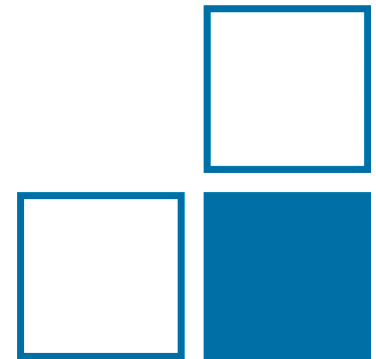


MU Training



Good practice at PTB – The classroom example

Katy Klauenberg



WG Data Analysis & Measurement Uncertainty



“Introduction to Evaluating MU According to the GUM”

audience	<ul style="list-style-type: none"> • PTB employees: (MSc, PhD) students, post docs, experienced lab personnel,... • max. 20 participants • prerequisite: basic knowledge in Math, interest in reliability of meas. results 	
key data	<ul style="list-style-type: none"> • 3x / year, 7 hours,  or , free 	
content	<ul style="list-style-type: none"> • JCGM 100 (main part), JCGM 101, 102, foundations of MU in Bayesian stats 	
material	<ul style="list-style-type: none"> • slides available in PTB & consortium 	
organiser /teachers	<ul style="list-style-type: none"> • Katy Klauenberg, Gerd Wübbeler (PTB WG Data Analysis & MU) 	
QM	<ul style="list-style-type: none"> • feedback survey after each course 	

“Introduction to Evaluating MU According to the GUM”

audience	<ul style="list-style-type: none"> • PTB employees: (MSc, PhD) students, post docs, experienced lab personnel,... • max. 20 participants • prerequisite: basic knowledge in Math, interest in reliability of meas. results 	<ul style="list-style-type: none"> • long experience teaching MU
key data	<ul style="list-style-type: none"> • 3x / year, 7 hours,  or  , free 	
content	<ul style="list-style-type: none"> • JCGM 100 (main part), JCGM 101, 102, foundations of MU in Bayesian stats 	<ul style="list-style-type: none"> • solid theoretic basis joined with hands-on running example
material	<ul style="list-style-type: none"> • slides available in PTB & consortium 	
organiser /teachers	<ul style="list-style-type: none"> • Katy Klauenberg, Gerd Wübbeler (PTB WG Data Analysis & MU) 	<ul style="list-style-type: none"> • close link between teachers & deep knowledge of MU
QM	<ul style="list-style-type: none"> • feedback survey after each course 	

PTB The classroom example

- implement in software
 - illustrates each step of evaluating MU
 - interactive, discussions evolve at each step
1. jointly specify the measurand & measurement method
length of artifact at 20°, align with standard & read difference with measuring tape
 2. jointly build and review the (non-linear) model
often C_M is missing at first
 3. characterize input quantities
Type A: each participant measures the difference
Type B: interpret EU directive for measuring tape, Wikipedia for A4 paper, ...
 4. evaluate measurement result
GUM WB, discuss uncertainty budget
discuss applicability of LPU (non-linearity, independence of observations & input quantities)
discuss limitation (expanded uncertainty cannot be derived)
 5. report results
easy export from GUM WB
 6. apply MCM (JCGM 101)
easy in GUM WB
discuss results in comparison to JCGM 100

GUM Workbench Pro - wood280422.smu

File Edit View Picture Diagram Option Tools Help

Model Observation Correlation Budget Last Result

Title Model Equation Quantity Data Partial Deriva

Equation:

$$L = (L_S * (1 + T_D * \alpha_P) + L_D + C_M) / (1 + T_D * \alpha_W)$$

Quantity	Unit	Definition
L	mm	Length of piece of wood
L_S	mm	Length of A4 paper (short edge)
T_D	K	Temperature difference to 20°C
α_P	1/K	Thermal expansion coefficient of paper
L_D	mm	Result of repeated measurements of the length difference
C_M	mm	Correction of measuring tape
α_W	1/K	Thermal expansion coefficient of wood

- Feedback
 - constantly positive for course in general (Ø 1-2 out of 5) and on examples
 - often request for more examples ↔ equally often for more theory
- Lessons learned
 - introduction round “Why do you want to apply the GUM?” to break the ice
 - emphasize demonstration purpose of example
 - carefully guide example
- The example
 - adapted from GUM H.1
 - used also for similar course for accredited labs, verification authorities (offered by DKD)
 - consortium partners use similar ones: exchange!