**TC-Chair Annual Report 2013/2014
TC-IM (Interdisciplinary Metrology)**

20 May 2014

1. General aspects

At the Euramet General Assembly in 2010, new Terms of Reference have been defined. New actions was defined, regarding the needs of all Euramet members, with the input of the BoD. TC-IM should report on the on going actions to the EURAMET BoD. Taking into account the priorities given by the BoD and proposed subjects to start, from the last EURAMET General Assembly, two meetings of TC-IM were held at UME (Turkey) in October 2013 and in Berlin (Germany) in March 2014.

2. Main issues

After the last TC-IM meeting in March 2013, it was agreed to draft a paper to the attention of the BoD summarizing possible TC-IM. This paper was highly appreciated by the BoD and welcomed positively the proposal to work on specific topics regarded as of importance. The proposed activities have been presented to the EURAMET General Assembly in 2013.

The topics of importance being identified (*see appendix 2*), during the meeting of October 2013, it has been decided to constitute small groups for each topic to set the objectives, the target, to define a timetable in order to give quick feedback to the BoD and to the General Assembly.

The proposed groups are as follows :
- CIPM MRA : Christian Bock, Robert Edelmaier, Ionel Urdea Marcu, Maria-Luisa Rastello, Ömer Altan, Rado Lapuh and Robert Wynands
- Smart Specialisation : Marc Pieksma, Maria-Luisa Rastello, Maguelonne Chambon, Ian Serven
- Foresight studies : Maguelonne Chambon, José Robles
- Conformity assessment : Miruna Dobre
- Guides and e-learning : José Robles, Erkan Danaci, Hans Jensen, Ian Serven, France,

This report presents the actions done from the last EURAMET General Assembly up to now on the different topics.

- ***CIPM-MRA / JCRB matters***

- Considering the content of the CIPM MRA, its evolution from 1999 up to now, the increased number of laboratories involved and the workload of each RMO, some actions were proposed to improve what can be done within EURAMET from the CIPM MRA.

TC-IM gave an input for the EURAMET position paper presented at the last JCRB meetings "towards a sustainable CIPM MRA". Comments are waiting from the other RMOs.

Whatever, and more generally, the CIPM MRA is a high level topic since the *Conference Générale des Poids et Mesures* will take place in Versailles in 2014 and that BIPM sent a

CIPM MRA resolution on "importance of CIPM MRA, and to incite Member states to give input for a more sustainable CIPM MRA".

The CIPM will create a sub-group to work on this topic, and the resolution mentions that « all signatories of the CIPM MRA to support and participate actively in the activities and work of the sub-committee on the CIPM MRA.

The main outcome is that despite great confidence in the CIPM MRA which is recognized and used, the CIPM MRA created 15 years ago is no more sustainable at the present time. The challenge is now to adapt CIPM MRA to today's expectations of customers.

EURAMET considers as a priority to work on this subject, and the TC-IM group, leaded by Christian Boch, Director of METAS/CH, prepared a paper which will be presented at the EURAMET General Assembly in June 2014 (during the joint BoD and TC Chair meeting - see agenda .TB08.08) and during the plenary session (see agenda G08.07) :
"*Making the CIPM MRA sustainable: MRA Phase II*".

The TC-IM group analysed the whole mechanisms, the time consuming for CMC review and inter-laboratory comparisons, and elaborated different proposed solution for the "evolution" of CIPM MRA processes.

- Another big issue related to the CIMP MRA process, is the organisation, participation, and time schedule of inter-laboratory comparisons.
Taking into account the time frame of some inter-laboratory comparisons, TC-IM proposed a "guidance rule document" on ILC, complement to the guidelines for CIPM key comparisons, to agreed on a realistic timetable, in view to get the ILC completed in a « reasonable time », to be useful for the CMC review process.

EURAMET is presently responsible for 138 keys comparisons and of 142 supplementary comparisons. Exchange should be done with TC Chairs to see if there is an interest to implement such a guidance.

- ***Smart Specialisation***

The BoD expects inputs on what can be developed, where are the competences and to try to identify "excellence" niches. On another hand, in the frame of EMPIR, development of Excellence Centres is under discussion (like for Mathematics & Statistics or Smart Grids) to enable research beyond the capabilities of single institutes, to coordinate national metrology research programmes leading to a balanced metrology infrastructure in Europe.

Clearly, the "smart specialisation" topic is a sensitive topic. .

