

1. General Aspects

This report summarises activities of the EURAMET Technical Committee for Acoustics, Ultrasound and Vibration (TC-AUV) for 2019-2020.

TC-AUV has representatives from 23 of the members of EURAMET.

Three Sub-Committees (SCs) are organised under the Technical Committee covering three different technical areas. These Sub-Committees are:

<u>Sub-committee</u>	<u>Convener</u>	<u>No. members</u>
SC-A "Sound in Air"	Erling Sandemann-Olson (DPLA)	15
SC-U "Ultrasound and Underwater Acoustics"	Gianni Durando (INRIM)	6
SC-V "Vibration and Acceleration"	Thomas Bruns (PTB)	14

The SCs assume responsibility for technical activities within their own specialisms and are coordinated by an appointed Convener, whereas the TC is concerned with general issues including aspects coming from EURAMET, technical activities cutting across all three AUV themes, and EMPIR activities in particular.

TC-AUV also has a Working Group (WG) consisting of members from each Sub-Committee for review of CMCs (within EURAMET and between RMOs).

2. Projects

Project 1481: *Secondary calibration of accelerometers in medium frequencies.*

The specific task of this comparison is the measurement of the magnitude of the sensitivity of two single-ended accelerometers in medium frequency domain (10 to 10 000 Hz). This comparison will be linked to the key comparison EURAMET.AUV.V-K5 which is under progress. The sensitivity shall be calculated as the ratio of the amplitude of the output of the accelerometer to the amplitude of the acceleration at its reference surface with secondary means in accordance with ISO 16063-21:2003 "Methods for the calibration of vibration and shock transducers - Part 21: Vibration calibration by comparison to a reference transducer". The project is led by BEV (Austria) and has the following partners: BIM (Bulgaria), CMI (Czech Republic), IPQ (Portugal), METAS (Switzerland), MIKES (Finland). A further non-EURAMET partner from AFRIMETS is KEBS (Kenya). The project started in September 2019 and is due for completion in March 2021.

Project 1464: Bilateral comparison in primary calibration of accelerometers

This bilateral comparison involves the measurement of the magnitude of the complex charge sensitivity of two accelerometers (SE and BB) in frequency range from 10 Hz to 1 kHz). There are two participants: GUM and BIM. BIM will use this bilateral comparison in order to confirm technical competence and to get an evidence for BIM CMCs at primary calibration of vibration transducers. The sensitivity of accelerometer shall be calculated as the ratio of the amplitude of the output of the accelerometer to the amplitude of the acceleration at its reference surface with primary means in accordance with ISO 16063-11 : 1999 "Methods for the calibration of vibration and shock transducers - Part 11: Primary vibration calibration by laser interferometry". The project is registered in the KCDB as EURAMET.AUV.V-K2.

Project 1418: *Primary calibration of accelerometers in medium and high frequencies.*

This comparison involves the measurement of the magnitude and phase of the complex voltage sensitivity of two accelerometers, one single-ended and one back-to-back, in medium and high frequency domain (10 to 20 000 Hz). This comparison will be linked to the key comparison CCAUV.V-K5 which is under progress. The voltage sensitivity shall be calculated as the ratio of the amplitude of the output of the accelerometer to the amplitude of the acceleration at its reference surface with primary means in accordance with ISO 16063-11: 1999 "Methods for the calibration of vibration and shock transducers - Part 11: Primary vibration calibration by laser interferometry". The project started in 2017 and the participating laboratories are: LNE (France) (Coordinator), BKSVDPLA (Denmark), CEM (Spain), CMI (Czech Republic), GUM (Poland), INRIM (Italy), METAS (Switzerland), MIKES (Finland), PTB (Germany), RISE (Sweden), UME (Turkey). Further partners may include NSAI (South Africa). Pilot laboratory is BKSVDPLA (Denmark), and the work is scheduled for completion by December 2020.

Project 1302: *Comparison of secondary free-field calibration of WS2 microphones according with IEC 61094-8:2012.*

EURAMET.AUV.A-S2 was a Supplementary Comparison realised under the auspices of the CCAUV-BIPM. The standards circulated among the laboratories were two WS2 microphones of the type Brüel & Kjær 4191. The microphones had to be calibrated using a secondary free-field method, particularly the method described in the International Standard IEC 61094-8 (2012) in the frequency range from 500 Hz to 20 kHz (optionally up to 25 Hz and/or 40 kHz). Eight national measurement institutes took part (LNE, BEV, DFM, INMETRO, INRiM, PTB, and NPL) and LNE (France) piloted the project. The measurements took place between February 2014 and June 2016. Two WS2 microphones were circulated. The Draft A and Draft B reports were produced and circulated. NPL asked to withdraw their data from the comparison after their capability for air acoustic metrology was closed down. The comparison has been completed and results are published in the KCDB.

