.*
17-16	RMO report: SIM, G. Ripper
17-17	Status report of INMETRO, G.P. Ripper
17-18	Status report of GUM, D. Dobrowolska
17-19	Status report of NMIJ, R. Horiuchi
17-20	Status on comparisons carried out within the frame of the CCAUV, G.Panfilo
17-21	Status report NMIA, L.P. Dickinson

17-22 RMO presentation: APMP, Y.C.Huang

17-23 RMO report: COOMET, V.Pozdeeva, A.Enyakov

17-24 Status report of NMC, C.Shan

17-25 Status report of NIST, M. Gaitan

17-26 Status report of LNE, D. Rodrigues

17-27 ISO TC 108 report to the CCAUV, I. Veldman

17-28 Status report of METAS, C. Hof

17-29 Status report of KRISS, W.H.Cho

17-30 Status report of NMISA, R. Nel

17-31 Status report of UME, E.Sadikoglu *et al.*

17-32 IEC TC29 report to the CCAUV, S. Dowson, S. Robinson

17-33 Report from IMECO TC 3, TC5, TC22 Joint conference, C.Bartoli

17-34 On the revision of the KCDB 2.0, S. Picard

17-35 JCRB Report to the CCAUV, N.Zviagin

17-36 The international monitoring system: overview, measurement systems and calibration, J. Marty

17-37 CCAUV Workshop – Introduction, T. Usuda

17-38 Free-field calibration of an underwater sound receiver in a laboratory water tank at very low frequencies, A. Isaev

17-39 Metrology issues with long-term monitoring of very low frequency deep-water ocean noise, S. Robinson

17-40 A 6DOF micro-vibration measurement and generation test facility, C. Jarvis

17-41 Hearing below the low-frequency-limit: measurement, perception and impact of infrasound noise, C. Koch

17-42 Biographies of presenters in workshop, G. Panfilo

17-43 Realization of acoustic primary standards for airborne ultrasound and applications, R. Horiuchi

17-44 RMO presentation: SIM, G.P. Ripper

17-45 CCAUV KCWG Report to the CCAUV, G.P. Ripper

17-46 CCAUV SPWG Report to the CCAUV, M.Gaitan

17-47 News from CCU, E.de Mirandés

17-48 CCAUV RMOWG Report to the CCAUV, S. Qiao

17-49 RMO presentation: AFRIMETS, R.Nel

17-50 APMP.U-K1 RMO key comparison, Wan-Cho Cho

17-51 RMO presentation: COOMET, V.Pozdeeva, A.Enyakov

17-52 RMO presentation: EURAMET, S.Robinson

17-53 RMO presentation: GULFMET, E.Sadikoglu

17-54 Phase-insensitive ultrasonic computed tomography (piUCT) for the diagnosis of breast disease, B. Zeqiri

17-55 Presentation of LNE, D. Rodrigues, C. Bartoli

17-56 Presentation of SASO-NMCC, F.N.Alsubaey

17-57 Presentation of KRISS, Wan-Cho Cho

17-58 IEC TC87, ISO TC43 SC3, IEC TC29, ISO TC12 reports to the CCAUV, S. Robinson *et al.*

17-59 ISO TC 108 presentation, I. Veldman

17-60 Recommendation to the CIPM, T.Ususda

17-61 Units for CCAUV, S. Robinson

17-62 Presentation of UAL MI MRC, A. Biber

17-63 Presentation of DFM and BKSV-DPLA, S. Barrera-Figueroa

Appendix 2

LIST OF ACTIONS AND DECISIONS RECORDED FOR THE MEETING

Dr Usuda went through the list of actions and decisions recorded for the meeting, as recorded by the Rapporteurs.

Actions of the 11th meeting of CCAUV

CCAUV11/A1 An *ad hoc* group composed of RMO TC Chairs will discuss and make a decision on the way units used in the AUV field are presented on the KCDB and will provide feedback to the BIPM KCDB office by the end of October 2017.

CCAUV11/A2 CCAUV President, Dr Usuda, to present the CCAUV positions regarding the CIPM MRA review and redefinition of the SI units to the CIPM.

CCAUV11/A3 CCAUV President, Dr Usuda, to present the CCAUV position regarding the SI Brochure to the CIPM.

CCAUV11/A4 CCAUV RMOWG to finalize the work on service categories and CCAUV President, Dr Usuda, to consult with relevant CCM WGs about services in dynamic force and pressure.

Decisions of the 11th meeting of CCAUV

CCAUV11/D1 The CCAUV approved publication of the Strategy Document on the website shortly after the meeting.

CCAUV11/D2 LNE (France) will pilot the key comparison CCAUV.A-K6 on calibration of LS2p microphones in the frequency range from 20 Hz to 25 kHz with an option to make calibrations down to 2 Hz.

CCAUV11/D3 DFM (Denmark) will pilot the key comparison CCAUV.A-K7 on free – field calibration of LS2p microphones in the frequency range from 1 kHz to 40 kHz, which will start in 2020.

CCAUV11/D4 The CCAUV confirmed the current membership of the committee.

CCAUV11/D5 The next meeting of the CCAUV and its Working Groups will be scheduled for September 2019.