As regard to Smart Specialization, during the meeting held in Turkey, it was agreed to establish a landscape on where are the competences, to try to identify "excellence niches" and the metrology future needs. It was decided to set up a quick survey among the different countries.

Marc Pieksma VSL/NL, leads the group.

The brief questionnaire was as follows:
- What country/NMI do you represent?
- What are the main (current and or future) national needs in your country regarding metrology?
- What metrology (sub)fields does you national metrology institute want to strengthen through international, collaborative R&D?
- What initiatives should be taken (European Metrology Centres, EURAMET Task Groups, etc.)?

This questionnaire has been sent to TC-IM contact persons to get a First idea. For the moment a few answers have been received. But it will be interesting in particular to see what could be proposed in "Capacity Building" actions in the frame of EMPIR, in particular for emerging countries.

A second proposal was to try to get a European landscape on traceability. TC-IM group will work in 2014 on these two items.

- *Conformity assessment*

TCs provide technical guides which are sometimes neither followed nor promoted, whereas EURAMET's guides should be recognized and implemented by all countries.

Another point can be the improvement of relationship with Conformity assessment bodies, and to see what are the possible common actions / best practices which can be proposed. Miruna Dobre SMD/BE, proposed to set up a group to discuss this topic and to see how to deal with it.

TC-IM group can worked on a first area, accreditation : a mapping on that point should be made and then an action with EA would then be a second step. Miruna Dobre will draft an half page on that topic, submit it to TC-IM Contact persons for internal review and analysis before taking any decision.

- *Interactive e-learning*

The TC-IM group leads by José Robles – CEM/ES elaborated the two first modules on interactive e-learning. This was presented at the last EURAMET General Assembly (see the proposed e-learning content *in Appendix 1*).

The next step proposed is to develop the Module 3, on "Mathematics and Statistics". This means that more volunteers are needed to develop this Module 3, to have persons who can contribute from some NMIs/DIs.

Considering the work to be done, alternatives have to be found to develop such a module:
- to have this topic transformed as a PRT as part of the Capacitiy Building
- to create a platform on which modules will be uploaded. The main constraints are, on the one hand, to have it created and, on the other hand, to generate materials on different issues relating to metrology. This means that we not only need people to work on it but also to find a financing

TCs can help to provide examples and more specifically the FG on "mathematic and statistics"

It was agreed that by the end of 2014, a draft should be available.

3. Projects

Ref.	Starting date	Title	Coordinating Institute	Status	Collaboration Type	TC-Chair Comments
1298	2014-01-01	Future of the CIPM MRA	METAS	agreed	traceabillity	
1237	2012-07-31	Calibration of Short Gauge Blocks by Mechanical Comparison	UME	agreed	consultation	More the topic of TC-L...
1148	2010-03-23	Follow up on the COordination of NANOMETrology in Europe, Co-Nanomet	DFM	agreed	comparison	Should be completed ?
1078	2008-11-01	Development of methods for the evaluation of uncertainty in dynamic measurements	PTB	agreed	research	Forthcoming 8th workshop at INRIM, Italy, in spring 2014.
1026	2006-12-31	Metrology Knowledge Transfer in the European Metrology Research Programme[1]	SP	agreed	consultation	Should be completed ?
1001	2007-07-02	Agreement of traceability in measurement fields	MIKES	agreed	traceabillity	on-goping project on traceability
567	2000-03-01	International measurement software library (EUROMETROS)	NPL	agreed	research	Should be completed ?

4. Any other business

A new TC-IM Chair has been elected: Robert Edelmaier from BEV / Austria, for the period June 2014 - May 2016.

I take this opportunity to thank all the TC-IM Contact Persons for the work done, for their unconditional support, and the very good ambiance and fruitful discussions we had during these four years. I also thanks Sylvie Le Roy LNE/FR for her assistance.

My best wishes to Robert.

