

EURAMET PROJECT PROTOCOL



1. Reference Number: <i>(please leave blank)</i>	2. Technical Committee: TC-AUV	
3. Project Title: Key Comparison of pressure calibration of LS1P microphones (EURAMET.AUV.A-K5)		
4. Proposed start date: 2 September 2013	Proposed end date: November 2015	Project Duration (months): 27
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Summary of Participation in Work Packages

WP No	Work Package Name	Active Partners (Institutes; WP Leader in Bold)
WP0	Measurement Phase	NPL (UK), LNE (France), CEM (Spain), PTB (Germany), INRiM (Italy), METAS (Switzerland), UME (Turkey), BIM (Bulgaria), DMDM (Serbia), SP (Sweden), BEV (Austria), NIS (Egypt)
WP1	Draft A	NPL (UK)
WP2	Draft B	NPL (UK)
WP3	IMPACT: exploitation, dissemination and knowledge transfer	NPL (UK)

Project Description

A – Introduction and Projected Impact.

The first CIPM key comparison of microphone calibration CCAUV.A-K1, concerning the pressure calibration laboratory standard microphones type LS1P, was completed in August 2003. Because there is a nominal seven year cycle for carrying out key comparisons, and a need to maintain a Key Comparison Reference Value (KCRV) for the calibration of this type of microphone a new key comparison was instigated in 2010 and the measurements began in 2011. The scope of the intercomparison was expanded significantly to reflect recent developments and experience that has been attained since CCAUV.A-K1 was first proposed.

The new key comparison was denoted CCAUV.A-K5 and the measurement phase and Draft A report were completed in 2012. The final report is expected to be published in late 2013. Subsequent RMO key comparisons will now take place to allow the inclusion of as many NMIs or DIs in the Key Comparison Database (KCDB) as possible. RMO key comparisons are required to follow the same technical protocol as their preceding CIPM intercomparison. This document outlines the protocol for the subsequent key comparison of the RMO EURAMET. It should be read in conjunction with “Measurement comparisons in the CIPM MRA” (CIPM MRA-D-05) which includes more details on the purpose and conduct of key comparisons in general. The purpose of this document is to “specify the procedures necessary for the comparison, but not the procedures used for the realization of the standards being compared.”

Two participants of CCAUV.A-K5, NPL, UK (the pilot laboratory) and INRiM, Italy, will take part in this EURAMET.AUV.A-K5 key comparison, providing the essential links between the key comparisons.

B – Scientific and Technological Frame and Objectives.

Table 1. Scope of key comparison

Frequency range	Sensitivity level	Sensitivity phase
2 Hz - 20 Hz (1/3-octave)	Optional	Optional
20 Hz – 10 kHz (1/3-octave)	Mandatory	Optional
20 Hz – 10 kHz (1/12-octave)	Preferable to 1/3-octave	Optional

Table 1 shows the measurands and frequency ranges within the scope of this key comparison. Participants shall complete the mandatory elements. Those labs that declared the ability to perform measurements at 1/12-octave frequencies shall do so, to conform to the protocol used for CCAUV.A-K5 and to enable the analysis of the results in the form of reference curves. (Measurements made at 1/3-octaves can still be analysed in relation to the Key Comparison Reference Curve (KCRC) at discreet points.) Each laboratory is to determine the open-circuit pressure sensitivity level of each reference microphone, and optionally the open-circuit pressure sensitivity phase. The open-circuit pressure sensitivity level shall be reported in decibels with a reference value of 1V/Pa.

The convention to be used for reporting the sensitivity phase is that it approaches 180° at low frequency and is 90° at the resonance frequency of the microphone, i.e. the sensitivity phase shall be reported as positive values.

It is IEC TC29 policy that specifications referring to frequency in all new or revised standards, use the base 10 system of frequencies specified in IEC 61260. It is therefore appropriate to adopt this policy for key comparisons. Accordingly measurements shall be carried out and reported at frequencies generated by the formulae given below. In all calculations, the reference frequency f_r is 1000 Hz (NB. the octave frequency ratio of $G = 10^{(3/10)}$ described in IEC 61260, is implicit in these equations).