Project 1281 *Reference data for pressure reciprocity calibration according to the standard IEC 61094-2:2009.*

Pressure reciprocity calibration is the most widespread method for realising the unit for acoustic pressure, the pascal (Pa), via the determination of the sensitivity of a microphone and is described in the international standard IEC 61094-2. To validate the changes for the latest version of the standard, a set of reference data can be introduced in the measurement software to compare the obtained sensitivity to the "reference" sensitivity. This research project should allow us to validate the correct implementation of the physical models involved in the reciprocity calculations (such as the model taking into account the thermal conductivity as well as the viscosity of the gas affecting the low frequency behaviour) and to check the degree of equivalence of the implementation of the calculations. The project has been delayed somewhat by lack of available resource, but work is still ongoing.

Coordinating Institute: DFM (Denmark); Participating Partners: BKSVDPLA (Denmark), CEM (Spain), INRIM (Italy), LNE (France), METAS (Switzerland), PTB (Germany). Non EURAMET partners include: INMETRO (Brazil), NMIJ (Japan), NMISA (South Africa), NRC (Canada).



**Acoustics, Ultrasound
and Vibration**

3. Comparisons

EURAMET.AUV.A-K5 (EURAMET Project 1474) *Pressure calibration of laboratory standard microphone.* The project is now complete and the report is available on the KCDB. This comparison links to the KCRV established in CCAUV.A-K5. In this comparison several laboratories (LNE,

METAS, NPL as well as PTB) measured down to 2 Hz and presented consistent results. One laboratory presented discrepant results (DMDM) and corrective action is underway at the NMI with the work supervised and approved by the SC-A Convener.

EURAMET.AUV.A-S2 (EURAMET Project 1302) *Secondary free-field calibration of working standard microphones.* This was a Supplementary Comparison realised under the auspices of the CCAUV-BIPM. The standards circulated among the laboratories were two WS2 microphones of the type Brüel & Kjær 4191. The comparison has been completed and results are published in the KCDB.

EURAMET.AUV.V-K2 (EURAMET Project 1464) *Bilateral comparison in primary calibration of accelerometers* This bilateral comparison between GUM and BIM involves the measurement of the magnitude of the complex charge sensitivity of two accelerometers (from 10 Hz to 1 kHz) in order to confirm technical competence and to get an evidence for BIM CMCs at primary calibration of vibration transducers. The project is registered in the KCDB as.

EURAMET.AUV.V-K5 (EURAMET Project 1418) *Primary calibration of accelerometers in medium and high frequencies.* This comparison involves the measurement of the magnitude and phase of the complex voltage sensitivity of two accelerometers over 10 Hz to 20 000 Hz. This comparison will be linked to the key comparison CCAUV.V-K5 which is under progress.

CCAUV Key Comparisons

CCAUV.W-K2 *Comparison of free-field hydrophone calibrations in water.* This key comparison of hydrophones covers an extended frequency range of 250 Hz – 500 kHz and is piloted by NPL. It has seven participants including two from EURAMET (UK and Turkey), along with USA, Russia, Brazil, China and South Africa (with an eighth participant from India as a guest participant). The Draft A report should be circulated by October 2020.

CCAUV.V-K4 *Comparison of accelerometer shock calibration.* CCAUV.V-K4, a comparison on accelerometer shock calibration, has 9 participants: NIM (pilot), NMIJ/AIST (co-pilot), KRISS, CENAM, PTB, INMETRO, NMIA, NMISA, VNIIM. V-K4. Technical protocol is approved and circulation of accelerometers has begun.

CCAUV.V-K5 *Comparison of calibrations of accelerometers in the frequency range from 10 Hz to 20 kHz.* This is a comparison of calibrations of accelerometers in the frequency range from 10 Hz to 20 kHz with three accelerometers used, Brüel & Kjaer (B&K) type 8305, type 8305-001 and type 4371 as transfer standards in the comparison. Participants of the comparison are: PTB (pilot), DPLA, CEM, METAS, NIST, CENAM, INMETRO, NIM, NMIJ, NMIA, NMC/A*STAR, NMISA, UkrMet and VNIIM. It is expected that the Draft A report will be completed in 2020.

