

Bureau International des Poids et Mesures

Consultative Committee for Acoustics, Ultrasound and Vibration (CCAUV)

Report of the 3rd meeting
(1–2 October 2002)
to the International Committee for Weights and Measures



Comité international des poids et mesures

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Note:

Following a decision made by the International Committee for Weights and Measures at its 92nd meeting in October 2003, Reports of meetings of Consultative Committees will henceforth be published only on the BIPM website in the form presented here.

Full bilingual printed versions in French and English will no longer appear.

T.J.Quinn,
Director BIPM,
November 2003.

**LIST OF MEMBERS OF THE
CONSULTATIVE COMMITTEE
FOR ACOUSTICS,
ULTRASOUND AND VIBRATION**

as of 1 October 2002

President

Dr J. Valdés, member of the International Committee for Weights and Measures, Instituto Nacional de Tecnología Industrial, San Martín.

Executive Secretary

Dr P.J. Allisy-Roberts, International Bureau of Weights and Measures [BIPM], Sèvres.

Members

Bureau National de Métrologie, Institut National de Métrologie [BNM-INM], Paris.

Centro Nacional de Metrología [CENAM], Querétaro.

CSIR, National Measurement Laboratory [CSIR-NML], Pretoria.

D.I. Mendeleev Institute for Metrology [VNIIM], Gosstandart of Russia, St Petersburg.

Danish Institute of Fundamental Metrology [DFM], Danish Primary Laboratory for Acoustics [DPLA], Naerum.

Istituto Elettrotecnico Nazionale Galileo Ferraris [IEN], Turin/Istituto di Metrologia Gustavo Colonnetti del Consiglio Nazionale delle Ricerche [IMGC-CNR], Turin.

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

National Institute of Metrology [NIM], Beijing.

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

National Measurement Laboratory, CSIRO [NML CSIRO], Lindfield.

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

National Physical Laboratory [NPL], Teddington.

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

National Research Council of Canada [NRC], Ottawa.

Nederlands Meetinstituut, Van Swinden Laboratorium [NMI VSL], Delft.

Physikalisch-Technische Bundesanstalt [PTB], Braunschweig.

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

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

Observers

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

Český Metrologický Institut/Czech Metrological Institute [CMI], Prague.

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

Institute for Physical, Technical and Radiophysical Measurements [VNIIFTRI], Gosstandart of Russia, Moscow.

Instituto Português da Qualidade [IPQ]/Laboratório Nacional de Engenharia Civil [LNEC], Lisbon.

International Electrotechnical Commission [IEC].

International Organization for Standardization [ISO].

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

Standards, Productivity and Innovation Board [SPRING Singapore], Singapore.

State Agency for Metrology and Technical Surveillance [SAMTS], Sofia.

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

1 **OPENING OF THE MEETING; APPOINTMENT OF THE RAPPORTEUR; APPROVAL OF THE AGENDA**

The Consultative Committee for Acoustics, Ultrasound and Vibration (CCAUV) held its third meeting at the Bureau International des Poids et Mesures (BIPM) Sèvres, on Monday 1 and Tuesday 2 October 2002.

The following were present: R. Barham (NPL), C. Barreau (BNM-INM), S. Barrera-Figueroa (CENAM), G. Basile (IMGC-CNR), K. Beißner (PTB), J.-N. Durocher (BNM-INM), J.S. Echeverría-Villagómez (CENAM), A. Elías-Juarez (CENAM), J. Filliben (NIST), E. Frederiksen (DPLA), C. Guglielmone (IEN), M. Lecollinet (BNM-INM), V. Nedzelnitsky (NIST), T.J. Quinn (Director of the BIPM), K. Rasmussen (DPLA), R. Reibold (PTB), S. Robinson (NPL), S. Sato (NMIJ/AIST), V. Smirnov (VNIIM), S.J. Suh (KRIS), S. Thwaites* (NML CSIRO), T. Usuda (NMIJ/AIST), J. Valdés (President of the CCAUV), A.L. Van Buren (NIST), P. van Kan (NMI VSL), C.S. Veldman (CSIR-NML), H.-J. von Martens (PTB, ISO TC108), G. Wong (NRC), Yue Zhang (NIM), B. Zeqiri (NPL).

Observers: A. Enyakov (VNIIFTRI), A. Konkov (VNIIFTRI), E. Sadikoglu (UME), M. Sinojmeri (BEV), M. Szelag (GUM).

Invited: G. Ripper (INMETRO).

Also attending the meeting: P. Giacomo (Director emeritus of the BIPM), P.J. Allisy-Roberts (Executive Secretary, BIPM), C. Thomas (Coordinator of the BIPM key comparison database), A.J. Wallard (Deputy Director, Director Designate of the BIPM).

Apologies were received from: M. Bartos (CMI), F. Berthod (METAS), A.E. Isaev (VNIIFTRI), S.M. Lee (SPRING Singapore), V. Mohanan (NPLI), R. Preston (IEC TC87), (NIST), A. Todorova (NCM).

The Director of the BIPM, Dr Quinn, welcomed the members to this third meeting of the CCAUV held at the BIPM. He apologized for not being able to attend the entire meeting explaining that Prof. Andrew Wallard, his Deputy, would be present.

Prof. Wallard reflected briefly on the history of the CCAUV, commenting that its objective was not only to execute key comparisons.

The President, Dr Valdés, formally opened the meeting and welcomed all the participants. Apologies were noted from members unable to attend, followed by a brief introduction by each of the participants, observers and guests. Dr Valdés summarized the agenda, giving a brief overview of the objectives of the meeting.

* Dr Suzanne Thwaites died tragically on 7 October 2003 and this report is dedicated to her memory.