In the optional low frequency region, the third-octave calibration frequencies f_n between 2 Hz to 20 Hz shall be calculated from:

$$f_n = f_r 10^{n/10} \quad (1)$$

where n is an integer between -27 and -17.

In the mandatory frequency region the twelfth-octave calibration frequencies f_n between 20 Hz to 10 kHz shall be calculated from ‡:

$$f_n = f_r 10^{n/40} \quad (2)$$

where n is an integer between -68 and 40.

The actual frequency that can be set during a measurement will be determined by the particular equipment used. The effect of any significant variation in the set frequency from that calculated above, on the measured sensitivity level shall be accounted for in the uncertainty analysis.

Any other frequencies (for example, preferred nominal frequencies) reported by the participants will not be collated by the pilot laboratory.

The frequency range of any calibration and measurement capability (CMC) that the laboratory has declared, or intends to declare, under the CIPM MRA, as being supported by this key comparison, must correspond or fall within the range where data is reported.

It is expected that most laboratories will fulfil the measurement requirements by implementing reciprocity calibration. Where reciprocity calibration is to be used, this shall be according to IEC 61094-2:2009.

The reference microphones will have suitably flat front surface to make the use of grease on the contact surface unnecessary for couplers filled with air.

The use of hydrogen-filled couplers is not recommended, but where a participating laboratory intends to use such a method, the reference microphones shall only be used as receivers. This intention must be stated on the 'Agreement to participate' form.

‡ The twelfth-octave frequencies calculated according to IEC 61260 correspond to the centre frequencies of band-pass filters. However, these frequencies do not coincide with the third-octave frequencies normally used in acoustic measurement. In order to maintain consistency with existing data in the KCDB and with laboratories who perform their calibrations at only third-octave frequencies, Eq. (2) specifies lower band edge frequencies of twelfth-octave bands, which do periodically coincide with third-octave frequencies.

This key comparison is concerned only with primary methods of calibration and will only consider results from such methods.
The microphones require a polarising voltage of 200 V. Any protection grid fitted to the microphone shall be removed before conducting measurements.

C - Description of the work.

Two LS1P microphones have been selected for this comparison. The microphones are Brüel & Kjær type 4160 serial numbers 811014 and 2036126. These microphones are referred to as the reference microphones in the remainder of this document. Additional microphones will be maintained by the pilot laboratory should any reference microphone fail during the key comparison.

Each participant is responsible for transporting the reference microphones to the laboratory scheduled to next receive them. Local customs formalities must be observed and if the participating laboratory requires NPL to supply an ATA carnet (or any other documentation) for this purpose, they must inform NPL, using the 'agreement to participate form' shown in Annex A. In this regard, please bear in mind that the reference microphones may come to you directly from another participant (see Timetable in Section E).

The reference microphones will be packaged in a suitable form for transportation by courier. It is essential that this packaging is used when using air or land couriers to transport the microphones between participating laboratories. The microphones may also be hand carried, but it is recommended that the same packaging be used. The microphones shall be stored appropriately while in the possession of the participating laboratory. Ideally this should be in temperature controlled environment maintained at the reference temperature of 23°C. Any protection grid fitted to the microphones for transportation, shall be removed before conducting measurements.

The microphone cases will be marked as key comparison reference standards and the microphones must not be used for any purpose other than that associated with their calibration for this comparison. Sudden shocks can be caused by applying sound calibrators, pistonphones or dehumidifiers to the microphones and these actions should also be avoided.

C1 – WP1: Measurement Phase - NPL

C1a: Description of work

Pre-participation

The key comparison is scheduled to begin on 3 June 2013, when the pilot laboratory will start their measurements. The reference microphones will then be circulated to other participants for the first time.

Prior to the circulation of the microphones, participants shall complete the 'Agreement to participate form' shown in Annex A. This includes a statement of the measurements they expect to carry out and report. An electronic version of this form has been circulated with this protocol.