Maguelonne CHAMBON, LNE
EURAMET TC-IM Chair

28 May 2014

APPENDIX 1
Proposed e-learning course

Outline

Module 1: Metrology and its impact on Society

Unit 1
- § Brief history of metrology
- § Needs for Metrology
- § Division of Metrology
- § Technical Areas
- § Metrology field of activity and its benefits

Unit 2
- § International Organisms and MAS Infrastructure.
- § CIPM-MRA
- § R&D+i in Metrology
- § Present and future of metrology in Europe. EMRP/EMPIR

Module 2: General concepts. International System of units

Unit 3: Definitions and concepts
- § Quantities and units
  - – Measurement quantity, system of quantities, base quantity, derived quantity, quantity dimension, quantity value, true quantity value, conventional quantity value
  - – Measurement unit, symbol for units, base unit, derived unit, system of units (construction, choice of base units), decimal multiples and submultiples of SI units
- § Measurements
  - – Measurement, measurement principles, measurement method, measurement procedure, measurand, influence quantity, measurement signal
- § Measurement results
  - – Results, indication, measurement accuracy/precision, repeatability, reproducibility, measurement errors , measurement uncertainty, correction
- § Measuring instruments
  - – Measuring instrument, main components of an measuring instrument, material measure, measuring chain, measuring system, indication range, scale interval, range of a nominal indication interval, scale, adjustment.
- § Characteristics of a measuring instrument
  - – Nominal range, measuring interval, nominal value, measuring range, reference operating condition, characteristic output, sensitivity, discrimination threshold, resolution, deadband, stability, transparence, drift, step response time, accuracy, accuracy class, measurement trueness
- § Standards
  - – Measurement standard, types of measurements standards, measurements standard hierarchy, traceability, calibration, verification, test, reference material, maintenance and dissemination
- § Documents
  - – Technical specification, standard, technical reglament
- § Actions and procedures
  - – Certification/ approval, inspection, calibration, verification, accreditation/authorization, qualification, audit

Unit 4: International System of Units, SI

- § Historical unit system predecessors of SI
- § SI base and derived units. Decimal multiples and submultiples
- § Units with special names and symbols;
- § Units outside the SI
- § Non-SI units accepted for use with the SI
- § Units for dimensionless quantities
- § Rules for writing unit symbols and names, quantities and numbers
- § Advices for the correct use of SI in technical documents

Module 3: Statistics and uncertainty evaluations

Unit 5

- § Sampling – Sampling theory
  - – Probability sampling.
  - – Simple random sampling: estimate, sampling error, confidence level, sample size.
- § Statistics concepts. Random variables: discrete and continuous.
  - – Probability distributions: Gaussian, Chi-square,   t-student, F of Fisher-Snedecor, uniform.
  - – Central limit theorem.

Unit 6

- § Basic concepts on uncertainty of measurement estimation:
  - – Reference documents: GUM, EA4/02, EURACHEM...
  - – Uncertainty evaluation type: Type A evaluation and type B evaluation.
  - – Law of Propagation of uncertainties: Propagation of uncertainties in direct and indirect measurement
  - – Main sources of uncertainty in a measurement: uncertainties due to lack of repeatability. resolution or discrimination uncertainties. uncertainties in standards or in calibration equipment. uncertainties associated with drift during a lapse of time. uncertainties due to the equations, uncertainties due to operator error, ...
- § Correlation and linear regression
  - – The structure of the regression models
  - – Estimation of the parameters of simple linear regression model. Properties of estimators. Inferences and contrasts
  - – The linear correlation coefficient and coefficient of determination
  - – Contrast of hypotheses by residual
  - – Prediction.
  - – Interpretation of results in a multiple regression example
- § Analysis of uncertainties in regressions:
  - – Propagation of uncertainties in interpolation equations.
  - – Uncertainty in different types of fits.
- § Correlated quantities :
  - – Types of correlations:
  - – Importance of correlations in the uncertainty analysis
  - – Correlation for repeatability.
  - – Correlation of intrinsic relationship between the input variables.
- Combined standard uncertainty and expanded uncertainty: effective degrees of freedom:
  - – Probability distribution of the combined uncertainty
  - – Application of Central Limit Theorem and its limitations
  - – Levels of confidence
  - – Calculation of the effective degrees of freedom according to Welch - Satterthwaite
- § Uncertainty analysis in Inter-laboratory comparisons:
  - – Degrees of equivalence between laboratories

Unit 7
- § Hypothesis test (application, limitation y examples)
  - – Introduction.
  - – Methodology of contrast.
  - – Different contrasts.
  - – Interpretation of the contrast of hypothesis and confidence intervals.
- § Application to metrology of hypothesis tests:
  - – Application in thermal metrology.
  - – Applications in dimensional metrology.

