Mathmet Measurement Uncertainty Training Activity:

Curricula for legal metrology and accreditation

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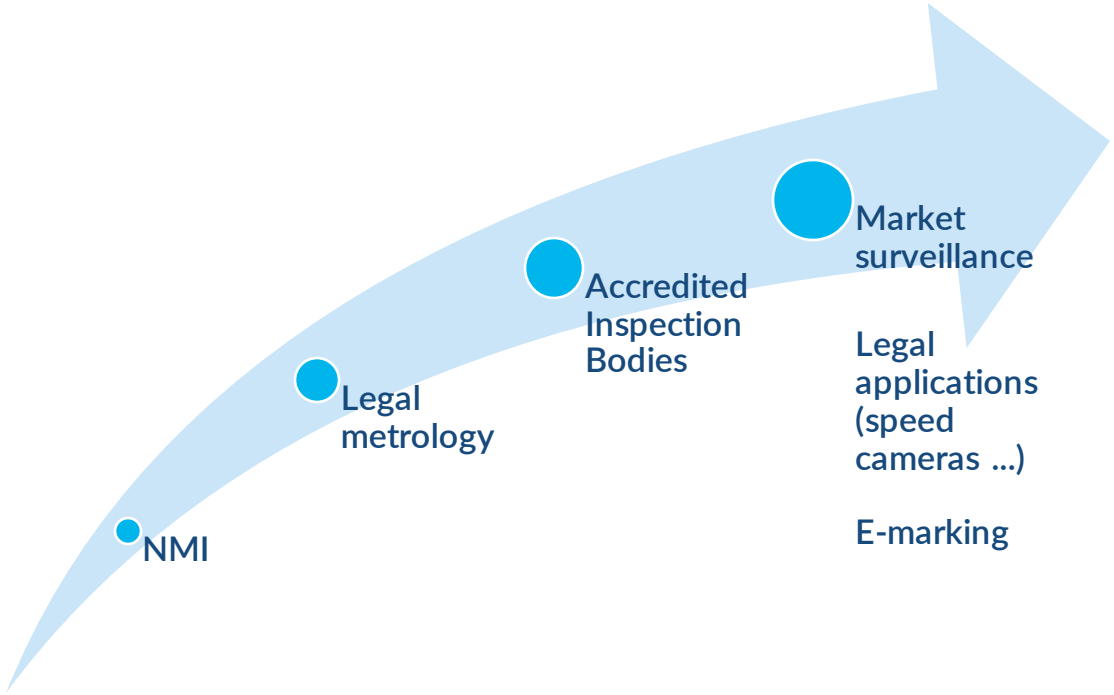
on behalf of the consortium

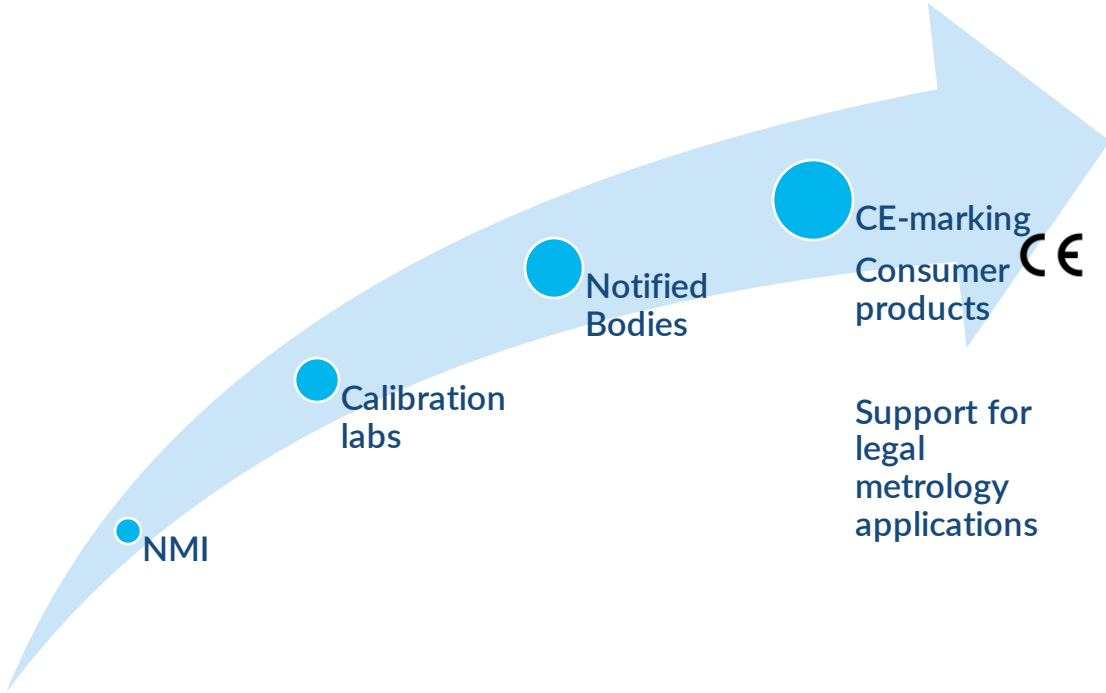
Why MU training for legal metrology and accreditation ?