Reporting Results

Each laboratory shall report their results using the standard certificate that they would normally issue to a customer. However, results shall also be reported in the pilot laboratory's pro-forma spreadsheet, that has been circulated with this protocol. Please remember to check the box confirming that the data reported in the pro-forma spreadsheet is consistent with that reported in the certificates, as the spreadsheet data will be used as the basis for the analysis.

Results shall be corrected to the reference environmental conditions given in IEC 61094-2.

Results shall be accompanied by a statement of the associated measurement uncertainty, estimated for a confidence probability of 95%.

Where necessary an additional covering letter or report shall be provided to include any details not covered in the certificate, including:

- Details of any deviations from the recommendations in IEC 61094-2 and an estimate of the affect this has on the reported results.
- The values of the front cavity volume, cavity depth, and microphone acoustic impedance parameters used in the calculation, where appropriate.
- Values of the temperature and static pressure coefficients of the microphones used in the calculations.

A summary of the uncertainty calculation, listing and quantifying each of the components considered, and indicating the method used to produce the overall estimate of measurement uncertainty. Where a frequency dependent analysis is carried out, this summary should cover the whole frequency range, but be limited to the third-octave frequencies only for brevity.

The final results and the accompanying information should be received at NPL within four weeks of the end of the scheduled measurement period. Dated deadlines can be found in the schedule shown in Annex A. A reminder will be sent by email one week before the due date and this deadline shall be strictly enforced: failure to submit results by the deadline may result in the exclusion of the participant laboratory. An email to the pilot laboratory should be sent to announce that the results have been despatched. The completed pro-forma spreadsheet should be attached to this email. It is also acceptable to send all other material by email to meet the deadline, but hardcopies of calibration certificates should follow in the post.

The pilot laboratory will carry out their measurements at the start of the circulation period and their results shall be lodged with the CCAUV secretariat within 4 weeks of the end of their measurement period.

When all participants have completed the measurements, the data will be analysed by the pilot laboratory. If a result is found to be anomalous the laboratory in question will be notified and given three weeks to respond. A Draft A report will then be prepared.

Finance

Participants are responsible for their own costs, the cost of delivering the microphones to the next recipient, any ATA carnet required and for any damage to the microphones while they are in their possession.

Timetable

The timetable is given in Section E.

The timetable must be followed regardless of any delays caused by customs irregularities and this could cause a laboratory to lose the opportunity to participate in the comparison.

Each participating laboratory has been allocated a 5-week period in the schedule. The first four weeks should be used to acclimatise the reference microphones to their laboratory environment and to carry out measurements. During the fifth week, the participating laboratory must finalise their measurements and despatched the microphones to the next participant or back to NPL, so that they are received by the start date assigned to the next laboratory, as indicated in the timetable.

It is essential that the microphones are passed on to the next participating laboratory or back to NPL on time even if measurements are not complete. If an individual laboratory has difficulty with their allocated time, it may be possible for two participants to exchange their place in the timetable.

The microphones will return to NPL for an interim calibration, typically after calibration by two participating laboratories. This is so that the stability of the devices can be monitored and so that results from different laboratories can still be compared should a change occur.

In the event of one of the microphones failing then NPL will find a substitute, though this may make the analysis of the results more complicated.

C1b Total person months for this work package:

WP number	NPL	LNE	CEM	PTB	INRiM	METAS	UME	BIM	DMDM	SP	BEV	NIS	TOTAL Σ
WP1	2	1	1	1	1	1	1	1	1	1	1	1	14

C1c: Deliverables List

WP number	Task	Deliverable description	Lead Partner	Other Partners	Delivery date
WP1	D1.1	Preparation phase – creation of protocol	NPL		March 2013
	D1.2	Registration with CCAUV and EURAMET	NPL	CCAUV, EURAMET	May 2013
	D1.3	Protocol KCWG circulation	NPL	KCWG	May 2013
	D1.3	Measurement phase	NPL	LNE, CEM, PTB, INRiM, METAS, UME, BIM, DMDM, SP, BEV, NIS	September 2013 – March 2015

C2 – WP2: Draft A - NPL

C2a: Description of work

The pilot laboratory will undertake to analyse the microphone stability data and the data received from the participants. The preliminary results will then be communicated to the participants in the form of a Draft A report. The process is described in detail in section 4.7 of *Measurement comparisons in the context of the CIPM MRA (CIPM MRA-D-05)*.