Mr Veldman, CSIR-NML, was appointed as *Rapporteur* for a third term. He was invited to compile the report immediately after the CCAUV meeting in an effort to expedite the report.

The agenda (CCAUV/02-00) was accepted as presented, with no proposals for change.

2 REPORT ON THE SECOND MEETING OF THE CCAUV, OCTOBER 2001

The President delivered a short summary of the full [report of the 2nd meeting](#) of the CCAUV, highlighting important issues and complimenting the participants in the various key comparisons.

3 PROGRESS AND RESULTS OF KEY COMPARISONS

The BIPM, through a working group, had proposed guidelines ([CCAUV/02-36](#)) for the evaluation of key comparison data and producing the key comparison reference value (KCRV). Dr Quinn confirmed that the document would be published in *Metrologia*. He emphasized that the document should be seen as guidance.

A lengthy debate followed. Dr Filliben of the NIST expressed his strong views against the use of the weighted mean as a method of determining the KCRV. He was concerned that this method would be widely implemented as the weighted mean is the method favoured by the guidance document.

Dr Quinn disagreed with Dr Filliben's suggestion that if the BIPM published the guide document, it would be seen as the only way to calculate reference values. He expressed the view that the publication would encourage experts to publish their research either in support or opposition of the guidance.

Dr Filliben's views were met with opposition from some of the delegates. At the second convocation of the CCAUV, the pilot laboratories had presented investigations into the application of different methods for determining the KCRV for the different key comparisons. The methods that were considered included the mean, median, weighted mean and others. Data was presented that showed negligible differences between the methods for the key comparisons in question. In cases where the weighted mean had been applied, the pilot laboratory performed "validation checks" on the results to determine the robustness of the calculations. In cases where such checks revealed unsatisfactory results, different methods were then used to determine the KCRV for that specific measurement.

3.1 CCAUV.A-K1

Mr Barham presented the Draft B report (CCAUV/02-27) on the [CCAUV.A-K1](#) key comparison for approval by the committee. As part of his summary he commented that the aim of the comparison was to determine the sound pressure sensitivity of LSP1 microphones in accordance with IEC 61094-2. The protocol was not prescriptive as to the methodology to be followed, with the result that a variety of systems and equipment were used by the participants, making the small spread in the results even more remarkable.

The KCRV was depicted in the report as the 0 dB line on the graphs. This value was the mean value of the results obtained for the two microphones used. Degrees of equivalence for 250 Hz and 1 kHz will be reported in the BIPM key comparison database (KCDB).

As a matter of interest, Mr Barham showed results from a similar comparison that had been performed during the 1980s. A comparison between the results of the two comparisons showed an improvement in the spread of measurements from 0.2 dB in 1980 to 0.05 dB for the recent key comparison.

Dr Nedzelnitsky pointed out that the NIST used hydrogen as a filling gas and that the report mentions that some laboratories used helium as a filling gas. He was of the opinion that all the data, including the actual measurement results should be included in the report. The meeting concluded that the measurements should not be included as this would preclude the use of the same devices in future comparisons.

Dr Valdés enquired about the feasibility of using a dummy impedance to validate the response of reciprocity calibration systems. He referred to Dr Duncan Jarvis' thesis on the subject. However, the committee felt this not to be an appropriate subject for a key comparison. The main disadvantage being that such a device only validates the electrical transfer impedance of the system, leaving the acoustical transfer impedance unchecked.

The Draft B report was approved in principle and is to be circulated to all participants by e-mail for final comments. Participants will then have ten days to respond before publication proceeds.

3.2 CCAUV.A-K2

Dr Nedzelnitsky reported on the progress of the [CCAUV.A-K2](#) comparison. He stated that the NIST is no longer able to pilot this comparison. He then raised some items for consideration for the comparison, as given in his report (CCAUV/02-39).

After some discussion, it was agreed that the lower frequency limit of 20 Hz originally proposed should be reduced, optionally, to 2 Hz. Dr Nedzelnitsky raised the issue of a suitable device to be used. Prof. Rasmussen assured the meeting that the LSP1 microphones would be suitable devices. He also pointed out that the same parameter is to be measured as in [CCAUV.A-K1](#) and that this would eliminate the possible confusion highlighted in Dr Nedzelnitsky's report.

The BEV agreed to pilot the comparison with assistance from the NPL. The exact level and detail of assistance will be agreed upon between the two laboratories. It was suggested that the comparison

could start in the middle of 2003. The participants are likely to be the BEV, DPLA, NIST, PTB and the NPL.

3.3 CCAUV.A-K3

Dr Echeverría-Villagómez and Prof. Rasmussen, the CENAM and the DPLA being joint pilot laboratories, reported on the progress of the [CCAUV.A-K3](#) comparison (CCAUV/02-19). Dr Echeverría-Villagómez informed the meeting that the two laboratories had agreed that the DPLA would arrange, manage and execute the key comparison while the CENAM will analyze the measurement data and compile the reports. This was accepted by the CCAUV.

Prof. Rasmussen reported that some laboratories might not be ready to participate in the CCAUV.A-K4 (LSF2 microphone) key comparison as currently scheduled in parallel with the CCAUV.A-K3 (LSP2 microphone) key comparison. The proposed frequency range of 31 Hz to 25 kHz with 31.5 kHz as an optional frequency point was accepted.

It was agreed that the comparisons CCAUV.A-K3 and CCAUV.A-K4 will be separated completely. Prof. Rasmussen will amend the protocol for the two comparisons with specific reference to the timetables and participants. Both the NIM and the INMETRO will be added to the list of participants for CCAUV.A-K3.

