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Five sets of newly designed and manufactured ear simulators for three different age groups

Welcome

The first half of the project "*Metrology for modern hearing assessment and protecting public health from emerging noise sources*" is over and we are pleased to present the third project newsletter. The project has made strong progress in different parts of the work and we greatly appreciate the opportunity to provide you an update with news, achievements and results of our work.

While the first period of the project work focussed on the preparation of technical and methodology prerequisites for the various studies, these have now moved into the implementation phase, and in some cases the first significant results have been obtained. After an intense designing and construction phase the demonstrators of the new ear simulator have been manufactured and the test and validation phase has started. After defining requirements, an ultrasound reference working place was built up and was used to evaluate collaboratively developed novel measurement methods. The determination of hearing thresholds for a combination of infrasound and audible sound showed interesting and slightly unexpected results. In another experiment a vestibular response on low-frequency and infrasound stimuli could not be detected.

I am also pleased to announce that international workshops will again be organised, to engage with and inform potential users of the project outcomes. Please see the "News and Facts" section of this newsletter for more details. We cordially invite you to join us at these events.

Another time I hope you find this newsletter valuable and enjoy reading it.

Christian Koch
Coordinator

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News and facts

- Demonstrators of the new ear simulator were manufactured.
- The second project progress meeting was held in Oldenburg, Germany in November 2017.
- The planning of three workshops, to take place in early 2019, has been started. The subjects of workshops are “Perception and impact of infrasound", "Measurement and perception of airborne ultrasound at workplaces and in the public" and “Next generation ear simulators: raising hearing assessment quality for all”. Please visit project website for further details about workshops.

Highlights from the work packages

Implementation of universal ear simulator designs

At the project outset, work started on the definition of specifications for the ear simulator family followed by the design of the devices and the manufacture of prototypes.

A key outcome of the definition phase was to produce devices targeting nominal age groups of 3 months, 24 months and adults.

The design of the three physical devices in the universal ear simulator family followed a similar process to that used in first EARS project. An axi-symmetrical ear canal is terminated with an acoustic impedance formed by Helmholz resonators. The design is, however, developed to a more compact structure than the designs in the previous project. The previously determined common shape function for the ear canal was used.

In the implementation of these new ear simulators, particular consideration was given to microphone mounting and interfacing to external ear adaptors and calibration devices. The microphone can be calibrated separately, and the front with the ear canal opening allows simple extension of the ear canal and flush mounting of e.g. calibration adapters.

One of the manufactured ear simulators

The devices are now circulated to EARS II partners for interlaboratory comparison on determination of acoustic impedance. Subsequently they will be used in clinical trials in the project and at selected clinics at the further stages of the project.

Contact: ErlingSandermann.Olsen@bksv.com

Development of a measurement technique for airborne ultrasound

The concept of a reference workplace using a typical welding machine for studying airborne ultrasound fields in the laboratory was described in the previous issue of the newsletter (July 2017). In the past months, such reference workplaces have been established at IFA and PTB and were used for extensive measurement series. An ultrasonic welding machine served as sound source.

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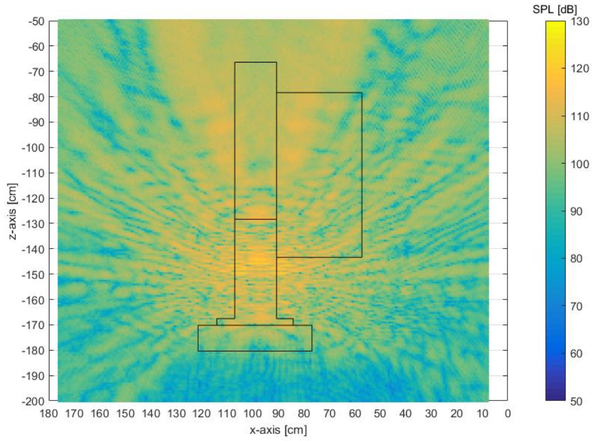
Welding machine used in test setup

At IFA, measurements were carried out according to methods defined in established standards for audible sound in order to get an understanding of any limitations and shortcomings. It was found that the sound fields on ultrasonic industrial appliances and other ultrasound sources tend to be much more complex than conventional sound fields, as expected. Example of the section of the welding machines sound field is depicted in the next figure. The reference workplace measurements identified certain shortcomings of conventional methods. Stationary measurements, for example, yield unreliable results.