Key comparison reference value

The determination of the Key Comparison Reference Values (KCRV) is an important outcome of this key comparison. These may be determined from the overall grand mean with no weighting. This is fine for normally distributed data where individual estimates of overall uncertainty are very similar, but there may be problems with anomalous results from one participant. It is the responsibility of the pilot laboratory to identify anomalous results and notify the participant according to CIPM Guidelines. The criteria that will be used for this purpose is the use of figures of merit.

There are various approaches to deal with this situation including using weights according to the reciprocal of the estimated uncertainty (or its square) or even using a 'Median' approach. The relative merits of these approaches depend on the statistics of the distribution of results and their uncertainties. Initially the approach taken by CCAUV.A-K5 was to use a weighted mean, and it is anticipated that this EURAMET.AUV.A.K5 key comparison will do the same, but the approach may change depending on the statistical nature of the data.

The guidelines for key comparisons deal with the principles of this issue and sets out useful procedures but does not provide a solution if anomalies remain. The BIPM guidelines will be followed initially but if a problem remains, the participants will decide how to deal with this situation prior to completing the final report.

The pilot laboratory also intends to apply Reference Curves in reporting the results of this key comparison in accordance with the reporting of CCAUV.A-K5. Measurements made at 1/3-octaves can be analysed in relation to the Key Comparison Reference Curve (KCRC) at discreet points.

C2b Total person months for this work package:

WP number	NPL	LNE	CEM	PTB	INRiM	METAS	UME	BIM	DMDM	SP	BEV	NIS	TOTAL Σ
WP2	3												3

C2c: Deliverables List

WP number	Task	Deliverable description	Lead Partner	Other Partners	Delivery date
WP2	D2.1	Analysis of microphone stability data completed.	NPL		June 2015
	D2.2	Analysis of participants' measurement data completed.	NPL		July 2015
	D2.3	Draft A report written.	NPL		July 2015
	D2.3	Draft A report circulated and comments from participants received by NPL.	NPL	LNE, CEM, PTB, INRiM, METAS, UME, BIM, DMDM, SP, BEV, NIS	September 2015

C3a: Draft B - NPL

After receipt of comments on Draft A from the participants, the pilot laboratory shall produce further versions of Draft A (A1, A2... etc.) until the report is approved by all the participants and is renamed 'Draft B Report'. These later drafts may contain a more sophisticated statistical analysis of the data, than the original Draft A. Draft B shall then be circulated to the WG and then the CC for their approval, before being renamed as the 'Final report'.

C3b Total person months for this work package:

WP number	NPL	LNE	CEM	PTB	INRiM	METAS	UME	BIM	DMDM	SP	BEV	NIS	TOTAL Σ
WP3	2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	7.5

C3c: Deliverables List

WP number	Task	Deliverable description	Lead Partner	Other Partners	Delivery date
WP3	D3.1	Draft A1	NPL		June 2015
	D3.2	Circulation of Draft A1	NPL	LNE, CEM, PTB, INRiM, METAS, UME, BIM, DMDM, SP, BEV, NIS	July 2015
	D3.3	Draft A2 (Note this is an iterative process and may require additional versions)	NPL		September 2015
	D3.4	Circulation of Draft B	NPL	KCWG, CCAUV	September 2015
	D3.5	Finalisation of report	NPL	KCWG, CCAUV	October 2015

C4 – WP4: Dissemination, Exploitation and Knowledge Transfer activities - NPL

C4a: Description of work

Transfer of the KCRV and/or KCRC to the KCDB. Publication of the final report.