3.4 CCAUV.A-K4

Prof. Rasmussen presented the draft protocol for the [CCAUV.A-K4](#) comparison (CCAUV/02-20) of the free field calibration of LS2 microphones. As mentioned at 3.3, the meeting agreed to run comparisons CCAUV.A-K3 and CCAUV.A-K4 independently of each other. The meeting took note of the unfortunate additional cost implications for laboratories participating in both comparisons.

Prof. Wallard reminded the meeting that the MRA transition period expires at the end of 2003 and that normally all key comparisons that are needed to support calibration and measurement capabilities (CMC) submissions should be completed by then.

As laboratories would probably measure both the pressure and free-field response, a proposal from Mr Barham to use the comparison to determine pressure to free-field corrections was accepted.

This comparison will be postponed to late 2003 or early 2004. The frequency range 2 kHz to 31.5 kHz with 40 kHz as optional was proposed and accepted. The protocol will be amended and redistributed to all participants.

3.5 CCAUV.U-K1

Dr Reißner reported progress with the [CCAUV.U-K1](#) comparison (CCAUV/02-12). The main application for these measurements is in the medical field. The comparison had been executed in four loops and the device was re-measured four times by the pilot laboratory. The participants were required to report two types of voltage measurements, G and P_{ref} (as in the report). As no noticeable

differences were experienced between the two types of results, only the type-1 (*G*) results were analyzed in detail.

Dr Beißner commented that the radiation force balance was the preferred device used to perform these measurements. His report also included analysis of the stability of the device used. Nine institutes participated in the comparison. Unfortunately, two participants could not perform all the measurements.

Dr Beißner reported that he had used the weighted mean to calculate the KCRVs. At the time that the report was compiled, Dr Beißner was not aware of the BIPM guidance document, so the document's recommendations had not been followed specifically. The mean values calculated were verified for robustness and results that did not comply with the criteria were recalculated using the median.

Dr Filliben reopened the debate concerning the use of the weighted mean to calculate the KCRV. However, it was noted that consensus had been reached at the previous CCAUV meeting, that where possible the weighted mean would be used to calculate the KCRV.

It was noted that the participants' uncertainty budgets as well as the weighting factors used to calculate the weighted mean values should be included in the report. The report was accepted as the final report.

3.6 CCAUV.U-K2

Dr Zeqiri's report (CCAUV/02-26) on the [CCAUV.U-K2](#) comparison highlighted that the results of only four of the seven original participants were included in the report. The other three laboratories were excluded on the basis that they did not realize the standard at a primary level.

Dr Zeqiri mentioned that the results of one laboratory were identified as outliers. The laboratory had submitted new results at the time that the Draft A report was discussed. All participants at the 2nd meeting of the CCAUV agreed upon the inclusion of the new results. Prof. Wallard confirmed that this was acceptable.

With reference to results that need to be considered as outliers, it was agreed that these should not be included in the calculation of the reference value, but should be included in the report and degrees of equivalence. It was noted that when results are not included in the calculation of the reference values, this needs to be stated clearly in the report.

It was agreed that the outlier results identified should be included in the degrees of equivalence (matrices and graphs). The exclusion of the outliers from the calculation of the reference value will be included in the report. The final report will be completed after the bilateral comparison between the NIM and the NPL, scheduled for the first half of 2003, has been completed and will be circulated by e-mail for approval by the CCAUV.

3.7 CCAUV.V-K1

Dr von Martens reported on the [CCAUV.V-K1](#) comparison (CCAUV/02-06 and -25). The comprehensive Draft B report had been circulated to all participants prior to the convocation of the CCAUV. All participants indicated their approval of the document and support for final publication by e-mail. In total, twelve laboratories participated in the comparison, determining the charge sensitivity of the circulated accelerometer in the frequency range 40 Hz to 5 kHz.

The pilot laboratory performed an extensive investigation into the determination of the KCRV. Five methods were considered in total, fit, mean, median, likelihood and weighted mean. The methods applied, produced KCRV values to within 0.1 % over the complete measurement range for the back to back accelerometer. Agreement to 0.1 % was achieved over the frequency range 40 Hz to 2 kHz for the single ended accelerometer. All participants agreed to exclude the calculation of a KCRV for the measurements performed above 2 kHz from the final report (as suggested by Dr von Martens).

The demography of participating laboratories was as follows, three from the SIM, six from the EUROMET and three from the APMP including South Africa from the SADC MET.

Dr Filliben pointed out that mean values calculated using selected sets of data points, did not result in the measurement value reported. It was explained to Dr Filliben that the participants were required to submit all the measurements as well as a final result. The protocol did not require that the result be the arithmetic mean of all the measurements. For the sake of clarity, Dr von Martens agreed to add a statement to the final report such as: “The stated results in the following table R1a and R1b are not in all cases the arithmetic mean values of the individual measurement results (that are sometimes only stability trials and not calibration values) given in Table 1a to Table 12a and Table 1b to Table 12b respectively”.

Dr Thomas of the BIPM provided some detail as to how data is published on the BIPM website. She commented that the rounding of uncertainties in the matrices of equivalence depended on the software that was used, but in general the differences had little significance. She queried the necessity of publishing all 44 tables of equivalence in the KCDB and it was agreed that this number could be reduced to the four frequency points suggested by Dr von Martens.

The view of the CCAUV was that the report had taken all the participants' comments into account, that it should include the clarifying statement and was then accepted by the meeting as an excellent report that should be published.

3.8 CCAUV.W-K1

Mr Robinson reported that the [CCAUV.W-K1](#) comparison was progressing to his satisfaction (CCAUV/02-17). In total, seven laboratories had participated. Results were outstanding from only one laboratory. Three devices had been circulated to cover the frequency range agreed upon for the free-field reciprocity comparison.