Unit 8
- § Multivariate analysis
  - – Introduction.
  - – Matrix algebra.
  - – Data matrix, vector of means and covariance matrix.
  - – Normal multivariate.
  - – Techniques for dimension reduction (analysis of main components and factorial analysis)
  - – Grouping and sorting techniques
- § Uncertainty in multivariate analysis: Applications on metrology.
  - – Different types of multivariate analysis applied to metrology
  - – Example on unit dissemination.
  - – Example on thermal metrology.
  - – Example on mass metrology.

Unit 9
- § Outlier detection
- § Design of experiment
  - – Variance analysis. An experimental model design.
  - – Principles of design of experiments.
  - – Randomized block design:
    - – Latin squares.
  - – An introduction to two-level full factorial designs.
- § Control Charts
  - – Introduction: quality control.
  - – Control charts for means and standard deviations.
  - – Control charts for proportions.
  - – Control charts for the number of events.
  - – instrument for process improvement.

Module 4: Theory of measurement and instrumentation

Unit 10: Generalities
- § Measurement methods.
- § Measuring System: measuring instruments. Sensors. Transducers.
- § Classifications of the sensors
- § Physical principles in the measure
- § General characteristics of the sensors: accuracy, precision, range, maximum capacity, repeatability, hysteresis, linearity, drift.
- § Dynamic characteristics: Zero order, first order and second order systems.
- § Response time. Response to the ramp and step input
- § Monitoring the parameters of a sensor.
- § Measurement results of a measuring instrument.

§ Calibration of an measuring instrument using another as reference standard
§ Interpretation and use of data from a calibration certificate

Unit 11: Sensor descriptions

§ Flow, and fluid level sensors
  – Positive displacement devices: Principle of measurement. Influence of environmental conditions. Obstruction devices: Principle of measurement. Discharge coefficient. Venturis and nozzles. Practical considerations
  – Drag effect flow sensors. Measuring principle and main features. Rotameters and turbines. Pressure sensors for flow measurement. Measuring principle. Mach number. Pitot tube
  – Magnetic sensors. Optical measurement of flow: basic optical effects. Laser interferometer and applications
  – Level sensors. Sensors based on electrical effects. Ultrasonic devices. Laser and radar radiation Meters. Major applications
  – Measurement of viscosity. Kinematic and dynamic viscosity. Density sensors
§ Temperature and humidity sensors
  – Temperature scales. Primary sensors of temperature. Liquid column thermometer
  – Electrical resistance transducers. Measuring principle and main features. Resistance thermometers, platinum sensors. Thermistor, NTC and PTC
  – Thermoelectric transducers (thermocouples). Measuring principle and main features. Base metal and noble metal thermocouples
  – Other electrical transducers. Optical pyrometry: Thermal radiation and emissivity
  – Relative humidity. Dew Point. Measurement of moisture in air and gases. Electric sensors
§ Sensors for measurement of radioactivity
  – Characteristics of nuclear radiation. Laws of disintegration. Particle counting. Geiger-Müller counter: Measurement principles and applications
  – Main devices of detection nuclear radiation systems: ionization chambers, photographic detectors, scintillation counters and neutron detectors
§ Vibration sensors:
  Displacement sensors:
  – Contact sensors: mechanical and electronic comparators. LVDT sensors. Main features: range, accuracy, dynamic behavior, practical applications.
  – Contactless sensors: magnetic and optical sensors. Measuring principle. Resolution. Dynamic range. Main applications
  Speed sensors:
  – Linear speed sensors of vibration. Electrodynamic sensors. Measuring principle. Frequency sensitivity and resonance behavior. Application forms. Examples of industrial use
  – Angular velocity sensors. Contact sensors: tachogenerators. Contactless sensors: optical and magnetic. Principles of operation. Dynamic behavior. Main applications
  Acceleration sensors:
  – Piezoelectric sensors. Principle of operation. Constructional features. Frequency response. Application forms. Preconditioning
  – Servo accelerometers. Principle of operation. Sensitivity to low frequency. Applications
§ Force sensors
  – Strain gauge sensors. Direct application of gages, sensors construction site. Extensometric load cells: types, fundamental characteristics.
  – Resonance sensors. Principles of operation. Sensitivity. Applications
  – Magnetic sensors. Principle of operation. Dynamic behavior. Applications.
§ Pressure sensors
  – Introduction to mechanical and pneumatic sensors
  – Resistive, magnetic, capacitive, strain gauge and piezoelectric pressure sensors. Measurement principles. Measuring ranges. Dynamic response. Assembly ways.