- First tier of stakeholders of NMIs in the dissemination of SI units/traceability
- Legal metrology: make a legal decision based on a measurement, considering its « risks »
  → conformity assessment



Why MU training for legal metrology and accreditation ?

- Accreditation: in the context of ISO/IEC 17025
  - requirement : MU must be evaluated
  - testing : evaluation of quality of the measurement
  - calibration : also but with the idea of enabling traceability downstream



Curricul-a (-um ?) for MU training

- Address specific needs and, as well as groundings for them
- Only headlines about the content, but good starting point for structure
- Sub-audiences are also possible
- Modularity :
  - Big institutes : rich portfolio of trainings, and dependency tree
  - Smaller institutes : fewer trainings, more a table of contents
- Options for refresh courses

Metrology concepts Probability and statistics	Accreditation	testing
		calibration
		technical assessors
		laboratories
	Legal metrology	Field inspectors
		Market surveillance planners

Overview

- Method and analysis
  - Legal metrology consultation (IMBiH and IPQ)
  - Survey within the accreditation community (ACCREDIA)
- Curricula
  - Legal metrology
  - Accreditation
- Synthesis of curricula
  - Common parts vs. very specific parts

Legal metrology consultation

- Led by IMBiH and IPQ
- Consultation of WELMEC by its chairs and WG chairs
- Further discussions with some WG and direct colleagues for feedback

- MU in place for their WG's activities but what if :
  new rule, new technology, new legislation, people leave ?
- More guidelines needed for sampling within MID (modules F and F1)
- Outcome of the workshop : not always quantification needed but first to detect factors of influence

Curriculum for legal metrology

- 5 modules
  - 3 for measurement, measurement uncertainty and statistics :
    - designing a first budget of uncertainty, discussing the measurement
    - elaborating a simple budget of uncertainty
    - non-normal probability laws
    - how to read a certificate ?
  - module about conformity assesment : vocabulary, content (JCGM 106:2012)
    - conformity (yes/no decision)
    - evaluation of consumer's and producer's risks
  - module about statistical sampling : lot acceptance (→ MID modules F and F1), market surveillance.
    - more explanation, use of model curves, software

Accreditation survey

- Led by ACCREDIA
- Survey Questions/Topics elaborated by a focus group in Italy
- Circulation of the survey as a Google Form via EA.
- Analysis at Italian level and EA level (outside Italy)
- High number of responses → Enough for numerical data analysis

- 21 topics
- For each, rate 1-4: interest and knowledge
- Preferred teaching approaches
- Subanalysis in categories : (tech. assessor vs lab) X (test vs cal.)
- Significance of difference by (Wilcoxon-)Mann-Whitney test