Mr Robinson reported that the results agreed to 0.5 dB in the low frequency range and to within 1 dB in the high frequency range. He indicated that it should be possible to link the results from a EUROMET comparison to the CCAUV comparison. His preliminary analysis indicated that the

spread of the results from this comparison was smaller than the spread of results from a similar previous comparison.

The Draft B report will be submitted to the CCAUV for approval once all the participants agree on the Draft A report.

4 REGIONAL KEY COMPARISONS AND RESULTS TO BE CONSIDERED FOR THE COMPARISON DATABASE

Dr Thomas highlighted the currently unique situation in the CCAUV, where more than one regional comparison needs to be linked to a key comparison, and for more than one key comparison. She urged the meeting to take care in deciding on the method of linking regional and key comparisons and pointed out that in the areas where more than one regional comparison is to be linked to the same key comparison, the method used for linking, should be the same. She pointed out that the linking of Consultative Committee (CC) and regional metrology organization (RMO) comparisons need only be done at a single point, for example at one frequency.

It was also brought to the meeting's attention that as soon as the regional and key comparisons are linked, the KCRV is the reference value for both comparisons. The meeting was reminded that only CIPM key comparisons have a KCRV and that any values calculated in regional comparisons should therefore not be referred to as KCRVs, but only as the "comparison reference value".

4.1 APMP.AUV.V-K1

Dr von Martens reported on the method used for the linking of [APMP.AUV.V-K1](#) with CCAUV.V-K1 (CCAUV/02-23). The two comparisons were linked through four laboratories participating in both comparisons using 160 Hz as the linking frequency.

Dr von Martens presented the results showing the degrees of equivalence for all the laboratories that took part in the CC and RMO comparison. These results included the degrees of equivalence for the reference laboratories that participated in both comparisons. It was agreed that this was a good method of linking the two comparisons.

4.2 COOMET.AUV.A-K1

Dr Reibold reported on the COOMET.AUV.A-K1 comparison (CCAUV/02-15 and 16). The PTB is the pilot laboratory for this comparison. A total of six laboratories are participating in measuring LSP1 microphones over the frequency range 31.5 Hz to 10 kHz. The comparison started in April

2002 and is progressing according to the schedule. The target date for completion is May 2003 and it was proposed to present the Draft B report at the COOMET annual meeting.

4.3 EUROMET.AUV.A-K1

Mr Barham reported that the Draft B report for the [EUROMET.AUV.A-K1](#) comparison is not yet complete as he had focused his attention on the CCAUV Draft B report. He commented that all the data has been collected and the final link to the CCAUV comparison is being performed.

Thirteen laboratories had participated in the comparison of LSP1 microphones with the DPLA, NPL and the PTB forming the linking laboratories to the CCAUV.A-K1 comparison. Nine laboratories participated in the LSP2 comparison, with the DPLA, GUM, NPL and the PTB forming the linking laboratories for the future CCAUV.A-K3 comparison.

Mr Barham proposed to use the difference between the CCAUV and RMO comparison results of the linking laboratories as the adjustment factor to link the EUROMET and CCAUV comparisons. This was agreed to in principle.

4.4 SIM.AUV.A-K1

Dr Wong reported (CCAUV/02-34) on more detailed analysis that was performed by the NRC to determine the stability of the microphones that were circulated during the [SIM.AUV.A-K1](#) comparison. The results indicated a stability of better than 0.01 dB over the period of the comparison. Dr Wong presented some comparison results between the SIM and CCAUV comparison noting that the difference between the results was much less than the uncertainty estimation of the participating laboratories.

Dr Wong will ask the SIM laboratories to submit their uncertainty budgets to him so that he can complete the SIM Draft B report.

4.5 SIM.AUV.V-K1

Dr Payne had not submitted a report on the [SIM.AUV.V-K1](#) comparison to date and Dr Nedzelnitsky reported that the analysis was not yet at the Draft B stage.

The NIST is waiting for the submission of detailed uncertainty budgets. The data with the uncertainty budgets will be submitted to the NIST statisticians for evaluation and analysis to determine the most suitable approach to derive the regional comparison reference value.

Dr Thomas commented that there were several comparisons that needed to be linked together. Dr Nedzelnitsky was of the opinion that it was appropriate to link the participants within a comparison and then make one link to the corresponding CCAUV comparison to have degrees of equivalence with the KCRV. However, the methodology was unclear at present.

4.6 EUROMET.AUV.U-K1

It was agreed that the EUROMET.AUV.U-K1 comparison should be deleted, as the laboratories that would have participated are already participants in the CCAUV comparison.

4.7 EUROMET.AUV.U-K2

As there are only two laboratories that have the capabilities to perform the measurements for the [EUROMET.AUV.U-K2](#) comparison; it was proposed and agreed that a bilateral comparison be run between the PTB and the NPL.

4.8 EUROMET.AUV.V-K1

Dr von Martens reported (CCAUV/02-09) that the EUROMET.AUV.V-K1 comparison will mirror the CCAUV comparison as far as possible. Minor deviations are required as the participating laboratories may use secondary methods. This requires the use of three devices; a single ended accelerometer and two back-to-back accelerometers. One back-to-back accelerometer will be prepared for use by the laboratories with primary calibration systems and the second back-to-back accelerometer will be used for the laboratories with secondary calibration systems.

The comparison is scheduled to start in July 2003 and be completed by 2005.

5 SUPPLEMENTARY COMPARISONS: PROGRESS REPORT ON SIM.AUV.A-S1

Dr Elías-Juarez reported (CCAUV/02-31) on a supplementary comparison that was submitted for approval, [SIM.AUV.A-S1](#). The comparison ran from July 2001 to January 2002. Two piston-phones were circulated. Three parameters were measured; the sound pressure level, frequency and total harmonic distortion.