C4b Total person months for this work package:

WP number	NPL/BIPM	TOTAL Σ
WP4	1	1

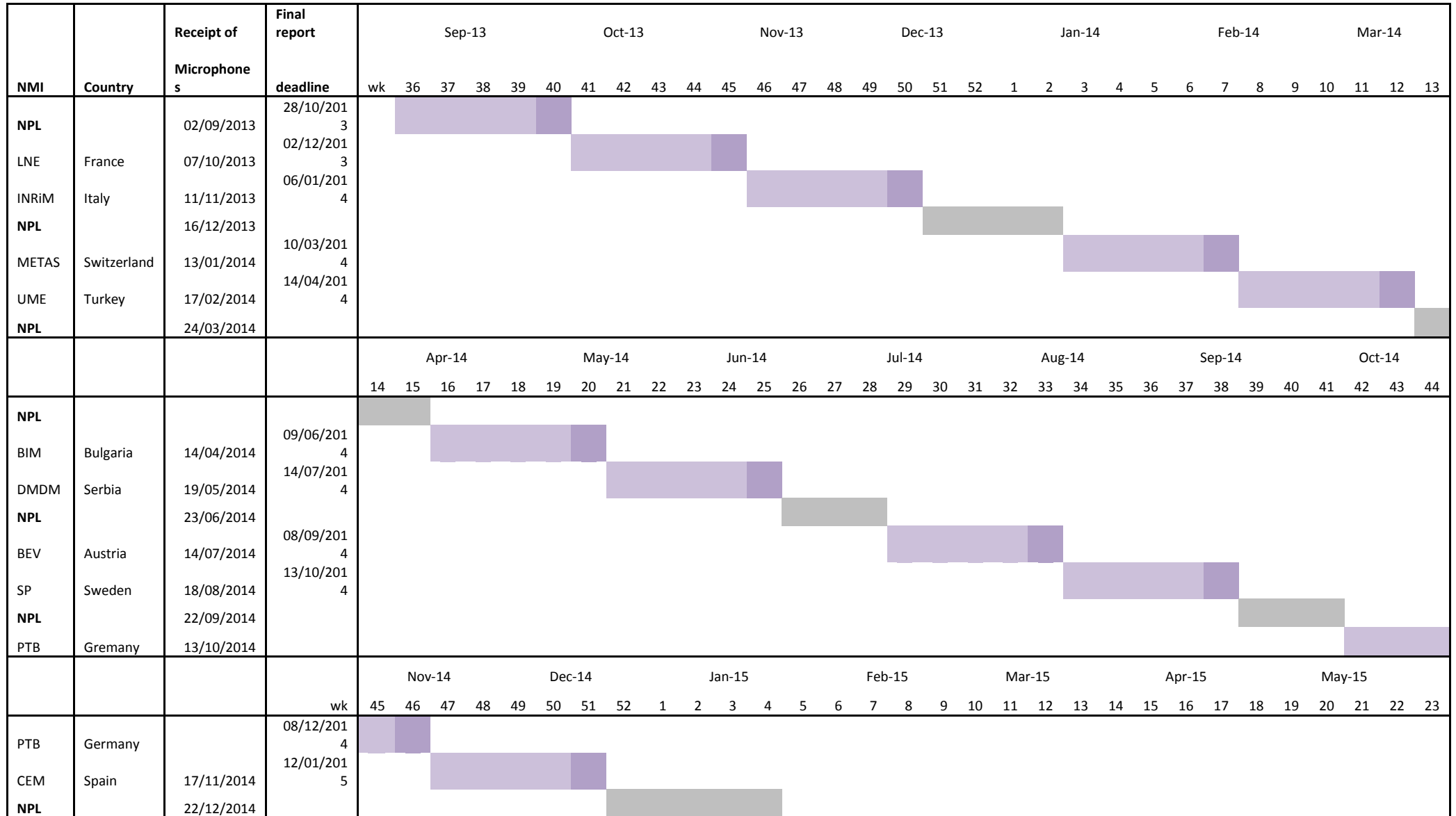
C4c: Deliverables List

WP number	Task	Deliverable description	Lead Partner	Other Partners	Delivery date
WP4	D4.1	Publication of final report.	NPL		November 2015
	D4.2	Liaison with BIPM to publish KCRVs/KCRC and degrees of equivalence in the KCDB.	NPL	BIPM	November 2015

