
# EMUE

## Examples of measurement uncertainty evaluation

## Progress on current technical tasks

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Report to JCGM-WG1, Sèvres, December 2018

# EMPIR project EMUE (July 2018 – June 2021): Examples of Measurement Uncertainty Evaluation

- Promote the harmonized evaluation of measurement uncertainty according to internationally recognized standards and guides across broad disciplines of measurement
- Accomplish by providing new or improved examples to the Joint Committee for Guides in Metrology (JCGM), international standards committees, and other bodies and end-users
- Improve the use by these bodies of accepted uncertainty principles
- Many examples in a form that can readily be adapted to other areas: "Learn by example" principle
- Walter Bich: Chief Stakeholder on behalf of JCGM-WG1

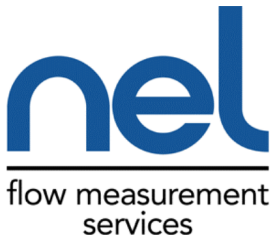
Project kick-off meeting held July 2018 at NPL

# EMUE project partners
















# Impact on relevant standards and guides 1

| Standards Committee / Technical Committee / Working Group | Partners involved | Likely area of impact / activities undertaken by partners related to standard / committee |
|---|---|---|
| JCGM/WG1<br>JCGM Working Group on the Expression of Uncertainty in Measurement (GUM) | NPL, INRIM, VSL, PTB, LNE, LGC | NPL and other partners will give an update on the examples under development and the progress made at each twice-yearly meeting of WG1 of the JCGM. Specific feedback will be sought from the representatives of the member organisations of the JCGM, namely, BIPM, IEC, IFCC, ILAC, ISO, IUPAC, IUPAP, OIML. |
| IEC/TC 62<br>Electrical equipment in medical practice | VSL | Provide material to IEC/TC 62 concerning IEC 60601, Medical Electrical Equipment and Systems, especially concerning micro flow considered in A2.3.4. |
| ISO/TC 30<br>Measurement of fluid flow in closed conduits | NEL | Provide material to support the revision of ISO 5167, which is produced by ISO/TC 30, as considered in A2.2.2. |
| ISO/TC 48<br>Laboratory equipment | IPQ | Provide material to ISO/TC 48 relating to very small volumes and flows, and also to rheology, as considered in Activity A2.3.4. This material also supports the IPQ primary standard for microflow measurement. |
| ISO/TC 84<br>Devices for administration of medicinal products and catheters | IPQ | Provide material to ISO/TC 84 relating to very small flows, as considered in A2.3.4. |

Obtaining feedback from JCGM member organizations

# Impact on relevant standards and guides 2

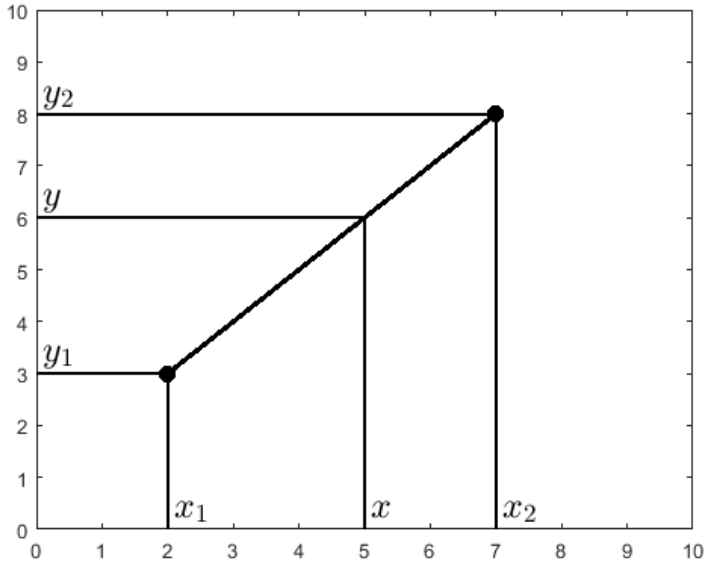
| | | |
|---|---|---|
| ISO/TC 69<br>Application of statistical methods | NPL | Report at the annual plenary meetings of ISO/TC 69 and any interim meeting on progress on the project and invite feedback. The report will be made by NPL, which provides the liaison officer between ISO/TC 69, a major ISO stakeholder for the project, and JCGM. |
| ISO/TC 158<br>Analysis of gases | VSL | Provide relevant examples to ISO/TC158 related to standards developed by this TC. |
| ISO/TC 159/SC 5<br>Ergonomics of the physical environment | LNEC | Provide material to ISO/TC 159/SC 5 related to the thermal comfort and energy-saving example considered in A2.2.5. |
| ISO/TC 164<br>Mechanical testing of metals/SC 3 Hardness | BAM | Provide relevant examples to ISO/TC 164/SC 3 relating to hardness testing as considered in A2.4.3. |
| ISO/REMCO<br>ISO Committee on Reference Materials | VSL | Provide relevant examples to ISO/REMCO taking account of correlated input quantities. |
| CEN/TC 264<br>Air Quality | VSL | Provide material to CEN/TC 264 as considered in Activity A2.1.8. |