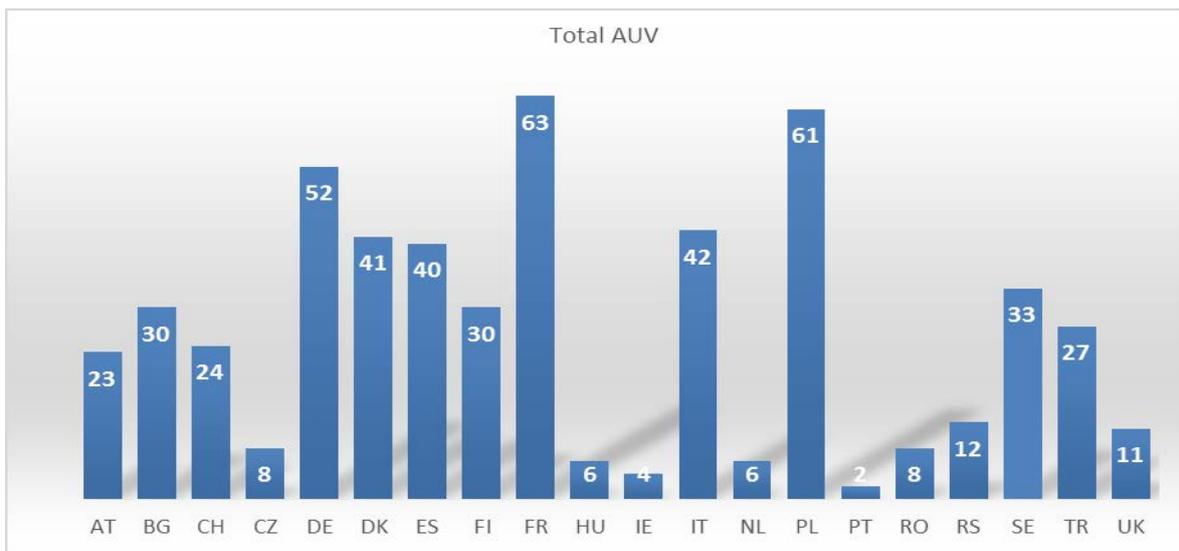
CCAUV.A-K6 *Comparison of calibration of LS2P microphones in the frequency range from 20 Hz to 25 kHz* LNE (France) are piloting the key comparison CCAUV.A-K6 on calibration of LS2P microphones in the frequency range from 20 Hz to 25 kHz with an option to make calibrations down to 2 Hz. The protocol has been drafted and circulated.

Future Key Comparisons

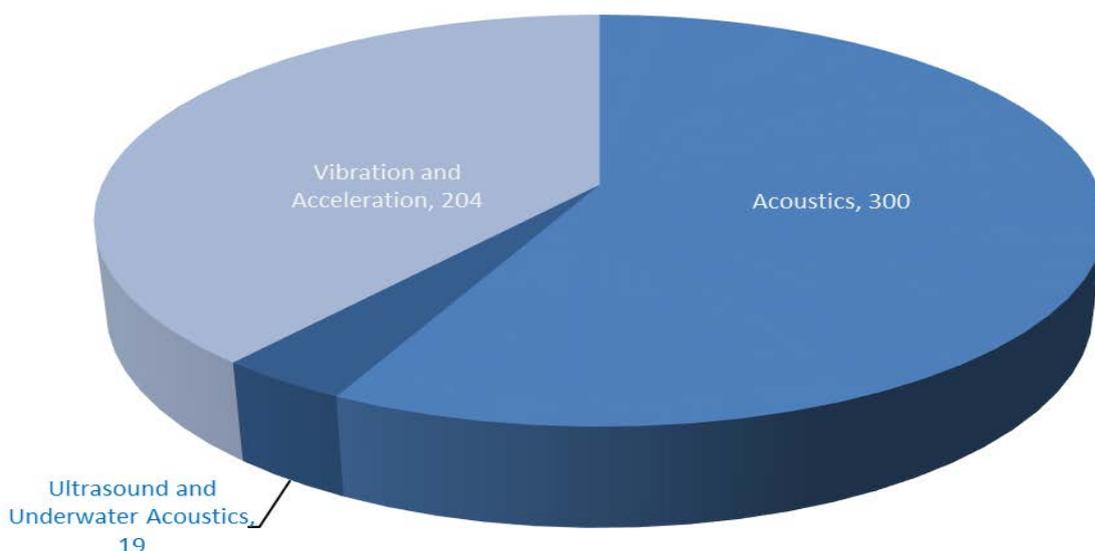
DFM (Denmark) will pilot the key comparison CCAUV.A-K7 on free – field calibration of LS2p microphones in the frequency range from 1 kHz to 40 kHz, which will start in late 2020.

