Workshop of the Consultative Committee for Acoustics, Ultrasound and Vibration

-Measurement of imperceptive matters-

20 September 2017 14:00-18:00

Introduction: Aim of the workshop

<u>Takashi Usuda, CCAUV President, NMIJ (Japan)</u>

Invited talk

The IMS network: Overview, Measurement Systems and Calibration

<u>Julien Marty – Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) (Vienna, Austria)</u>

The Comprehensive Nuclear-Test-Ban Treaty (CTBT) prohibits States Parties from carrying out, encouraging, or in any way participating in the execution of any nuclear explosion. The Treaty was adopted by the United Nations General Assembly on September 10, 1996 and currently enjoys near-universality with 183 States Signatories and 166 ratifying States. The Treaty has not yet entered into force as it still awaits pending ratification from eight States out of the forty-four specific nuclear technology holder States listed in the Annex 2 to the Treaty. In the meantime, the Preparatory Commission (PrepCom) for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) is responsible for promoting the CTBT and establishing a verification regime. The objective of the verification regime is to ensure compliance with the Treaty. The verification regime is composed of four elements, one of them being the International Monitoring System (IMS). The IMS comprises 337 globally distributed facilities for seismological, hydroacoustic, infrasound and radionuclide monitoring as well as respective means of communication between these facilities and the International Data Centre (IDC) located in Vienna, Austria. This presentation will start with a quick introduction about the CTBT and the IMS network. It will then focus on the characteristics of the measurement systems used by the three IMS waveform technologies (i.e. seismological, hydroacoustic and infrasound) as well as the strict IMS requirements associated them. Calibration processes which are essential to ensure data quality and trustworthiness will also be described. The recent efforts made together with seismo-acoustic expert laboratories and national metrological institutes to define and implement calibration procedures in agreement with the IMS Operational Manual requirements will be highlighted. Issues such as the absence of primary standards in the IMS frequency range will be discussed.

Selected topics from CCAUV members

Report on CCAUV.V-K3

<u>Qiao Sun, NIM (China)</u>

During the 8th meeting of CCAUV in 2012, the decision was taken to make preparations for a further comparison targeted at low frequency range. Recent developments in technology and improvements at the NMIs have extended the low-frequency vibration limit of calibration capabilities down to 0.4 Hz and even down to 0.1 Hz or lower frequencies. Therefore, CIPM key comparison CCAUV.V-K3 was to measure the voltage sensitivity of one accelerometer standard set with primary means at 27 frequencies from 0.1 Hz to 40 Hz. Fourteen Metrology Institutes from five RMOs have participated in the comparison. One quartz-flexure servo accelerometer of single-ended type and a signal conditioner was circulated among the participants. All but one of the participating laboratories provided their calibration results, which were mostly consistent within their declared expanded uncertainties for magnitude results. Only two participants failed to contribute to the KCRV values calculated for five frequencies. For phase shift, three participants could not contribute to the calculation of the KCRV values in a total of sixteen frequencies. This first low-frequency vibration key comparison from 2014 to 2016 revealed the current calibration capabilities of the fourteen participants from five RMOs.

Hearing below the low-frequency-limit: Measurement, perception and impact of infrasound noise

<u>Christian Koch, PTB (Germany)</u>

In our daily life, many sources emit infrasound because of their function or unintended There are numerous indicators that sound at these frequencies influences human beings can be perceived. The talk will briefly describe the current status of measurement capabilities, the knowledge about perception mechanisms, and the assessment of infrasound. To contribute to the question whether these sounds can be of any risk for the hearing system the results of a study using audiological methods and neuroimaging are presented. It was implemented within an EU-funded international project in order to improve the objective rationale of the auditory perception of infrasound and also airborne ultrasound in humans.

