Measurement Uncertainty

# Talking points

Traceability chain INTRO

NMIs INTRO

GUM INTRO

Accreditation Systems INTRO

Measurement Process

Input Quantities IQ

Propagation – calculating combined uncertainty PROP

Expanded Uncertainty EU

Distributions IQ

Classical/Bayesian IQ

GUM inconsistency IQ

# Introduction

MU underpins our lives. Standardised parts, international trade etc.

No measurement is perfect, how imperfect is it, how imperfect can it be?  
NMIs have to have best uncertainty to accommodate most critical requirements

NMIs set up to develop and harmonise units of measurement

Traceability chain

Accreditation systems to ensure traceability and minimise added uncertainty

GUM provides widely agreed framework for uncertainty evaluation of measurements

Used throughout this work, but not perfect and paper on inconsistencies part of chapter.

A measurement is an observation of a physical effect or quantity which provides useful information. This information, through the ages, has been used to facilitate advancement of both scientific knowledge and industrial development – from the production of standardised stone blocks to build the pyramids of ancient Egypt, to the production of standardised car parts for the Henry Ford’s Model T. In the scientific realm, advanced measurement techniques at laboratories such as CERN are used to convince the world that new subatomic particles exist.

To communicate information about a measurement, the recipient needs to be able to either make or mentally construct a similar observation to that of the original measurer (or *metrologist*). The most simple way of doing this is to provide the recipient with the same physical effect or quantity for which to make their own observation (if you require a new nut for a bolt from a hardware shop, you might intuitively take the bolt with you), however this can be inconvenient or impractical with larger objects, or if the recipient is located far away. Instead, you might substitute the physical effect or quantity with a more portable representation. For example, if you were to measure the size of a doorway to see if a new piece of furniture may fit through it, you might cut a piece of string to the same length, and use this as the representation of the width of the item. However, this approach is very wasteful and also impractical for many physical effects (temperature, flow, pressure).

The solution which is widely thought to have been established in the 3rd or 4th Millenium BC, is a system of units. In this system, a discretised value of a physical effect or quantity is standardised and knowledge of its value is disseminated to all people who wish to use it. Typically, a range of discrete values are chosen, such that the system of units can be conveniently used to represent all measurements. Knowledge of the discretised values is obtained from a “golden standard” which becomes the definition of the unit and is used to create copies of the standard which can be given to users of the unit system to perform measurements with. The most common method of performing measurements using a unit system is to use a standard to calibrate a measuring instrument, which can then be used to measure an arbitrary value of a physical effect of quantity in the units defined by the standard.



Figure : Egyptian royal cubit rod of Maya (treasurer of King Tutankhamun) 1336 – 1327 BC. The cubit is thought to have been first used in the 3rd or 4th Millennium BC.

# Input Quantities

## Type A Evaluation

## Type B Evaluation

## Multivariate Input Quantities

# Propagation Techniques

## Monte Carlo Methods

## Law of Propagation of Uncertainty

## Finite Difference Methods

# Expanded Uncertainty

# Conclusions

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