Thus, a new spatially averaging approach was tested. Sound pressure level scans with high spatial resolution were performed at PTB to characterise the sound field. The collected data were analysed statistically to evaluate the reproducibility and reliability of the new averaging approach. Additionally, results from IFA and PTB were compared to check the comparability between laboratory and practical measurements. First tests of the new approach gave promising results.

The current draft of measurement procedure is now under revision by practitioners and experienced measurement engineers. Once this review is completed, the method will be applied in field tests scheduled to begin shortly.



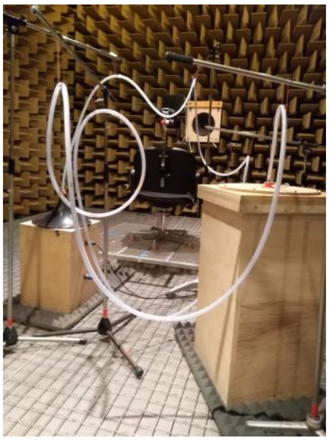
Sound field in front of the welding machine as measured in laboratory reference workplace setup

Contact: Andrea.Wolff@dguv.de

Hearing threshold measurements for infrasound combined with audiosound

Since human exposure to infrasound is usually accompanied by sound in the conventional hearing range (between 20 Hz and 20 kHz, for simplicity called “audiosound”), it is highly valuable to investigate the role played by the combination of infrasound and audiosound in the perception of infrasound. Therefore, hearing threshold measurements for infrasound combined with audiosound were performed. One of the objectives was to investigate whether the presence of audiosound influences the hearing threshold levels of infrasound, and vice versa, whether

the presence of infrasound influences the hearing threshold levels of audiosound.
13 normal hearing subjects aged between 18 and 30 years participated in the hearing threshold measurements. The sound signals were generated by a specially developed sound source system, the details of which were described in the previous newsletter (July 2017), and were presented to the subjects through eartips.



Measurement setup for hearing threshold measurements for infrasound combined with audiosound.

The hearing threshold measurements were separated in three experiments. First, hearing threshold levels for isolated infrasound and audiosound stimuli were measured. Then, threshold levels were determined for infrasound stimuli in the presence of audiosound presented at 5 dB and 50 dB above the individual threshold level. Vice versa, threshold levels were measured for audiosound stimuli in the presence of infrasound presented at levels within 10 dB above and below the individual threshold level.

In the end, it was observed that the threshold levels of audiosound were hardly influenced by the presence of infrasound. On the contrary, the threshold levels of infrasound were on average increased by the presence of audiosound presented at 50 dB above the individual threshold level. In addition, it was found that some subjects were hardly affected by the presence of audiosound, whereas others showed large threshold shifts of infrasound.

Contact: elisa.burke@ptb.de

Vestibular responses to low-frequency and infrasound

It is often rumoured that the vestibular system is sensitive to acoustic infrasound stimulation, because it responds best to head vibrations below 10 Hz. For fifteen subjects, vestibular evoked myogenic responses (VEMPs) were recorded using different types of acoustic stimulation. VEMPs are a standard clinical tool for vestibular diagnostic, recorded in response to very short 500 Hz tone pips from the sternocleidomastoid neck muscle. In addition to this clinically used stimulus (our control for normal vestibular function), the myogenic frequency-following response (FFR) to 40 Hz amplitude modulated 500 Hz tones was recorded (reported previously in the scientific literature), and also 40 Hz, 16 Hz and 4 Hz pure tones. The first two kinds of stimuli were presented at 119 dB SPL and 116.5 dB SPL (peak)), respectively, using TDH-50P headphones, while the pure tone stimuli were presented at 90 phon with the in-ear sound source that was especially designed during the EARS project for acoustic stimulation between 2 Hz and 250 Hz. FFR responses were recorded for 120 second continues stimulation. A typical FFR spectrum to 40 Hz tone stimulation is shown in the next figure.