Coffee/Tea breaks 30 min

Realization of acoustic primary standards for airborne ultrasound and applications

<u>Ryuzo Horiuchi, NMIJ (Japan)</u>

There is an increasing number of equipment emitting airborne ultrasound in our daily life. IRPA (International Radiation Protection Association) developed a guideline for allowable sound pressure level of airborne ultrasound but acoustic primary standards were not provided over audible frequencies at the time. Thus NMIJ established reciprocity calibration technique up to 100 kHz for free-field sensitivity level of WS3 microphones. This talk will introduce the reciprocity calibration system by the NMIJ and some applications such as rat-proof source and tactile display.

A Primary Method for the Complex Calibration of a Hydrophone from 1 Hz to 2 kHz

<u>S.E. Crocker, NIST-USRD (United States)</u>

Primary calibrations of hydrophones at frequencies less than about 1 kHz are typically performed in a coupler reciprocity chamber ("coupler"); a closed test chamber where time harmonic oscillations in pressure can be achieved and the reciprocity conditions required for a primary calibration can be realized. The closed and controlled environment in the coupler allows for the performance of primary calibrations over the temperature and hydrostatic pressure range found in the ocean. The coupler reciprocity system employed by the United States, in service since the 1960s, provides only the magnitude of the pressure sensitivity and not the phase. Recent work has demonstrated a method for the primary calibration of both the magnitude and phase of the complex sensitivity for a hydrophone at frequencies ranging from 1 Hz to 2 kHz. The combined expanded uncertainties of the magnitude and phase of the complex sensitivity at 1 Hz were 0.1 dB re 1V/mPa and ±1◦, respectively.

Metrology issues with long-term monitoring of very low frequency deep-water ocean noise

Stephen Robinson, NPL (United Kingdom)

Abstract: The monitoring of deep-water ocean noise at very low frequency (0.1 Hz to 100 Hz) may be undertaken using hydrophone-based monitoring stations such as those operated by the CTBTO. Ocean acoustic monitoring poses considerable metrology challenges with regard to calibration, traceability and long-term stability. This presentation addresses these issues, and provides a description of the latest work on standardization of low frequency calibration techniques to be included in a revised version of IEC 60565-2. Finally, an example is provided of analysis of long-term ocean acoustic noise, and what this can tell us about the trends in such noise data.

Free-field calibration of underwater sound receiver in a laboratory water tank at very low frequencies

A.E. Isaev, A.S. Nikolaenko, FSUE VNIIFTRI (Russia)

Free-field calibration of an underwater sound receiver is performed in a laboratory water tank using a tone-burst measurement method. In this case, the finite frequency resolution of the tone-burst method limits the lowest frequency of free-field calibration. In the laboratory water tank of typical sizes the free-field calibration at frequencies below several kilohertz is not possible to perform, because this limitation within the tone-burst method can't to be overcome.

An approach that allows overcoming dependence of lowest calibration frequency on finite frequency resolution is considered. Method can be useful for hydrophone calibration as well as for calibration of underwater sound receiver with hydrophone mounted on measurement platform. Calibration results for hydrophone and receiver in water tank at frequencies from several kilohertz down to tens of hertz are shown.

A 6DOF micro-vibration measurement and generation test facility

Charlie Jarvis, NPL (United Kingdom)

Micro-vibrations generated by spacecraft sub-assemblies limit the performance of the on-board instrumentation. The increasingly stringent stability requirements needed for future missions (particularly for meteorology, earth observation and astronomy satellites) necessitate increasingly sensitive ground-based test facilities. The National Physical Laboratory has developed a 6 degree of freedom micro-vibration test system for the European Space Agency. This system both measures the micro-vibrations produced by a test specimen and subjects a specimen to a known micro-vibration environment. The system measures forces and torques in the range of < 10 µN to 1 N (1 µNm to 1 Nm) and creates accelerations in the range 10^{-5} ms^{-2} to 10^{-3} ms^{-2} (10^{-5} $rads^{-2}$ to 10^{-2} $rads^{-2}$), at frequencies from 0.03 Hz to 50 Hz. The operating principles, mechanical design, instrumentation and metrology challenges of this test system are outlined.

Finished by 6 pm.