4. CMCs

20 EURAMET NMIs & DIs have a total of 523 CMC entries approved and published on the BIPM KCDB. The distribution by country and technical area is shown below in the figures below. Of the 523 EURAMET CMCs, 300 are Sound in Air, 204 are for Vibration, and 19 are for Ultrasound and Underwater Acoustics. The total number of CMCs for 2020 shows a slight decrease compared to the value for the previous year (517), mainly due to the revision of the CMC entries for Poland.



Number of EURAMET AUV CMC entries in the KCDB by country



Number of EURAMET AUV CMC entries in the KCDB by technical area

Those countries updating CMCs in the 2019-2020 period include Poland and France. Overall, the number of CMCs appearing for review is not excessive, and the situation is manageable. However

TC-AUV's position is to resist expansion of the service categories into tertiary application area as sometimes promoted by other RMOs.

Vitality and validity of CMCs

The questions raised about the CMCs in Vibration for BIM (Bulgaria) due to loss of expert staff have been addressed within SC-V. TC-AUV agreed an action plan for the verification of their capability and to ensure the validity of services including: (i) participation in a comparison; (ii) submitting to peer review; and (iii) engaging in capacity building actions. EURAMET project 1464 is addressing this issue by providing for a bilateral comparison with GUM.

The sound-in-air acoustic capability of DMDM (Serbia) was observed to be discrepant in EURAMET A-K5. After investigation under the auspices of the SC-A Convener, the cause was found to be inexperienced staff undertaking the calibrations for the comparison after a key member of staff had left. After some administrative changes and review of the quality assurance system in 2016, new staff for calibrations were hired in early 2017 and successfully trained, and the DMDM capability has been restored. To demonstrate the restored capability, a bilateral comparison with UME, linking to CCAUV.A-K5 through EURAMET.AUV.A-K5, is being arranged. With a positive outcome of the comparison, the CMCs can be considered valid.

5. Activities of the Subcommittees

The activities of each Sub-Committee are coordinated by the appointed Convener. The level of membership in Sub-Committees varies significantly, and it is common for invited guests from other RMOs and additional technical experts to attend as observers. As an example, although SC-U has only 6 official members listed on the EURAMET web-site, typically 10 or more people attend the SC-U meetings, including guests from COOMET. Each Sub-Committee meets annually. The work of the Sub-Committees is reflected in the variety of past collaborative TC-projects.

6. Participation in EMRP/ EMPIR

There are currently four projects funded by EMPIR which have AUV content.

EMPIR 17IND12 Met4FoF Metrology for the Factory of the Future The project aims to develop calibration framework for sensors with digital pre-processed output and internal signal processing, reference system for in-situ calibration of MEMS measuring ambient conditions, develop a metrological infrastructure for real-time data aggregation and machine learning in industrial sensor networks, and implement the methods and frameworks developed in industry-like test environments. The project includes some aspects which cover acceleration and vibration sensing. The project began in June 2018.

EMPIR 18HLT06 RaCHy Project.

The aim of this project is to provide a reliable metrology framework for the evaluation of a class of radiation-based therapies coupled with hyperthermia induced by Therapeutic Ultrasound (TUS), conventional Electromagnetic Radiation (EMR), magnetic nano particles (MNPs). There are 11 partners in 5 different countries and the project began on 1st June 2019.

EMPIR 19ENV03 Infra-AUV: Metrology for low-frequency sound and vibration

Low frequency Acoustics, Ultrasound and Vibration (AUV) phenomena in air, water and ground are used to detect major natural events such as earthquakes, tsunamis and volcanic activity. Low

frequency AUV is also used by the International Monitoring System (IMS) to check compliance with the Comprehensive Nuclear-Test-Ban Treaty. However, the majority of the frequency ranges used for AUV detection are not covered by current measurement standards, limiting the reliability of data obtained. IMS stations are also often located in extreme environments posing additional challenges for assuring the accuracy of AUV sensors. The project will develop new primary calibration methods for airborne and underwater AUV sensing systems down to, and below, the low frequency range of 0.1 Hz. Secondary calibration methods for working standards will also be developed to enable traceability and reliability of sensors deployed in live environmental monitoring networks. Following the end of the project, these are expected to be incorporated in new international standards and aid more accurate and traceable measurements for both natural and man-made environmental events.