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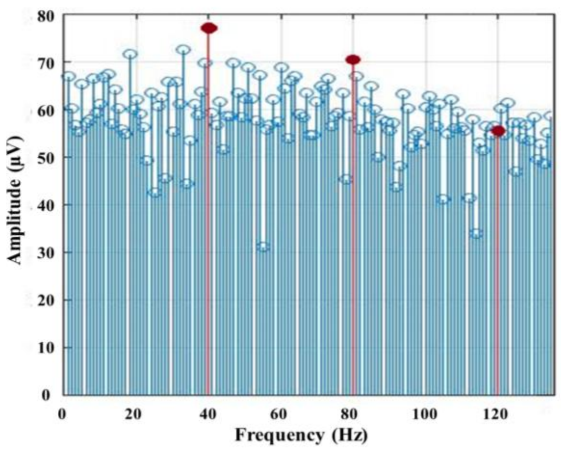
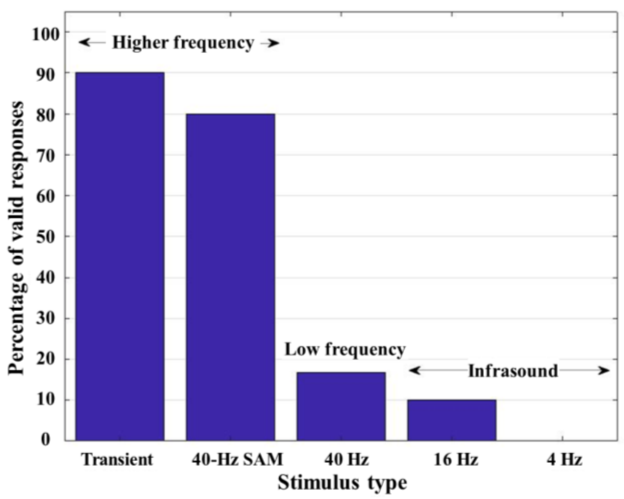


Typical FFR spectrum to 40 Hz tone stimulation

A summary of the results of study is presented in the figure below. The results are presented as the percentage of significant responses (as determined by phase coherence) obtained for each stimulus type.



Percentage of ears producing a valid vestibular-evoked myogenic responses to the various acoustic stimulus types.

Despite that most of the 30 ears produced a response to the 500 Hz stimuli, only 5 (16.7 %) showed significant VEMP responses to the 40 Hz pure tone stimulation; this decreased to 3 (10 %) for 16 Hz, and no response at all to 4 Hz infrasound.

Although the vestibular organ is tuned to very low frequencies of head vibration, these findings suggest that activation of vestibular responses by airborne sound decreases with decreasing frequency. It should be noted, however, firstly that current results were obtained for a group of healthy subjects, and may not apply to persons affected by vestibular pathologies, or people that tend to complain about environmental infrasound.

Secondly, measurements involved vestibular responses recorded from the sternocleidomastoid muscle (cVEMPs), which are believed to test the organs of the saccule, whereas VEMPs recorded from the extraocular muscles (oVEMPs), which test for utricular responses, were not systematically measured. However, informal pilot data suggested that these required even higher acoustic stimulation, and were completely absent to tonal stimulation at 40 Hz and below. In summary, at least for saccular testing in healthy subjects, results suggest infrasound well below 90 phon does not evoke a vestibular response.

Contact: t.marquardt@ucl.ac.uk

Dissemination of work

Alongside the technical research, the consortium is also actively managing its planned dissemination activities so that the project creates the greatest possible impact.

EARS II at the DAGA (Munich, Germany) Conference

IFA from DGUV and PTB took the chance to promote the project activities on airborne ultrasound noise measurement and on the perception of infrasound on the annual meeting of the German Acoustical Society (DAGA) in Munich on 19-22 March 2018. In total, four presentations were given in three sessions on airborne ultrasound and infrasound. In a particular, two posters on the development of a new measurement method for ultrasound exposure were presented in the session on the noise at working places, and this led to a couple of fruitful discussions with experts, who all appreciated the work done. Due to the very positive feedback, future contributions to the DAGA 2019 are planned.

EARS II at the BSA Basic Auditory Science meeting

Ultrasound and infrasound were also the topics of the two EARSII contributions to the annual meeting of British Society of Audiology held in Nottingham on 4 – 5 September 2017. University of Southampton talked about the many new types of ultrasound sources appearing in public places. They presented field measurements of their sound pressure levels, which could be as high as 100 dB at 20 kHz. They also reported on first laboratory listening test.

University College London presented EEG frequency following responses (FFR) to steady sinusoidal sounds of 11 Hz and 38 Hz. In contrast to the 38 Hz responses, the FFR at 11 Hz grows more steeply and could be obtained already close to sensation threshold.

EARS II presented to CTBTO

The project was presented by the coordinator and two other project partners at a meeting of the Comprehensive Test Ban Treaty Organisation (CTBTO), which operates global monitoring networks for radionuclide, seismic, underwater and infrasound signals in the environment, primarily to detect unlawful testing of nuclear weapon but also for a range of other scientific applications including environmental climate changes. There was great interest in the exchange of ideas and inter-disciplinary discussions relating to improvement in infrasound measurement technique and calibration, and the human and environmental impact of infrasound.