Accreditation survey - questionnaire

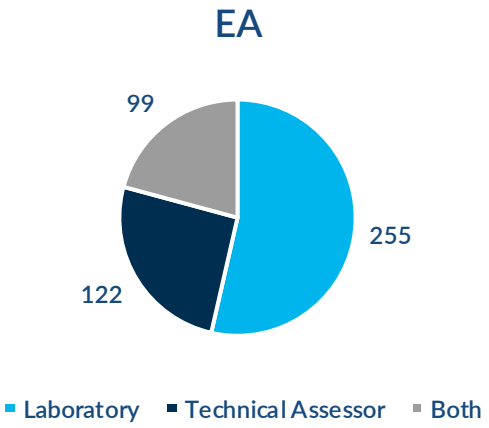
Q 1	Mathematic elements for the evaluation of uncertainty	Q 12	Monte Carlo Method for the propagation of the probability distributions applied to measurement models with more measurands (Multivariate model)
Q 2	Probability and statistics elements	Q 13	GUM approach vs Monte Carlo method in measurement uncertainty evaluation
Q 3	Fundamental concepts of metrology	Q 14	Alternative methods for the evaluation of the measurement uncertainty based on Bayesian approach
Q 4	GUM approach: evaluation of type A and type B uncertainty components	Q 15	Evaluation of measurement uncertainty based on methods validation data
Q 5	GUM approach: combined standard uncertainty evaluation with uncorrelated input quantities	Q 16	Evaluation of measurement uncertainty based on data from participation in interlaboratory comparisons/Proficiency Testing and data from practical experience
Q 6	GUM approach: combined standard uncertainty evaluation with correlated input quantities	Q 17	Fitness for purpose of evaluated measurement uncertainty and target uncertainty
Q 7	GUM approach: determination of expanded uncertainty (U) and coverage factors (k)	Q 18	Reporting measurement result
Q 8	GUM approach: application of Multivariate Measurement Models (with multiple measurands)	Q 19	“Coverage factor”, new approaches for expanded measurement uncertainty evaluation
Q 9	Definition and use of theoretical or empirical measurement models	Q 20	Evaluation of uncertainty from sampling and its contribution to the overall measurement uncertainty
Q 10	Least Squares Method applied to metrology (with or without correlation between the input quantities)	Q 21	Statements of conformity to specifications
Q 11	Monte Carlo Method for the propagation of probability distributions applied to measurement models with a single measurand (Univariate model)		

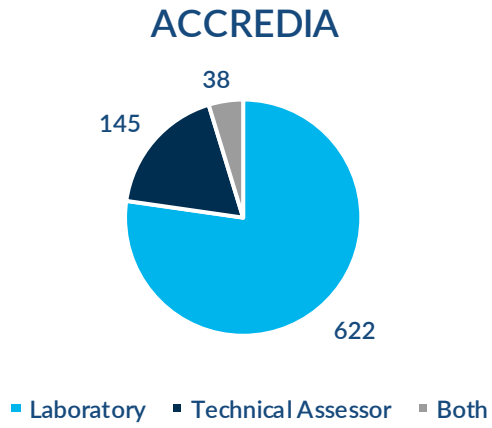
Responses to survey

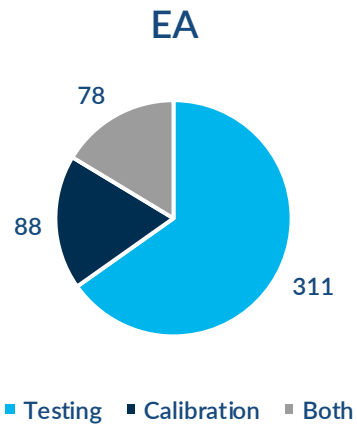
- Majority is from testing and from laboratories, for Europe (outside Italy) and Italy

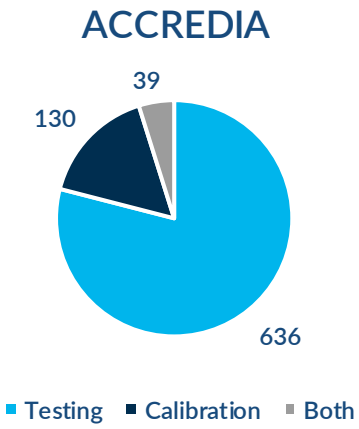
- Numbers of responses :
  - Italy : 805
  - EA (outside Italy) : 477