     – Special application to microphones
     – Introduction to vacuum sensors
- § Torque sensors
     – Measurement principles: extensometric, electromagnetic and optical sensors.
     – Contact torque sensor. Static and dynamic sensors. Installation and connection forms
     – Non-contact torque sensors: measuring transformers, high frequency wireless transmission and optical devices. Working ranges. Dynamic behavior

Unit 12: Conditioning and Control
- § Conditioners Signal: Differential amplifiers. Acquisition of data:
     – Analog and digital multiplexers
     – Analog and digital filters
     – Converters Analog / Digital and Digital / Analog. Sampling Theorem. Anti-aliasing filter
     – Data storage: storage in analog magnetic tape and digital. Storage in flash memory and hard drive
- § Transmission of signals:
     – Analog signal transmission. Maximum cabling distances. Attenuation. Requirements transmission paths
     – Digital signal transmission. Transmission in copper and optical transmission. Converters
- § Transmission protocols:
     – Fieldbus Concept
     – Determinism in communication
     – Common industrial buses: Profibus, HART, Interbus, Modbus, J Bus, Industrial Ethernet.
     – Protocol converters.
- § Virtual Instrumentation
     – Hardware support: PC, Embedded PC, Soft-PC, PC-PLC. User Interfaces
     – Communication with field instruments. Ports
     – Software Support. SCADA most common programs: In-Touch, Win-CC, Labview
     – Introduction to programming blocks in the SCADA environment.
     – Examples of controls of instrument.

Module 5: Introduction to Quality

Unit 13
- § Introduction to quality. The standardization of the quality in the industry and testing / calibration laboratories. Economic aspects of quality
- § General requirements to be satisfied by quality management systems
- § Design and development of the QMS documentation. Quality manual, procedures, instructions, etc.
- § Quality Indicators. Techniques for improving the quality

Unit 14
Standard EN-ISO 17025
- § Organization, personnel, quality management system, documents, records, management review
- § Requests, tenders and contracts, Subcontracting, purchasing services and supplies, complaints, service to the client, control of nonconforming testing or calibration work, corrective actions, preventive actions, improvements, internal audits.
- § Test and calibration methods, validation and uncertainties
- § Measurement traceability, reference materials
- § Equipment, accommodation and environmental conditions.
- § Assuring the quality: Quality control, comparisons
- § Testing/calibration records, Data control (soft. validation), reporting the results

Module 6: Metrology Laboratories

Unit 15
- § Construction and environmental requirements
- § Inter-laboratory comparison
- § Accreditation
- § Management of measurement processes and metrological confirmation of measuring equipment (EN ISO 10012)

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APPENDIX 2

Actions planned and started / to be started

Subject		Priority	Comments
A	Ensuring best practice across EURAMET		
2	Structure & distribution of competences in European metrology	1&2	smart specialisation and networking
3	Conformity assessment. To identify common subjects to be developed		legal metrology, accreditation, standardisation. e-learning tools can be common and useful for both world. To go beyond what is already existing.
B	Raising profile / proving value of EURAMET		
6	To develop some courses	2&3	- innovation courses with different tools (to force the ideas, to get some tools) - training courses (uncertainties, project management, etc... standardization, accreditation - e-learning activities - theoretical modelling and validation methods, simulation tools (should be with the mathematics group in EURAMET, which aims to establish a European infrastructure)
7	To perform foresight studies	1	e.g. - studies of metrology impact on economy, science, Society - on metrology and education (how metrology is implemented in the curricula (school, university) and programmes to propose to Government some actions (e.g. high technology, how can metrology support it by education ? etc.)

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8	EURAMET Guides	1&2	- revision and harmonisation of documents supplied by EURAMET ? to have a group and not a unique person to review with "EURAMET spirit" - generate some new guides ? to be discussed
9	Key stakeholders information	1&2	Need of cross-cutting information to allow BoD to make decision. By initiating studies (survey of industry needs), to help government to decide
10	Survey of industry needs	1&2	To set up a sub-group within TC-IM to get information
C	Supporting the BoD		
12	Pre-normative R&D	2	to help discussion on structure of EMPIR, which are not yet defined on the pre-normative aspect
14	CIPM MRA	1&2	development of a EURAMET member position regarding issue related to CIPM MRA, and considering the need for a lighter CIPM-MRA, as the actual structure is too costly, with too many ILC (sometimes never ended), too many services. Keeping the idea of maintaining and increasing the confidence and reliability in declared CMCs
15	Capacity building : regional concept of offering services	1&2	Panorama to be updated regularly