EARS II at the CCAUV meeting

A presentation entitled “Hearing below the low-frequency-limit: measurement, perception and impact of infrasound noise” has been made by project coordinator during workshop on “Measurement of imperceptive matters”. The workshop was organized in conjunction with 11th meeting of the Consultative Committee for Acoustics, Ultrasound and Vibration (CCAUV) and held at the International Bureau of Weights and Measures (BIPM) from 20 to 22 September 2017. The workshop was attended by experts in acoustical metrology from all over the word.

Business card of partners:

In this column of every Newsletter we introduce one or two of the institutes from the consortium to you. In this issue we present the TÜBİTAK National Metrology Institute of Turkey.

TÜBİTAK National Metrology Institute (UME) is the highest technical authority in Turkey for the field of scientific metrology. Having established in 1992, TÜBİTAK UME

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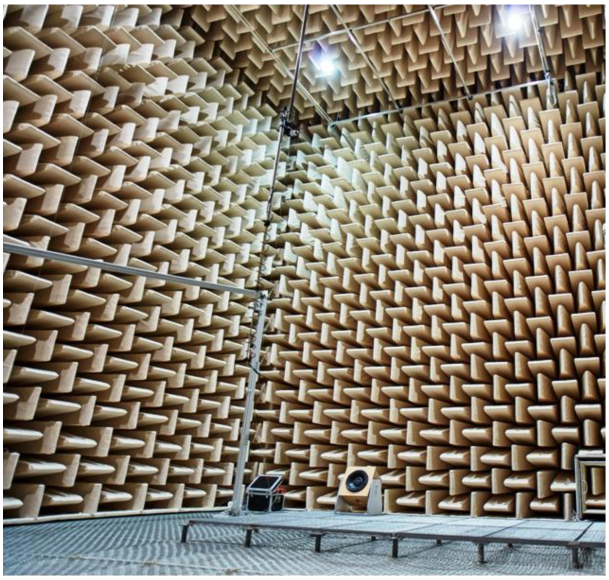
operates as national reference laboratory in metrology under the auspices of the Scientific and Technological Research Council of Turkey (TÜBİTAK) placed under the Ministry of Science, Industry and Technology. It meets the requirements for calibration and testing laboratories as defined in the ISO/IEC 17025 standard, employing a staff of more than 300 people. It is a fundamental task of TÜBİTAK UME to realize and maintain the standards of the units in compliance with the International System of Units (SI) and to disseminate them, above all within the framework of legal and industrial metrology as well as pursuing its scientific and technological development in order to anticipate new measurement and testing requirements in the areas of energy, safety, health, quality and environmental protection. TÜBİTAK UME provides government authorities and key economic players with the technical assistance they require to draft new regulations and standards at national level.

View of the TÜBİTAK UME

Activities in the field of acoustics are carried out by the Acoustics Laboratory, which is one of the 26 operational laboratories of the institute. The Acoustics Laboratory mainly performs primary and secondary calibrations of devices used for acoustical and vibration measurements, e.g. microphones, sound level calibrators, sound level meters, audiometers, ear simulators, as well as accelerometers, calibration exciters etc. In addition, the laboratory provides testing services such as sound power, sound intensity and sound absorption measurements. Acoustical tests are performed in full compliance with relevant international standards and are accredited by Turkish Accreditation Agency (TÜRKAK), signatory of the ILAC Mutual Recognition Arrangement (MRA).



Full Anechoic Room at TÜBİTAK UME

Since the establishment of basic calibration capabilities from the very beginning up to the recent years, TÜBİTAK UME has placed a growing emphasis on research activities that cross into areas that are outside its traditional remit as a national metrology institute. In the acoustics field, TÜBİTAK has completed successfully or is currently active in many research projects. They are mainly focused on investigation and development of new methods and techniques for acoustics measurements and calibrations, design and characterization of various sound sources and transducers. The institute was a partner in the

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EARS project and currently is active mainly within two work packages in EARSII project:

TÜBİTAK UME is involved in the characterization of ear simulators, the investigation of environmental dependence of the acoustics impedance of ear simulator, the inter-laboratory comparison and validation of the calibration method, as well as the clinical trials of newly developed ear simulator.

Visit the TÜBİTAK National Metrology Institute

http://www.ume.tubitak.gov.tr

How to contact us

EARS II project coordination:

Dr. Christian Koch
Physikalisch-Technische Bundesanstalt
Bundesallee 100
38116 Braunschweig, Germany
Email: christian.koch@ptb.de

Project website:
http://www.ears-project.eu

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