Five laboratories participated in the comparison. The pilot laboratory is waiting for the submission of results by one laboratory before the comparison can be finalized.

It was planned to submit the Draft B report to the SIM AUV meeting in December 2002.

6 FUTURE COMPARISONS

6.1 CCAUV

6.1.1 CCAUV.W-K2

Mr Robinson reported that to his knowledge, four possible participants, the NIST/USRD, NIM, NPL and the VNIIFTRI, exist for this CCAUV.W-K2 comparison. The proposal is for the comparison to cover the frequency range 20 Hz to 1 kHz or 2 kHz. The measurements will be a pressure calibration using the reciprocity technique, similar to the method employed in airborne acoustics. Mr Robinson commented that care should be taken in selecting the devices to be used for the comparison.

A pilot laboratory needs to be identified. It is proposed that the responsibilities for piloting the comparison be shared. A target date of 2004 was proposed.

6.1.2 Other proposals

No further proposals were made other than to confirm that the CCAUV.A-K2 comparison could be piloted by the BEV and the NPL together (see 3.2).

6.2 Regional comparisons

6.2.1 APMP.AUV.A-K1

Dr Sato reported ([CCAUV/02-29](#)) that the APMP was planning to run an [APMP.AUV.A-K1](#) comparison with a technical protocol almost identical to the CCAUV comparison, starting in 2003. This was to give time to those NMIs that were currently setting up their LS1P microphone reciprocity calibrations. The NMIJ/AIST will be the pilot laboratory for this comparison.

6.2.2 EUROMET.AUV.A-K3

Dr Guglielmo (CCAUV/02-24) reported that a large number of accredited calibration laboratories in Europe require traceability for sound pressure sensitivity up to 20 kHz. As there are too many laboratories interested in participating in CCAUV.A-K3, EUROMET TCAUV proposed (during a meeting held in Warsaw) to run a similar EUROMET key comparison, [EUROMET.AUV.A-K3](#).

The IEN was chosen as the pilot laboratory, with technical assistance from the DPLA. It is foreseen that 13 to 15 laboratories will participate with the four linking laboratories being the DPLA, GUM, NPL and the PTB. The comparison should start before the end of the CCAUV.A-K3 comparison.

6.2.3 Other proposals

There were no further proposals for regional comparisons.

7 PUBLICATIONS

7.1 Key and other comparisons

Dr Quinn reported that since the last meeting of the CCAUV, a new web based facility for the journal *Metrologia* had been installed. The BIPM will in future publish comparison results as Technical Supplements to *Metrologia*. The change had been implemented to minimize the effort required to publish results and to maintain *Metrologia* as a journal for the publication of scientific papers. In consequence of this change, comparisons will no longer be published in the main journal, but only in the Technical Supplement. An editorial explaining this had been published in *Metrologia* some time previously <http://www.bipm.org/utis/en/pdf/editorial.pdf>.

He continued by explaining the publication process for the comparison results. Once the final report is approved by the CC, the report and results are published in Appendix B of the KCDB. An abstract of the report as well as a link to the *Metrologia Technical Supplement* is published on the web.

Authors of final reports were requested to submit a short abstract of the report, together with the final report to the BIPM, once the final report has been approved by the CC. This will expedite the publication process.

Scientific publications that might follow a comparison or its outcome need to be submitted in the normal way, using the standard procedure for submitting papers for publication. Depending on the nature of the publication, approval from the author and pilot laboratory for such a publication must be obtained.

7.2 CCAUV web page and links

Dr Valdés commented on the substantial number of documents that are prepared by the participants of the CCAUV, in preparation for and as part of the CC. These documents contain information that is of interest to a wider community than just the CCAUV participants. Currently these documents are accessible to members only through restricted access on the BIPM website.

Dr Valdés tabled a suggestion to remove the restriction, allowing free access to selected documents. It was agreed that documents describing comparison results whether Draft A or Draft B reports should not be open access. Any other documents that contained confidential or pre-publication information would also remain restricted. Those documents to be open access in the list of working documents were then agreed as [Open access documents](#).

All participants were reminded to submit their recent bibliography lists to the BIPM for the CCAUV web page for the [CCAUV bibliography](#). Dr Allisy-Roberts thanked all the participants who had already done so.

8 SI UNITS – DISCUSSION CONCERNING THE NEPER (SI) AND THE BEL (NON SI)

Dr Valdés lead the discussion on the consideration of adopting the neper as an SI unit. Dr Valdés asked Dr Quinn to provide the meeting with an overview of the history and current status on the topic.

Dr Quinn mentioned that it might seem to be an obscure discussion, but yet a very important one. He continued, stating that the CCU does not “create” new units, new units are crystallized from the work of scientists and the CCU enables the use of the new unit by the community.

Dr Quinn informed the meeting (CCAUV/02-02 and -03) that in October 2001, the CCU recommended to the CIPM that the neper (Np) be adopted as the unit for the number one. This had not been accepted as some strong reservations had been expressed. The subject is very close to the CCAUV and the participants were invited to make comments.

Dr Valdés presented an overview of a paper that he had submitted for publication to *Metrologia* (CCAUV/02-01) arguing that confusion is generated by the use of dimensionless quantities. He also mentioned that a new proposal of the CCU to use the neper only for pure signals was withdrawn and finally stated that the best recommendation is to make more use of the accepted SI units underlying such ratios as the bel or neper.

