

Uncertainty Types

• Type A: uncertainty estimates obtained by statistical analysis of repeated measurements

• Standard uncertainty = standard deviation of repeated measurements

• Fundamentally caused by fluctuations in nature (shot noise, Brownian motion, Boltzmann statistics, etc.) that propagate through the measurement model

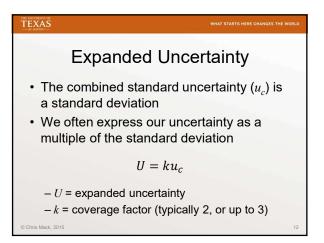
• Type B: uncertainty estimates evaluated by other techniques (scientific judgment)

• Prior experience or data, manufacturer's specs, calibration reports, reported uncertainty value

Sources of Type B Uncertainty

Incomplete definition of the measurement
Imperfect realization of the procedure
Sample is not representative
Environmental conditions
Biases in reading analog scales
Instrument resolution
Values of constants used in calculations
Changes in measuring instrument performance since last calibration
Approximations/assumptions in the measurement model

Combined Uncertainty (u_c) • Combine individual standard uncertainties (u_i) arising from Type A and/or Type B evaluation (including their covariances) $u_c^2 = u_1^2 + u_2^2 + 2cov(1,2)$ • We usually use a propagation of uncertainties approach



TEXAS

WHAT STARTS HERE CHANGES THE WORLD

Effective Degrees of Freedom

- When using the combined uncertainty, we usually assume that our measurement is t-distributed
- The effective number of degrees of freedom is given by the Welch-Satterthwaite approximation:

$$df_{eff} = \frac{\left(\sum u_i^2\right)^2}{\sum \left(u_i^4/df_i\right)}$$

 We often use this to calculate a coverage factor for a given probability (e.g., 95%)

Chris Mack, 2015