TC-Chair Annual Report 2012/2013
TC-IM (Interdisciplinary Metrology)

20 May 2013

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.
The last meeting of TC-IM was held at VSL (The Netherlands) in March 2013.

2. Main issues

From the last meeting, TC-IM, the following topics where identified as a first priority : CIPM MRA matters, and the promotion of EURAMET activities (in particular knowledge transfer, impact of some JRPs, etc).

- *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 on a possible simplification of CMC review.

- 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 promotion and dissemination*

It appears essential to develop some actions to promote EURAMET activities (including EMRP). This was initiated before EURAMET employed a Communication Officer.

In 2012, TC-IM worked on some case studies, example of projects with an "added value", which can be presented as success stories to support the EMPIR programme.
Four texts were provided to EURAMET on the following projects : "Liquified Natural Gas", "Boltzmann", "Qu-Candela" and "Long distance".

In 2011, José Robles (Spain) proposed to consider different ways of presentation, but also emphasised the fact that it will be essential for EURAMET to provide some knowledge transfer to its members. José Robles proposed to implement on the EURAMET website an interactive e-learning. The aim of this project is to offer metrology courses on a free platform, which would not be time consuming to keep it working, with a forum where people could help each others to solve problems. The target users are people from NMIs/DIs.

At the last meeting, in March 2013, José Robles (with the two other main contributors, Kostas Athanassiadis from the Hellenic Institute of Metrology and Erkan Danaci from TUBI-TAK UME), presented the first two modules.

Each module would be available for a short period of time and up-loaded on EURAMET' server. EURAMET' Secretariat would be the referee for any technical questions at the following email address : secretariat@euramet.org.

The full e-learning proposal is given *in appendix I.*

Then we will see what can be the modules to be developed.

3. Projects

1148 : Follow up on the Coordination of Nanometrology : this project should be closed.

1078 : Development of methods for the evaluation of uncertainty in dynamic measurements
    This is an ongoing project. A short report should be provided by Clemens Elster

1026 : Metrology knowledge transfer in the European Metrology Reasearch Programme
    The status needs to be check.

1001 : Agreement of traceability in measurements fields. This project is ongoing.

4. Meetings & other issues

Considering that a certain number of activities have been finalised, it has been proposed to start new activities (*see appendix 2*). A second meeting will be held in October – November 2013 to implement these activities.

Maguelonne CHAMBON, LNE
EURAMET TC-IM Chair

20 May 2013

APPENDIX I
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, Labwiew
  - 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)

APPENDIX II

Proposed TC-IM activities

Subject	Priority	Lead	Outcomes (deliverables)	Time schedule	Comments
1. Ensuring best practice across EURAMET					
Best practice in technology transfer for NMIs/DIs	1&2		Document		Panorama with practical "clues" to give advice, organise workshop, best practice exploitation of impact of JRPs, follow-up. What happen when EMRP will finish, incentive financing for actions
Structure & distribution of competences in European metrology	1&2		Document		smart specialisation and networking
Conformity assessment. To identify common subjects to be developed			Guides/Recom-mendations		legal metrology, accreditation, standardisation. e-learning tools can be common and useful for both world. To go be-yond what is already existing.
Knowledge transfer	2&3				best practices
2. Raising profile / proving value of EURAMET					
Possible studies on general EURAMET mem-ber overview	1&2				on metrology needs for countries : services, scientific, etc. Understanding our communities and working with partners to ensure delivery of continuously improving police services

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	Task	Priority				Description
	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… - e-learning activities - theoretical modelling and validation methods, simulation tools
	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.)
	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
	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
	Survey of industry needs	1&2		Questionnaire & synthesis of answers		To set up a sub-group within TC-IM to get information
	Building of existing services (connection with CMCs ?	2&3				considering what are the services existing in the countries, to see for a common use of resources (limited duplication). Collecting information could be useful. to be combined with "structure distribution of competences in EU NMIs/DIs"?

3. **Supporting the BoD**					
Pre-normative R&D	2				to help discussion on structure of EMPIR, which are not yet defined on the pre-normative aspect
Exploitation of JRP impact in term of follow-up after its ending	2&3		List of actions to be done		- For each action, to propose an action plan for EURAMET in order to increase the impact and demonstrate the benefit for Society and for advanced Science - to identify potential further actions. Potentially more the work of project managers and TC?
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
Capacity building : regional concept of offering services	1&2		Document		Panorama to be updated regularly