# Progress on current technical tasks in project EMUE

# Two-point and multi-point interpolation

## [A1.1.1 (M12): UKAS, IMBiH, LGC, NPL, VSL]

- Generic treatment of 2- and $n$-point interpolation of calibration data
- Uncertainties and covariances in both variables
- Uncertainties propagated using JCGM 100
- Approach applied to two instances:
  1. pH (hydrogen ion activity) measurement
  2. Calibration of mass spectrometer leak detector
- Results given and statements made that can be carried over to examples in other areas such as thermometry




Offer results to

- JCGM-WG1 for JCGM 110
- UKAS for guide M3003 "The Expression of Uncertainty and Confidence in Measurement"

# Key comparison of gauge blocks with underpinning of CMCs

## [A1.1.5 (M12): NPL, AIST, PTB, VSL]

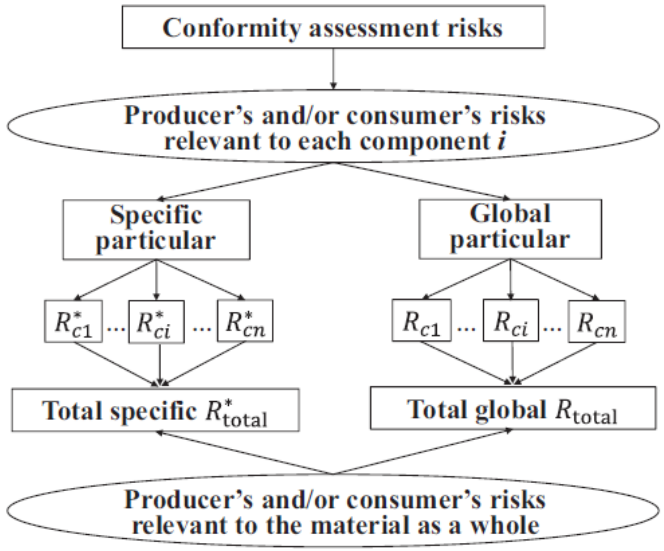
- Generic Bayesian approached developed
- Applied to KC for gauge blocks of several lengths
- CMCs: range of lengths from 175 mm to 900 mm
- Support/modify these CMCs using KC results
- Treat common measurement effects over range
- Single amplification factor for each lab
- Common correlation coefficient for each lab
- Weakness in our Bayesian approach to be addressed
- Comparison with 'conventional' approach
- AIST-NPL paper to be submitted

Offer results to JCGM-WG1 for JCGM 110 and communicate them to DAG

# Conformity assessment for multicomponent materials

## [A1.2.1 (M12): INRIM, LGC, NPL]

- MU in multicomponent materials conformity — partly based on 2017 paper
- Influenza medication contains several correlated components
- 'Total risk' of making false decision on medication sample as a whole
- Generalization of JCGM 106 'single component' treatment
- User-friendly MCMC-based MS Excel Spreadsheets developed




Offer results to

- JCGM-WG1 for JCGM 110
- IUPAC/CITAC 'Guide for evaluation of risks of conformity assessment of a multicomponent material or object due to MU'

# Conformity assessment and ISO/IEC 17025

- ISO/IEC 17025:2017: traceability provided by a statement of conformance, rather than through measurement results with associated uncertainties
- Placing new demands for accredited calibration and testing laboratories concerning use of MU in conformity assessment
- Two examples planned: UKAS and Accredia potentially to benefit
- UKAS to communicate the results to ILAC: guidance available through ILAC and other bodies needs to be brought up to date and made consistent with ISO/IEC 17025:2017

