



1. General Aspects

This report summarises activities of the EURAMET Technical Committee for Acoustics, Ultrasound and Vibration (TC-AUV) for 2020-2021.

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.

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

The current TC Chair, Stephen Robinson, reaches the end of his tenure in June 2021. At the 2020 TC-AUV meeting, a recommendation was made for an incoming Chair and this was ratified. The new TC-AUV Chair from June 2021 will be Enver Sadikoglu of UME (Turkey).

2. Projects

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).

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 2021.



**Acoustics, Ultrasound
and Vibration**

The Draft A report has now been sent to participants. The project is registered in the KCDB as EURAMET.AUV.V-S1.

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. The project is on track with DPLA, PTB, INRIM, UME, CMI, GUM and CEM having completed measurements.

3. Comparisons

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 recently completed and registered in the KCDB.

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.

EURAMET.AUV.V-S1 (EURAMET Project 1481) *Secondary calibration of accelerometers in medium frequencies (10 to 10 000 Hz).* This comparison will be linked to the key comparison EURAMET.AUV.V-K5. The sensitivity shall be calculated in accordance with ISO 16063-21:2003. 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). Measurements are complete and the Draft A report has been sent to participants.

Future comparisons: a trilateral comparison will be set up to underpin justification of CMCs for DMDM after discrepancies in the DMDM performance in EURAMET.AUV.A-K5. Participants will include UME and GUM (the latter acting as linking laboratory).

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). After some delay, the Draft A report will be circulated by June 2021.

CCAU.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. The comparison is now complete and the results are approved for equivalence.

CCAU.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 B report will be completed later in 2021.

CCAU.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 20 kHz with an option to make calibrations down to 2 Hz and options for phase calibrations, with 13 participants calibrating to IEC 61094-2:2009. Although delayed by COVID, the measurement phase was completed in February 2021. Draft A in preparation – to be circulated in summer of 2021.

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 (repeat of CCAUV.A-K4). Preparations will start in late 2021.

4. CMCs

A total of 19 EURAMET NMIs & DIs have a total of 511 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 511 EURAMET CMCs, 300 are Sound in Air, 192 are for Vibration, and 19 are for Ultrasound and Underwater Acoustics. The total number of CMCs for 2021 shows a slight decrease compared to the value for the previous year (523) after the revision of the CMC entries for some NMIs.

Those countries submitting updated CMCs in the 2020-2021 period include France, UK and Austria (all under review). 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.

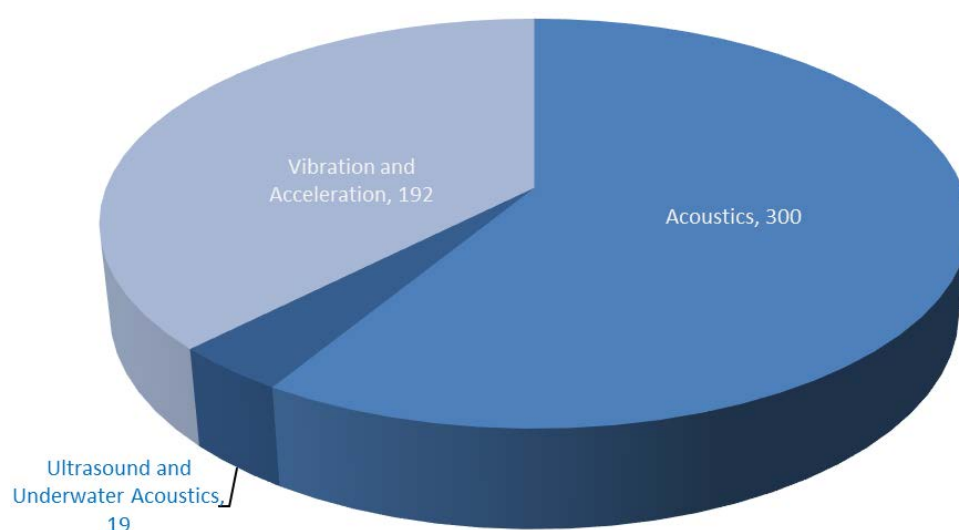
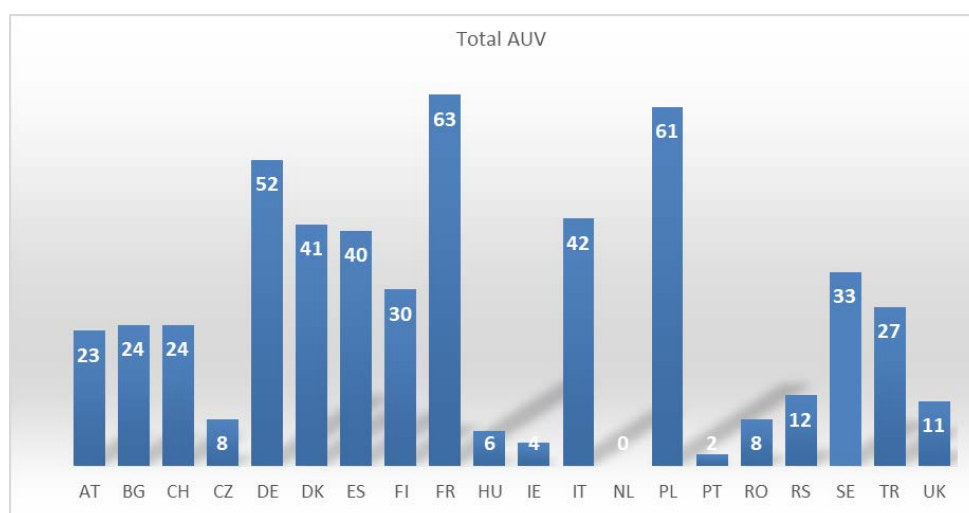
Vitality and validity of CMCs

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 addressed the issue by providing for a bilateral comparison with GUM (EURAMET.AUV.V-K2) the results of which have now been accepted for equivalence in the KCDB. Revisions are now in hand of the BIM CMCs to reflect the scope of the comparison and the current scope of service.

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, new staff for calibrations were hired and successfully trained, and the DMDM capability has been restored. To demonstrate the restored capability, a trilateral comparison with UME and GUM, 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.

SMU (Slovakia) have requested that their greyed-out CMCs in air acoustics be restored now that they have obtained sufficiently expert staff to cover the required metrology area. SMU staff attended the TC-AUV meeting and the SC-A meeting in 2021, and an action plan submitted by SMU to cover the restoration process was discussed by at the SC-A meeting. A further meeting is being scheduled with TC-Q, TC-AUV and SMU to agree the way forward. A bilateral comparison is likely to be required, and this will arranged later in 2021.



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, frequently 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.

The Sub-Committees are:

<u>Sub-committee</u>	<u>Convener</u>	<u>No. members</u>
SC-A "Sound in Air"	Erling Sandemann-Olson (DPLA)	16
SC-U "Ultrasound and Underwater Acoustics"	Gianni Durando (INRIM)	6
SC-V "Vibration and Acceleration"	Thomas Bruns (PTB)	15

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.

6. Participation in EMRP/ EMPIR

There are currently three 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, 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. As Members of TC-AUV, PTB and CEM are involved in the development and validation of primary calibration methods in hard- and software in kind of an extension to existing conventional (analogue) calibration systems. The validation was successfully demonstrated in a bilateral comparison between both NMIs. In addition, the same hardware extension was used by PTB to develop and implement a smart-sensor platform, which was successfully used in IoT-like two Testbeds of external project partners.

EMPIR 18HLT06 RaCHy Project.

The aim 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 fluid hyperthermia mediated by (radioactive) magnetic nano particles (MNPs). There are 11 partners in 5 different countries including some of the most influential therapeutic ultrasound groups in Europe, and the project began on 1st June 2019. In general, the cancer research community will be provided with metrological tools that are able to perform reliable, repeatable and transferrable tests of ultrasound-based methods for quantitative determination of temperature profiles. The findings of the project will also be discussed at the annual IEC TC87 meetings, which gather all the relevant NMIs and ultrasound equipment manufacturers throughout the world. Advances in modelling and the development of comprehensive heat delivery thermal models will reduce the time and the effort necessary for planning and delivery, which at the moment represent the bottleneck for fast and reliable treatment. To achieve the target, the

standardization of methods to evaluate and report the results will be made immediately available to the scientific community. Outcomes, such as best practice guidelines based on the expertise and experience of leading centres throughout Europe can be collected to improve recommendations, and will be more widely disseminated. Furthermore, the ability to leverage long-term outcomes by centres in different countries strengthens the evidence-base, accelerating clinical uptake. Four open access articles in peer-reviewed journals have been published. Project activities have been presented at ten international and national conferences. One training activity has been carried out regarding the TUS application in hyperthermia (12 participants from one stakeholder of the project).

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

Due to restrictions because of the COVID-19 pandemic, no further EURAMET **training courses** for air acoustic metrology have been scheduled since the courses held at GUM in Poland in June 2019. The possibility of further courses will be investigated after the travel restrictions are lifted.

Some demand has been expressed for **mentoring** and this is been followed up, though the travel restrictions have prevented visits to participating laboratories. GUM have offered to mentor NSAI in air acoustic metrology, and once the travel restrictions are lifted, NPL will follow up opportunities for mentoring for GUM in underwater acoustic metrology.

8. Meetings

The TC-AUV and the three Sub-Committees meet at minimum 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 COVID-19 pandemic has severely restricted the ability to hold face-to-face meetings in 2020 and 2021, and so all recent meetings have been held online.

The TC-AUV meeting for 2020 was held on September 17th and 18th 2020 with a short meeting also having been held on 2nd April 2020. The April meeting provided an opportunity for cascading of EURAMET news by Julien Vuillemin-Toledo (EURAMET Member Service Manager) and Tanasko Tasic (EURAMET Capability Officer). The September meeting included meetings of all three Sub-Committees.

In 2021, the TC-AUV meeting was held on May 10th and 11th with meetings of all three Sub-Committees also held. News and updates on EURAMET were provided by the EURAMET General Secretary (Duncan Jarvis).

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 were encouraged to register as in the “writer” category. All pilots of comparisons are 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. Some errors were discovered in the transfer of CMC data for the recently approved CMCs of PTB and GUM, and these are being addressed.

IEC/ISO 80000-15 standard

A new ISO/IEC standard called “IEC 80000-15 ED1: Quantities and units – Part 15: Logarithmic and related quantities, and their units” is in development and has reached CD stage. It has been prepared by IEC TC25 (in conjunction with ISO TC12), and covers definitions of units such as the decibel, neper and logarithmic frequency intervals (eg fractional octaves). IEC TC25 have reached out to acoustics standards committees for input, and CCUAV and TC-AUV have opportunity for comment.

European Metrology Networks

The EMN on Climate and Ocean Metrology (ClimOcNet) includes metrology related to ocean sound, an essential ocean variable. Stephen Robinson of NPL has made contributions to the Stakeholder Needs Report prepared by the EMN, and has attended and presented at the EMN meetings. The acoustic input is restricted to oceanographic and climatic applications of ocean acoustics.

The lack of AUV input to the EMN on pollution monitoring is detrimental to the acoustics field. A pollution EMN is of significant relevance to TC-AUV (for both urban noise and marine acoustics). There is concern within TC-AUV is that acoustic noise pollution will be omitted from the EMN in future, leaving TC-AUV with no participation in a strategically-relevant EMN. TC-AUV members have been encouraged to engage with the EMN to find relevant common interests.

10. Strategic Planning

Strategic plan for comparisons

A strategic plan for comparisons within EURAMET has been drafted. This is based on the CCAUV strategic plan which was developed in 2020 (EURAMET members had significant input into the CCAUV strategy). The Strategic Plan was reviewed drafted by the TC Chair and reviewed by the SCs at the May 2021 TC-AUV meeting.

Road maps

The technical road maps for Airborne Acoustics, Ultrasound, Underwater Acoustics and Vibration are currently being updated, with some progress made since the last TC-AUV meeting. SC-U has prepared updated road maps for Medical Ultrasound and for Underwater Acoustics. These will be uploaded to the EURAMET web-site by June 2021. Updated road maps are in preparation for air acoustics, and for vibration.

11. Outlook for 2021/2022

At the 2021 General Assembly, **Enver Sadikoglu** takes over as the new TC Chair.

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 2022 meeting has been provisionally set for 5th and 6th May 2022.

Stephen P. Robinson
EURAMET TC-AUV Chair