→ quantitative analysis possible



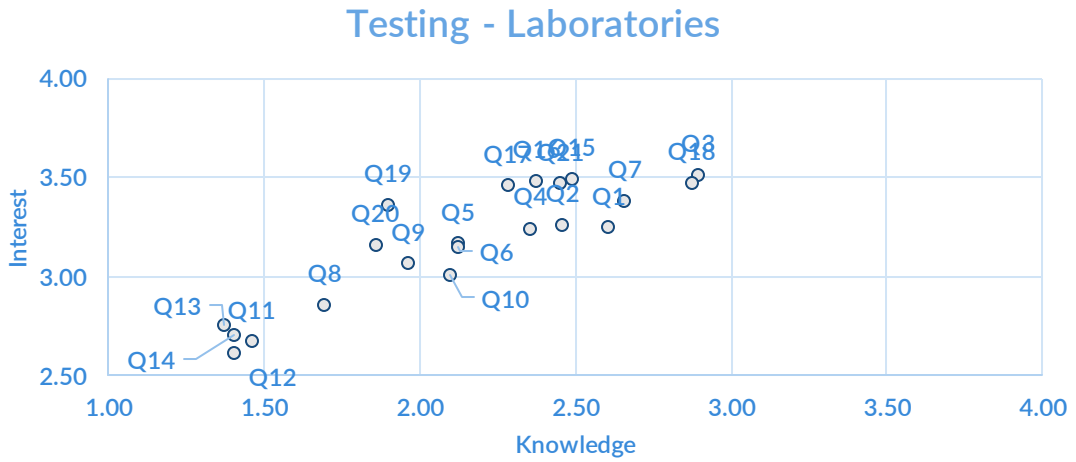


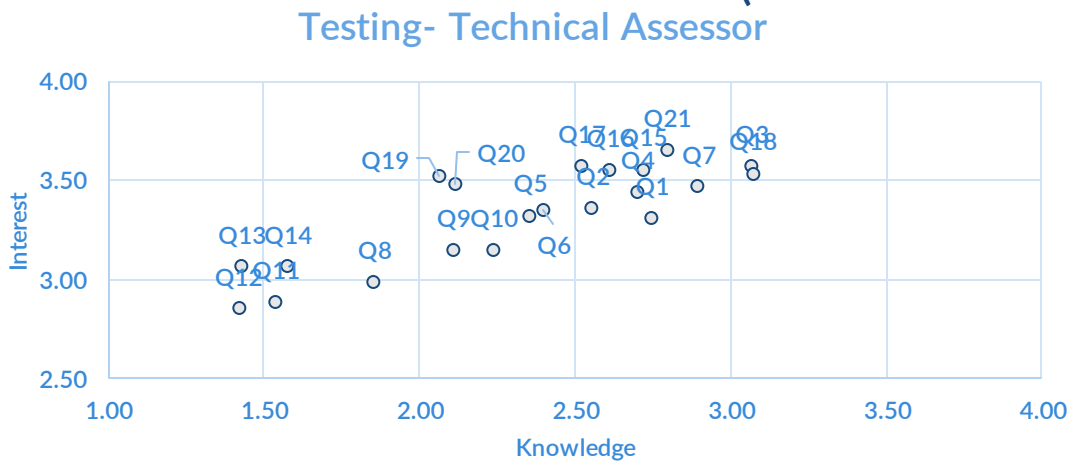


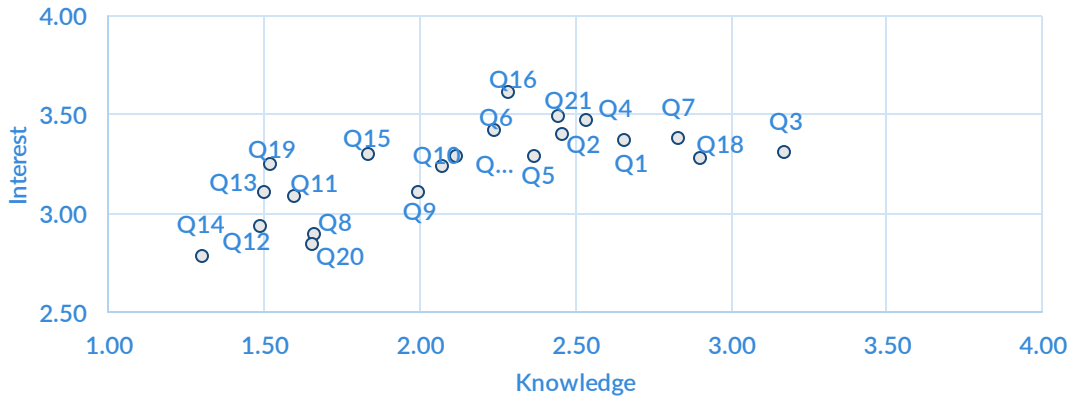


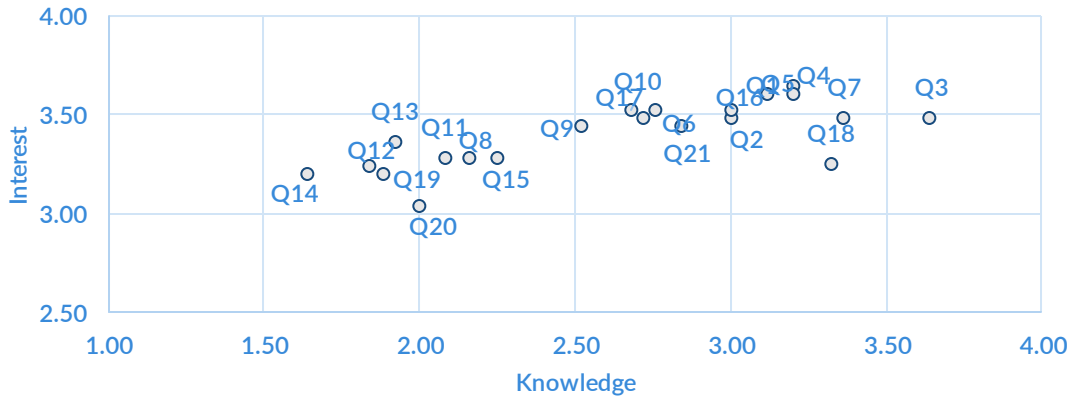
High interest and knowledge

(on results in Italy)









Mann-Whitney test

- Ordering by average and similarity testing by Mann-Whitney
- Knowledge :

ex. : Q3 :

2,89	<<	3,06	~	3,17	<<	3,64
Lab Test		Assessor Test		Lab Cal		Assessor Cal

→ Q3 «Fundamental concepts of metrology » can be split into

- « basic » (lab test)
- « intermediate » (assessors test and lab cal)
- « advanced » (assessors cal)

Grouping topics and levels

(on results in Italy)

		Homogeneous	labs test < TA test, labs cal < TA cal	labs < TA test < TA cal	labs < TA	… < TA cal	… < TA test	labs cal < …	Proposed attributions
Base mathematical concept	Q1 Q2 Q3								General concepts
Propagating uncertainties (GUM approach)	Q4 Q5 Q6 Q7 Q8 Q9 Q18								
Least squares method	Q10								More for calibration
Advanced methods : Monte-Carlo and Bayesian	Q11 Q12 Q13 Q14								
MU evaluation for specific applications	Q15								For testing
	Q16 Q20 Q21								Specific applications : one short lecture per topic
	Q17 Q19*								

Grouping topics and levels

Topic	Legal metrology (mod. Ref.)	Accreditation (Q#)	Several levels ?
Simple uncertainty budget	Module 1.1-1.2 Module 1.3 Module 1.4 1.5 Completing the uncertainty budget Reading a certificate	Q3 Q4 Q1-2 Q17 Q18 (reporting)	No (yes) (yes: lab-TA)