Dr Giacomo agreed with many points and was insistent that SI units should be coherent. In illustration, Dr Elías-Juarez gave a presentation of the influence and possible errors involved when using decibel as the “unit” when calculating uncertainty budgets (CCAUV/02-42). The effect of such errors is evident if the uncertainty component is larger than 1 dB. For correctness, the contribution of the uncertainty components should be calculated in the base unit and only the expanded uncertainty should be converted to decibel.

Prof. Rasmussen, as the IEC TC29 representative, explained that the neper was removed from the IEC TC29 documentation and that only the bel is referenced in IEC TC29 documents to be used for the definition of sound pressure level. He mentioned that several countries within the IEC TC29 objected to the use of the neper.

Dr Reibold agreed with Dr Valdés expressing his opinion that the status quo should be kept. Dr Nedzelnitsky commented that accepting the neper as a unit would open the door to other dimensionless units being accepted. Mr Barham reported that the NPL preferred to leave the situation as it is at present until a full consultation with users can be taken into account.

The meeting was in agreement that the status quo should be maintained. It was felt that an important reason for not changing would be to avoid any confusion that would otherwise be created by a change. Such confusion would reign not only in the metrology community, but in many other areas of commerce and industry. The proposal to maintain the current status was also supported by the IEC TC29.

9 CONTRIBUTIONS FROM PARTICIPANTS

9.1 Development and improvement of national standards

Dr Reibold shared an overview of development work being performed at the PTB ([CCAUV/02-13](#)). One question is whether ultrasonic devices are harmful to the human ear. In order to set international limits on such devices it is necessary to measure sound pressure accurately at these frequencies. The aim of the development work is to extend the calibration frequency of microphones from 25 kHz up to 200 kHz. Other developments include:

- A secondary calibration technique using ultrasonic loudspeakers.
- Primary calibration of hydrophones using optical interferometry.
- Development of an optical multiplayer hydrophone with constant frequency response in the range 1 MHz to 75 MHz.

Dr Guglielmono gave an overview of the development work currently in progress within the IEN ([CCAUV/02-10](#)). Areas of development cover:

- The national standard of acoustical pressure and calibrations.
- Measurement of ultrasonic power.
- Measurement of the speed of sound in gases and liquids.

Dr Suh gave an overview of the development work currently in progress within the KRIS ([CCAUV/02-21](#)). Areas of development cover:

- Measurement of the spatial distribution of the acoustic pressure field radiated from ultrasonic transducers using a miniature hydrophone – planar scanning method.
- A free-field reciprocity calibration system.
- Replacement of the absorbing wedges in the anechoic chamber.
- Planned peer review for calibrations in AUV.

Mr Robinson and Dr Zeqiri reported on the following areas of development at the NPL ([CCAUV/02-28](#)):

In the area of airborne acoustics, development work is undertaken in:

- Primary standards for sound pressure.
- Secondary calibration of measurement microphones.
- Sound calibrators.
- Sound level meters.
- Audiometric standards and ear simulators.

In the area of noise, development work is undertaken in:

- Machinery and product noise.
- Acoustic emission.

In the area of underwater acoustics, development work is undertaken in:

- Low frequency standards.
- Free-field standards.
- Standards for simulated ocean conditions.

In the area of medical and industrial ultrasonics, development work is undertaken in:

- Ultrasonic pressure standard.
- Ultrasonic power standards.
- Standards for ultrasound dose.
- Ultrasonic characterization and field measurements.
- High power ultrasound and acoustic cavitation.

Dr Nedzelnitsky gave a brief report on his work in the Accredited Standards Committee S1, Acoustics that had just published an ANSI Technical Report on bubble detection and cavitation monitoring. A significant number of techniques had been found useful to identify the number, size and distribution of bubbles and for monitoring cavitation activity. Guidance is offered on the techniques that are suitable for specific applications in medicine, oceanography and in materials processing. The report lists numerous references. (see <http://asa.aip.org>)

Ms Szelag reported on the following areas of development at the GUM ([CCAUV/02-37](#)).

In the area of acoustics:

- The measurement set-up for the calibration of sound level calibrators has been automated.

In the area of vibration:

- The measurement set-up for the primary calibration of accelerometers has been installed at GUM. Measurements are performed in accordance with the ISO 16063-11 method 3.

The GUM is also implementing a quality system, complying with ISO 17027:1999. The GUM quality system, covering the scope of submitted CMCs will be self-declared.

Mr Veldman reported on the following areas of development at the CSIR-NML.

In the area of acoustics:

- Some smaller systems are being automated, for instance the calibration of sound sources using the insert voltage method.
- The automated reciprocity calibration system is being evaluated. It is also adapted to enable the calibration of LSP2 microphones.

In the area of vibration:

- A measurement set-up for the primary calibration of accelerometers has been implemented. Measurements are performed in accordance with the ISO 16063-11 method 3. The activities have been accredited over the frequency range 40 Hz to 5 kHz. Development work is taking place to extend the frequency range from 1 Hz to 10 kHz.

Dr Elías-Juarez informed the meeting of development work at the CENAM with respect to:

- A shock calibration system, based on a PTB design.
- The construction of an anechoic chamber at the CENAM.
- A calibration system for LSP2 microphones using multiple couplers and only two microphones.

9.2 Research areas

Three areas of research in acoustics and ultrasound at the PTB were reported by Dr Reibold ([CCAUV/02-14](#)):

- Acoustic output of harmonic scalpel: airborne ultrasound and derived acoustic power in water.
- Reconstruction of ultrasonic fields by deconvolving the hydrophone aperture effects.
- Inter-laboratory tests of sound insulation measurements on heavy solid walls.