D – Summary deliverable list

WP number	Deliverable number	Deliverable description	Lead Partner	Other Partners	Delivery date
1	D1.1	Preparation phase – creation of protocol	NPL		March 2013
1	D1.2	Registration with CCAUV and EURAMET	NPL	CCAUV and EURAMET	May 2013
1	D1.3	Protocol KCWG circulation	NPL	KCWG	May 2013
1	D1.3	Measurement phase	NPL	LNE, CEM, PTB, INRiM, METAS, UME, BIM, DMDM, SP, BEV, NIS	September 2013 – March 2015
2	D2.1	Analysis of microphone stability data completed.	NPL		April 2015
2	D2.2	Analysis of participants' measurement data completed.	NPL		May 2015
2	D2.3	Draft A report written.	NPL		May 2015
2	D2.3	Draft A report circulated and comments from participants received by NPL.	NPL	LNE, CEM, PTB, INRiM, METAS, UME, BIM, DMDM, SP, BEV, NIS	June 2015
3	D3.1	Draft A1	NPL		June 2015
3	D3.2	Circulation of Draft A1	NPL	LNE, CEM, PTB, INRiM, METAS, UME, BIM, DMDM, SP, BEV, NIS	July 2015
3	D3.3	Draft A2 (Note this is an iterative process and may require additional versions)	NPL		September 2015
3	D3.4	Circulation of Draft B	NPL	WG, CC	September 2015
3	D3.5	Finalisation of report	NPL	WG, CC	October 2015
4	D4.1	Publication of final report.	NPL		November 2015
4	D4.2	Liaison with BIPM to publish KCRVs/KCRC and degrees of equivalence in the KCDB.	NPL	BIPM	November 2015

E – Timetable for EURAMET.AUV.A-K5



NIS	Egypt	26/01/2014	23/03/2015	5	
NPL		02/03/2015	30/03/2015	5	
Reports					Prepare Draft A

* It is the responsibility of the laboratory in possession of the reference microphones to ensure that they reach their destination by the date indicated

F –Project Resources

F1 - Summary of labour resources per work package in person months

Work package	Institute												TOTAL
	NPL	LNE	CEM	PTB	INRiM	METAS	UME	BIM	DMDM	BEV	SP	NIS	
WP1	2	1	1	1	1	1	1	1	1	1	1	1	13
WP2	3												3
WP3	2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	7.5
WP4	1												1
TOTAL person months	8	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	24.5

Annex 1: Participants

This protocol is necessarily based upon the preceding CCAUV.A-K5 key comparison. A questionnaire was circulated ahead of preparing this protocol and the laboratories listed below responded, detailing their capabilities.

Responding		Frequency step				Full/Partial Scope
NMI	Country/Economy	1/3	1/12	LF	Phase	
BEV	Austria	●	●	●		○
BIM	Bulgaria	●				○
CEM	Spain	●	●	●	●	●
DMDM	Serbia	●	●			○
INRIM	Italy	●	●		●	○
LNE	France	●	●	●	●	●
METAS	Switzerland	●	●	possibly	●	○
NIS	Egypt	●				○
NPL	UK	●	●	●	●	●
PTB	Germany	●	●	●	●	●
SP	Sweden	●	●		●	○
UME	Turkey	●	●	to 10 Hz only		○

● preferred frequency resolution ● Participation in full scope
● acceptable frequency resolution ○ Participation in partial scope