7. Capacity Building: Activities of the last year and future needs

In June 2019, the first EURAMET training courses for air acoustic metrology were held at GUM in Poland. This course resulted from the response to a questionnaire prepared Tanasko Tasic for planning capacity building activities in the field of AUV among BOD-WGCB and TC-AUV. A response was obtained from TR, UK, PO, RS, EE, GR, MK, ES, IE, BG, MD. Turkey and Poland offered to host training courses, and the first were held in at GUM in June 2019.

Some demand has been expressed to NPL for training in underwater acoustic metrology. Initially, this is likely to be followed up bilaterally between NPL and GUM.

8. Meetings

The COVID-19 pandemic has severely restricted the ability to hold face-to-face meetings in 2020. The TCAUV and the three Sub-Committees meet on an annual basis. In recent years, the meetings of the TC and all SCs have been held together, providing greater opportunities for cross-theme discussions and greater exposure of all delegates to wider EURAMET issues.

The planned TC-AUV meeting in April was held as an online meeting held on 2nd April 2020, with only the plenary meeting held (no SC meetings). The meeting provided the opportunity to report on and discuss general EURAMET matters and information arising from the joint meetings of the Board of Directors and TC-Chairs. The meeting was attended by Julien Vuillemin-Toledo (EURAMET Member Service Manager) and Tanasko Tasic (EURAMET Capability Officer).

A further TC-AUV meeting (with SC meetings) was planned for September 17th and 18th 2020 hosted by METAS in Bern. However, the continuing restrictions due to the pandemic have made this difficult to host, and when TC-AUV delegates were surveyed for their opinions the vast majority preferred another online meeting at this juncture. Therefore, the September 2020 TC-AUV meeting will be another online meeting. Plans for the meeting are in preparation.

9. Issues

KCDB 2.0

The new KCDB 2.0 is now being used for CMC submission and key comparison registration. All national TC-AUV delegates for AUV are encouraged to register as in the “writer” category (NMIs and DIs may need extra users on occasion). All pilots of comparisons have now registered in the “pilot” user category. The members of the TC-AUV Working Group for CMC Review have all been registered in the “reviewer” user category.

A training course was run for EURAMET TC Chairs and interested parties at BIPM in February (attended by TC-AUV Chair and by Enver Sadikoglu from TC-AUV CMC WG). Support from BIPM staff has been helpful, and those delegates that have used the system have found the instructions reasonably clear, and after some teething problems they have been able to use the system successfully. One issue that has been raised is that the new system requires far more people to interact with the new system (instead of all contact being through the TC Chair), requiring more experts to be familiar with the system and more training to be provided.

ISO 80000 standards

It is noted that the ISO 80000-8 *Acoustics* standard (a description of how the definitions of the International System of Quantities and Units is applied in acoustics) has now been published by ISO TC12 after substantial revision, and is regarded as much more acceptable to the acoustics community in general. Considerable comments were made by EURAMET TC-AUV members via TC12 liaison bodies such as CCAUV, ISO TC43, IEC TC29 and IEC TC87. The next standard in the series that is relevant to acoustics is part 15 which covers logarithmic units (including the decibel and frequency bands such as octaves and fractional octaves). This is under the auspices of IEC TC25 who have already reached out to the same liaison bodies listed above

European Metrology Networks

It is noted that the lack of an EMN on pollution monitoring is detrimental to the acoustics field (for both urban noise and marine acoustics). Such an EMN would be of significant relevance to TC-AUV. The proposed EMN on this topic failed to get approval, and further discussions are taking place about how to re-write a proposal so that it is more focused. The concern within TC-AUV is that acoustic noise pollution may be omitted from a future proposal, leaving TC-AUV with little participation in any EMN. TC-AUV already makes a contribution to the climate change and ocean measurement EMN, but this is restricted to oceanographic and climatic applications of ocean acoustics.

10. Strategic Planning

Strategic plan for comparisons

A strategic plan for comparisons within EURAMET is being drafted. This is being based on the CCAUV strategic plan which was developed in 2019 (EURAMET members had significant input into the CCAUV strategy).

Road maps

The technical road maps for Airborne Acoustics, Ultrasound, Underwater Acoustics and Vibration are currently being updated, with progress made since the last TC-AUV meeting. The deadline for new technical road maps is the end of 2020.

11. Outlook for 2020/2021

The second *online* TC-AUV meeting of 2020 is planned for September 17th and 18th.

Offers have been made by METAS, BEV and NSAI for venues for upcoming TC-AUV meetings in the next few years. The date of the 2021 meeting will be early April or late March of 2021.

Stephen P. Robinson
EURAMET TC-AUV Chair