Possibly to be considered in DAG meeting on 7 December 2018

# Straight-line calibration

## [A1.1.2 (M15): PTB, BAM, IMBiH, LGC, LNE, NEL, NPL, UKAS, VSL]

- Generic treatment of straight-line calibration (least squares regression)
- Account of prior knowledge (unlike ISO/TS 28037) using Bayes
- Circumstances in which Bayesian methods have advantages over approaches in JCGM 100, 101 and 102
- Three other EMUE activities to make use of treatment
- Preliminary work carried out: simulated linear EIV regression model and performed a first Bayesian analysis using INLA (integrated nested Laplace approximations, Muff et al., JRSS C 2014).
- Promising alternative when analytic solution and MCMC not options
- PostDoc starting in January 2019 to work on activity

Offer results to JCGM-WG1 for JCGM 110

# Mass calibration example in JCGM 101

## [A1.1.3 (M15): LNE, BAM, IMBiH, IPQ, LNE, NPL, PTB, UKAS, VSL]

- General approach for measurement models with multiplicative and additive corrections to support Bayesian guide JCGM 108
- Model encompasses mass calibration example
- Marginal posteriors for normally distributed data and conjugate normal/inverse $\chi^2$ distributions
- Conversion to observation model allowing estimation of parameters of interest (measurand, variance parameters, . . . )
- Priors assigned and posterior distributions compared with GUM and GUM S1 results
- Methodology applied so far in R software to the mass calibration example for uninformative priors

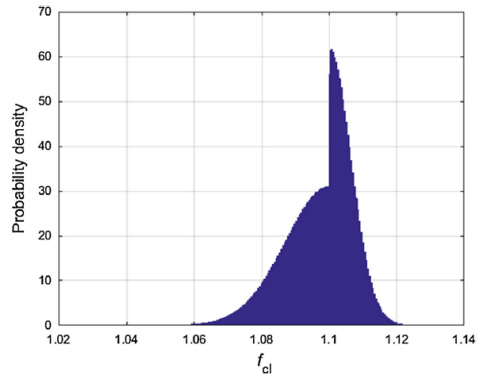
Next step: derive MCMC algorithms allowing flexibility in choice of priors

Offer results to JCGM-WG1 for JCGM 108, 110

# Energy efficiency and thermal comfort in buildings

## [A2.2.5 (M15): IPQ, LNEC, NPL]

- International Standard ISO 7730:2015: thermal indices depending on empirical formulæ
- Functions of water-vapour partial pressure, air temperature, mean radiant temperature, etc.
- Models have slope discontinuities
- No uncertainty consideration
- JCGM 100 gives misleading results
- Apply MC method of JCGM 101 and compare
- 2015 publication by IPQ, LNEC, NPL
- Proposals for ISO 7730:
  - Replace 'discrete' indices by continuous quantities to allow for thermal comfort enquiries
  - Measure of physical activity as new input quantity
- Raw data from University of Coimbra




Offer results to

- JCGM-WG1 for JCGM 110
- ISO/TC 159 responsible for ISO 7730

# Research Mobility Grant (RMG) researcher

Merima Čaušević (IMBiH) to work on project EMUE under direction of Maurice Cox under the EMPIR Research Mobility Grant scheme

- Complementary to main grant
- At NPL from September 2019
- Prepare examples in the fields of pressure and gas flow that compare GUM, Monte Carlo and Bayesian methods of measurement uncertainty evaluation
- Input anticipated from NEL and VSL

# EMUE website

http://empir.npl.co.uk/emue

Current contents:

- Introduction
- Objectives
- Project poster
- Work package outlines
- Partners
- New and events
- Publications and presentations

# Compendium

- Project to provide suite of template examples and set of worked examples facilitating users to make an informed choice about method for evaluating and propagating MU (cf. JCGM 104)
- Collated in evolving compendium in electronic form (à la JCGM 110) with updates announced on EMUE website and partners' websites
- Examples to be preceded by general introduction highlighting the general aspects of uncertainty analysis in measurement allowing the compendium to be used as a good practice guide for decision making
- To be disseminated to organizations — such as EA, Eurolab and Eurachem — and aimed at a wide target audience including staff from calibration, testing and research laboratories
- Likely to be produced in R Sweave in RStudio, requiring R and MikTeX
- Layout of examples broadly the same as for JCGM 110

# Acknowledgment


This project has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme