



DIP. DI INGEGNERIA INDUSTRIALE  
DAST (Doctorate in Aerospace Science and Technology)

## Uncertainty analysis for engineers

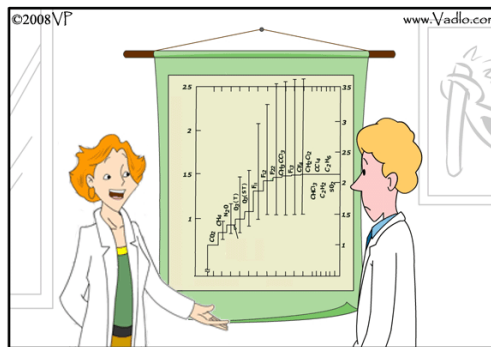
*Prof. Antonio Segalini, Uppsala University, Sweden*

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9-12 March 2026

Dipartimento di Ingegneria Industriale, Via Montaspro 97, Forlì, Italy



(picture from: <http://paul-baxter.blogspot.it/2010/06/error-bars-are-necessary-part-of.html>)

Day 1 – March 9<sup>th</sup> 11 a.m. – 1 p.m. ON-LINE - AS

### *Experimentation, Error and Uncertainty*

- Introduction (degree of goodness, uncertainty analysis)
- The experimental approach (questions and phases)
- Basic concepts and definitions (error and uncertainties, uncertainty intervals)
- Uncertainty of a measured variable: systematic (bias) error, random (precision) error, overall uncertainty
- Brief introduction to Data Reduction Equation (DRE) and sources of uncertainties
- Probability theory and statistics basics
- Definition of mean and variance of a sample population

Day 1 – March 9<sup>th</sup> 2 p.m. – 4 p.m. [ON-LINE](#) - AS

*Errors and Uncertainties in the Measured Variable*

- Gaussian distribution (measurement normalization, confidence intervals)
- Central limit theorem (statement and implications)
- Sample population confidence intervals
- Criteria for outliers' rejection
- Effect of insufficient sampling time in statistically steady measurements
- Examples
- Taylor Series Method for propagation of uncertainties (including correlation terms, sensitivity coefficients of TSM)
- Expanded uncertainty of a result
- Special functional forms in the TSM

Day 2 – March 10<sup>th</sup> 11 a.m. – 1 p.m. AULA 1.4 - AT

*Uncertainty in a Result Determined from Multiple Variables*

- Example with uncertainty which is a function of a variable
- Experiment planning (examples, comparison of two measurement techniques)
- Practical examples
- Repetition and replication (Moffat's analysis of a timewise experiment)
- Comprehensive example

Day 3 – March 11<sup>th</sup> 11 a.m. – 1 p.m. AULA 1.4 - AT

*General and Detailed Uncertainty Analysis*

- Random uncertainty (Direct vs TSM estimation)
- Systematic uncertainty (list of error sources, correlated systematic error estimation)
- Exercises on combined uncertainties
- Monte-Carlo methods with examples
- Examples of MCM
- Assignment

Day 4 – March 12<sup>th</sup> -10-12 a.m. [ON-LINE](#) - PS

*Validation of Simulations*

- Accuracy of derivatives
- Verification (algorithm) & Validation (real world comparison)
- Validation uncertainty (estimation and examples)
- Time-series uncertainty (batch methods, BMBC, maybe ARM, stationarity)

Day 4 – March 12<sup>th</sup> - 2-4 p.m. [ON-LINE](#) - PS

*Data Analysis, Regression and Reporting of Results*

- Regression model uncertainty
- Least square methods
- Uncertainties in the regression model: First model regression (conceptual - equation)
- Calibration errors

*Text book: Hugh W. Coleman and W. Glenn Steele, "Experimentation, Validation, and Uncertainty analysis for engineers", fourth edition, John Wiley & Sons, inc.*