Dr Suh reported on the research being performed at the KRISS ([CCAUV/02-22](#)). Areas of research cover:

- The development of a shock calibration system.
- Stable microphone positions for determining sound absorption coefficients with the ISO.
- Comparison and validation of determining precision sound power in a reverberation room.
- The effect of noise and vibration on humans and its assessment.

10 FUTURE NEEDS RELATING TO AUV METROLOGY

The President introduced the background relating to metrology and future needs mentioning the CIPM report on [National and International Needs in Metrology](#) published in 1998. Currently, the Secretary of the CIPM, Dr Kaarls, is preparing another document*, addressing more technical considerations on future needs of metrology. The President, who had produced a working document for the previous meeting (CCAUV/01-16 included as [Annex A in CCAUV/02-33](#)), had invited the CCAUV working group to produce a response as an input to the CIPM report for future needs in their fields of metrology.

* Published in 2003 as [Evolving Needs for Metrology in Trade, Industry and Society, and the Role of the BIPM](#)

10.1 Report from the Working Group on Future Needs

The progress on compiling information was reported by Dr Zeqiri ([CCAUV/02-33](#)). Views and comments from colleagues had been obtained through an informal e-mail working group. A questionnaire (Annex B) had been distributed in early 2002 with major responses from three laboratories, the IEN, NPL and the PTB (Annex C). The information requested included the scientific topic, the reason it was required, the probable time scale, possibilities for collaboration and the resource implications. A listing of the topics seen to be at high level for the future is given in Annex D of the report.

The recommendations on the new key areas for future metrology, such as the extension of optical methods for calibrations in both underwater and airborne acoustics are given in Section 5 of the main report. Dr Zeqiri now needed input from the CCAUV regarding any missing areas and more information regarding the proposals already included so that the report could be finalized before the end of the year.

Some discussion ensued with a suggestion from Dr Wong that extending acoustics calibrations above 20 kHz (the hearing limit) was probably a waste of time. However, Mr Barham pointed out that there was published evidence on high frequency effects causing ear damage and Dr Nedzelnitsky mentioned that non-linearities in the middle and inner ear could generate frequencies other than the original value.

Prof. Wallard commented that at the time that the CIPM launched their overall project, the outcome was not obvious. He felt it was very important to set the programme now for the CCAUV to respond to these demonstrated metrological needs and to encourage the involvement of RMOs as appropriate for joint projects. Long term planning, including key comparisons was crucial for good collaboration. He recommended that the report be finalized and disseminated to the AUV community as quickly as possible.

Dr Valdés commented that Dr Kaarls had launched the idea of CC input when he had presented the project at the NIST Centenary meeting so that all the CCs could help him to compile his new document on the future needs of metrology.

Participants of the CCAUV were requested to submit comments and inputs for the CCAUV contributory document to Dr Zeqiri within the next six weeks. This would enable the report to be finalized by the end of 2002.

10.2 Kaarls' report for the CGPM

Moving to the Kaarl's report, Prof. Wallard reported that the follow-up to the 1998 CIPM (Blevin) report being prepared by Dr Kaarls, aims to highlight the changes in global metrology. A survey of changes facing the metrology community was undertaken to provide input and had identified the extensions of metrology into chemistry and similar areas. Dr Kaarls' task was to compile this new report, with recommendations for the new budget cycle of the BIPM to be approved by the 2003 CGPM.

Prof. Wallard added that the CIPM would be looking at the first draft of Dr Kaarls' report at its meeting the following week and that a consultation draft will be made available before the final CIPM report (since published in 2003) is included in the CGPM convocation documents.

The contents of the draft report included chapters on:

- expanding international cooperation and new networks, including the BIPM's role in working with the ILAC and UNIDO to help countries developing metrology programmes, and work with the Joint Committee for Traceability in Laboratory Medicine;
- technical and economic studies into metrology over the last few years, including the KPMG report that was commissioned by the BIPM to look at the justification of metrology at the world level;
- national programmes in metrology, including nanotechnology and new developments;
- the changing role of the BIPM, particularly with the expansion into chemistry already started and future similar activities in clinical medicine and food metrology;
- the budgetary challenges and justifications to undertake these changes including a Watt balance and calculable capacitor.

The CIPM will produce a number of recommendations, including how the BIPM should be resourced in the future. The decisions will be taken by the CGPM and would also direct the BIPM's future actions to develop confidence in the results of the NMIs through the MRA and the CMCs.

11 REGIONAL METROLOGY ORGANIZATIONS

11.1 New CMC submissions for the JCRB

11.1.1 Proposal to include linear force in the classification of services

Dr Allisy-Roberts led the discussion ([CCAUV/02-05](#)). Several arguments were heard for placing the service category currently within acoustics, within vibration or as a separate service. Consensus was reached finally to add linear force to the service categories for CCAUV CMCs under a new acoustics section at 4.3 as follows:

“4. Ear simulators and impedance heads for calibration of artificial mastoids

4.3 Impedance head force transducer

4.3.1 Modulus of charge sensitivity: *frequency*

4.3.2 Phase shift of charge sensitivity: *frequency*

4.4 Impedance head force measuring chain

4.4.1 Modulus of voltage sensitivity: *frequency*

4.4.2 Phase shift of voltage sensitivity: *frequency*”

11.2 Reports from regional representatives

11.2.1 APMP (S.J. Suh)

Dr Suh reported on activities currently taking place within APMP ([CCAUV/02-29](#)). Points included:

- TCAUV member list.
- The TCAUV workshop and meeting.
- APMP key comparisons.

11.2.2 COOMET (V. Podzeeva)

A paper had been submitted by Dr Podzeeva ([CCAUV/02-30](#)) that gave a brief overview on the COOMET, its history and member countries. The paper also includes current activities and key comparisons undertaken by the COOMET.