Measurement model and sensitivity analysis	Module 2, 3	Q5-9	No
Conformity assessment	Module 4	Q21	yes
Sampling	Module 5	Q20	yes

Specific applications

- Accreditation :
  - More calibration-oriented :
    - Q10: least squares method
    - Q11-14: cover uncertainty propagation by Monte-Carlo method and Bayesian approach
  - More testing-oriented :
    - Q15: Evaluation of measurement uncertainty based on methods validation data,
    - Q16: Evaluation of measurement uncertainty based on data from participation in ILC/PT and data from practical experience

Implementing the curricula

- Help in designing trainings, regarding content
  → for the training methodology, also combine with outcomes of the workshop (see S. Demeyer's presentation)

- Adapt the content to the audience
  → several material documents – tailor to needs each time
  → single material but adapt the presentation

- Adapt to your manpower
  → provide trainings by module or by submodule / single document

Summary

- Elaboration of curricula based on two different consultations
  - Accreditation : broad consultation by questionaire
  - Legal metrology : by consultation of WELMEC (representative)
- Some gaps have been identified, as well as current shortcomings
- Structure the training program and provide a basic table of content
- Common parts are identified

- Still work in progress, a document is being drafted.
- Many thanks to Katy and João

Questions ?

Remarks ?

Suggestions ?

Thank you for your attention !