Contact details

Institute	Contact Name	Address	Tel	Fax	e-mail	Notes
BEV	Peter Rosenkranz	BEV Laboratory for acoustics and vibration Arltgasse 35 1160 Wien Austria	+43 1 21110 6515	n.a.	peter.rosenkranz@bev.gv.at	
BIM	Marin Chushkov	Bulgarian Institute of Metrology (BIM) 52-B, G.M. Dimitrov Blvd., 1040 Sofia, Bulgaria	+359 2 9702703, +359 2 8735288	+359 2 9702735	m.chushkov@bim.government.bg	
CEM	N Medina/S Ruiz	Centro Español de Metrología (CEM) C/ Alfar 2 , Tres Cantos, 28760, Madrid, SPAIN	+34918074789	+34918074807	mmedina@cem.minetur.es	
DMDM	Slobodan Zelenika	Directorate of Measures and Precious Metals (DMDM) Mike Alasa 14 11000 Belgrade Republic of Serbia	+381 11 2024 421	n.a.	zelenika@dmdm.rs	ATA Carnet required
INRIM	Claudio Gugliemone	Istituto Nazionale di Ricerca Metrologica Strada delle Cacce, 91 10135 Torino Italy	+39 011 3919626	n.a.	c.gugliemone@inrim.it	
LNE	Dominique Rodrigues	Laboratoire National de métrologie et d'Essais (LNE) Adress: 29 avenue Roger Hennequin, 78197 Trappes Cedex, France	+33130691487	+33130691234	dominique.rodrigues@lne.fr	

Institute	Contact Name	Address	Tel	Fax	e-mail	Notes
METAS	Christian Hof	Federal Institute of Metrology METAS Lindenweg 50 3003 Bern-Wabern Switzerland	+41 58 387 07 50	n.a.	christian.hof@metas.ch	
NIS	Hany Amir Shawky	Acoustic Department Electroacoustic Laboratory National Institute for Standard (NIS) Tersa St. El Haram, Giza, Egypt P.O. Box 136 Giza- code 12211	+20 002/01005242090	+202/333867452	hanysho@yahoo.com	ATA Carnet required
NPL	Janine Avison	F10-A2 National Physical Laboratory Hampton Road Teddington Middlesex TW11 0LW, U.K.	+44 20 8943 6706	n.a.	janine.avison@npl.co.uk	Pilot laboratory
PTB	Thomas Fedtke	Physikalisch-Technische Bundesanstalt, Braunschweig Bundesallee 100 D-38116 Braunschweig	+49 531 592 1511 +49 174 6986502	+49 531 592 691511	Thomas.Fedtke@ptb.de	
SP	Håkan Andersson	SP Sveriges Tekniska Forskningsinstitut SP Technical Research Institute of Sweden Akustik / Acoustics Box 857, SE-501 15 Borås, Sweden	+46 (0)10 516 50 00, +46 (0)10 516 54 23	+46 (0)33 13 83 81	hakan.andersson@sp.se	
UME	Enver Sadikoglu	TÜBİTAK Ulusal Metroloji Enstitüsü (UME) TÜBİTAK Gebze Yerleşkesi Barış Mah. Dr.Zeki Acar Cad. No:1 41470 Gebze-KOCAELİ, TURKEY	+90 262 679 5000 - 2044	+90 262 679 5001	enver.sadikoglu@tubitak.gov.tr	ATA Carnet required

Agreement to participate

Agreement to participate in EURAMET.AUV.A-K5

Name and address of laboratory

Contact person

Name:

E-mail:

Phone:

Methodology

IEC 61094-2:2009

Other (please give details in Additional Information below)

Scope

Frequency range	Sensitivity level	Sensitivity phase
2 Hz - 20 Hz (1/3 octaves)		
20 Hz - 10 kHz (1/3 octaves only)		
20 Hz - 10 kHz (1/12 octaves)		

Will you require an ATA Carnet?

Yes

No

The proposed date for participation is acceptable

Additional information (please mention any planned use of gas other than air)

[Please return this form to janine.avison@npl.co.uk](mailto:janine.avison@npl.co.uk)

The pilot laboratory has distributed this form electronically to participating laboratories. A further copy is available by contacting janine.avison@npl.co.uk

The completed form shall be returned to the pilot laboratory by 2 September 2013.