11.2.3 EUROMET (M. Szelag)

Ms Szelag presented an overview of a detailed report on activities within the EUROMET TCAUV, that have been submitted to the CCAUV ([CCAUV/02-11](#)). In total, 18 projects have been considered within the TCAUV over the past two years. Two projects have been completed. The EUROMET would like to revise the CMC entries to take into account the results from the key comparisons. It was hoped to start this work in the following year.

Prof. Wallard reminded all the RMOs to review their CMCs when the results of the key comparisons became available.

11.2.4 SIM (G. Wong)

Dr Wong reported on the activities within the SIM ([CCAUV/02-32](#)). His report covered aspects such as the SIM membership, SIM CMCs, SIM comparisons, SIM meetings and future work.

11.2.5 SADCMET (C.S. Veldman)

Mr Veldman announced that there was nothing specific to report from the SADCMET.

12 REPORTS FROM INTERNATIONAL OBSERVERS

12.1 IEC

12.1.1 TC 87

Dr Zeqiri reported on behalf of Dr Preston, the IEC representative for TC87, on current work within the IEC pertaining to ultrasound(CCAUV/02-07). His report covered the following aspects:

- Standards related to ultrasonic metrology.
- Standards related to hydrophone performance and calibration methods.
- Standards related to the measurement of ultrasonic power.
- Standards related to ultrasonic field measurement which require calibrated hydrophones or radiation force balances.

He mentioned that the next meeting of the IEC TC87 would be within 18 months and that it was disappointing that the committee had not yet been able to generate a safety standard.

12.1.2 TC 29

As the IEC representative for TC29, Prof. Rasmussen reported ([CCAUV/02-18](#)) on current work within the IEC TC29 pertaining to electroacoustics. His report covered the following aspects:

- Measurement microphones.
- Noise/sound measuring instrumentation.
- Ear simulators.
- Hearing aids.

He particularly mentioned progress with the standard on sound level meters saying that the second and third parts (on pattern evaluation and periodic tests) were circulating for a consensus. He was concerned that with the postponement of the CCAUV.A-K4 comparison, the results will not be available in time to be included in the revision of the IEC Publication 655 (to be issued as IEC 61094-7). In consequence, the standard may have to be amended shortly after its publication.

Prof. Rasmussen took the opportunity to remind the CCAUV that a complete list of the IEC TC29 documents was available on the CCAUV web page of publications and bibliography.

12.1.3 IEC 565 UAT

Dr Van Buren reported on work being done by the IEC 565 UAT with the expectation that a final draft for WG7 would be available in a couple of years.

12.2 ISO TC108

As the ISO representative for the TC108, Dr von Martens reported ([CCAUV/02-08](#)) on current work within the ISO. His report covered the following aspects:

- Standards and standardization projects significant for key comparisons and traceability.
- New ISO standards and standardization projects – methods for the calibration of vibration and shock transducers.

13 NEW MEMBERS/OBSERVERS FOR CCAUV

Dr Valdés informed the meeting of the INMETRO's application for membership of CCAUV. He continued by offering Mr Gustavo Ripper, who was an invited guest at the meeting, the opportunity to inform the meeting of the INMETRO's capabilities in AUV.

Mr Ripper thanked the President and explained the current capabilities of the INMETRO in the areas of acoustics and vibration. He listed the achievements of the INMETRO in these areas as well as the activities. The competencies of the 18 staff in these areas were supported by results obtained in key, regional and bilateral comparisons. The facilities include an anechoic chamber and two reverberation rooms and the laboratory undertakes calibrations and testing of microphones, pistonphones and audiometers. The published CMCs demonstrate this and there is a heavy demand for their calibrations from the Brazilian community.

The meeting supported the INMETRO's application for CCAUV membership* and recommended that they produce a list of their publications for the CCAUV bibliography.

Proposal for the CGPM

Prof. Wallard tabled a draft Resolution (CCAUV/02-35) to be presented to the CGPM, whereby Governments of the Member States of the Metre Convention make appropriate arrangements to associate the activities and facilities of national centres of expertise to the national metrology institutes by designating them under the MRA. This would then enable them to participate in meetings and the technical work of the CCAUV and other CCs.

Dr Nedzelnitsky stated that, as requested by the NIST, Dr Van Buren and colleagues at the NUWC/USRD already participate in the meetings and the technical work of the CCAUV. The laboratory provides services for industrial, scientific, medical and other organizations that require or

* Approved by the CIPM in October 2002.

benefit from calibrations in underwater acoustics that are traceable to the SI. He was supportive of the Resolution in principle for countries for which such participation has not yet been established.

The CCAUV supported the proposed Resolution.

14 OTHER ITEMS

14.1 Comparison forms

The participants were requested to complete the [comparison registration forms](#) for all comparisons, whether key or supplementary. This will assist the BIPM to maintain the key comparison database. Electronic copies (Microsoft Word format) of the comparison registration form are available on request from the Executive Secretary.

14.2 Low frequency vibration comparison

The proposal from the SIM for a low frequency vibration comparison is accepted, but that this should be a supplementary comparison as there is no low frequency vibration key comparison currently in existence.

Dr Elías-Juarez will submit a tri-lateral low frequency vibration comparison in support of CMC submissions to the BIPM.

The Executive Secretary was asked to re-distribute the [rules for submission of comparisons](#) in support of CMCs for clarification purposes.

15 DATE OF NEXT MEETING

The next meeting was proposed for the week before the CIPM in October 2004*.

C.S. Veldman, *Rapporteur*
October 2002, revised April 2004

* The CIPM subsequently decided to hold the next CCAUV meeting on 27 and 28 September 2004.