

# Ensuring Best Practice in Software and IT for Metrology

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# Outline of talk

- Software in support of modern metrology
- Validation and testing as the key to reliable results
- NPL's experience: SSfM programme
- New challenges in the metrology of networks

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# Software underpins all modern metrology

- Uncertainty calculations and the GUM
- Commercial software and in-house software
- Much embedded software in instruments
- Modelling used extensively to understand experiments
- How to ensure we can trust results? Validation is the key

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# Validation & testing is key to reliable results

- Ensure industrial and public sectors will have easy access to best practice and expertise
- Focus on real needs so that users are able to take up and benefit quickly from the outputs of the programme
- Encourage the take-up of new technologies
- Address increasing regulatory requirements for measurement systems used in safety-critical contexts to comply with IEC 61508
- Make use of the pool of expertise gathered during the previous SSfM programmes

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# The National Physical Laboratory (NPL)

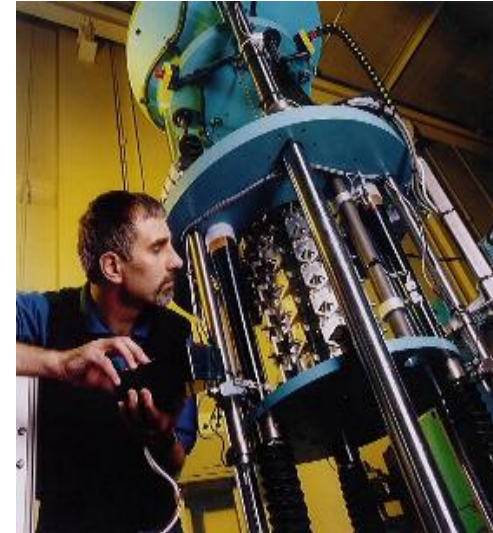
- UK's Primary Standards Laboratory
- Founded in 1900
- 570 people
  - Scientists
  - Engineers
  - Support staff
- Managed by Serco since 1995





# Expertise at NPL spans the physical, materials and life sciences

- Acoustics
- Dimensional measurement
- Electromagnetics
- Ionising Radiation
- Environmental Air Quality
- Lasers
- Mass and force
- Materials
- Thermal
- Optical communications
- Photonics
- Photometry/Colour
- Pressure
- RF and Microwaves
- Radioactivity
- Radiometry
- Scientific Software
- Time
- Physical-chemical measurements for life sciences
- Biometrology
- Nanotechnology



# Maths & Scientific Computing at NPL

- Mathematics & Scientific Computing Group (MSCG) has 13 Mathematicians, Statisticians, Software Engineers and Physicists
- The Group supports all areas of metrology in other NPL Divisions & National Measurement System (NMS) programmes
- It also supports the NPL Mathematical Modelling & Software Network
- Specialist NMS programme is Software Support for Metrology (SSfM)

# National Measurement System research programmes

## SI Unit Based Programmes

Length - m

Thermal - K

Optical - cd

VAM - mol

Electrical - A

Time - s

Mass - kg

## Derived Unit Programmes

Ionising Radiation

Acoustics

## Market Sector Focused Programmes

Materials

Flow

Photonics

Biotechnology

## National Co-ordination Programmes

Legal

Knowledge Transfer

International

UKAS

Faraday

Support Programmes

Quantum

Software support



# NPL's experience: SSfM programme

## Software Support for Metrology worth £3M (¥550M)

- SSfM: metrology, mathematics, statistics, software and theoretical physics, with strong links between the disciplines
- Promotes and develops best practice in the application of mathematics and software to metrology
- Supports NMS programmes, industry & public sector

# Four main technological themes in SSfM

- Modelling tools and techniques
- Uncertainties and statistical techniques
- Applications and supporting techniques
- Software development, testing and validation

*Details of the SSfM programme can be found at:*  
<http://164.36.164.20/nms/prog/new/ssfm0407prv.pdf>

# Modelling tools and techniques

- Best practice in discrete modelling ....
- .... and also in continuous modelling
- Data fusion techniques
- Modelling to support nanotechnology
- Visualisation and simulation
- Algorithms for discrete modelling
- User support for data fitting software

# Uncertainties and statistical techniques

- Best practice in uncertainty modelling and statistical evaluation
- Industrial uncertainty methodology
- Standards and international harmonisation, including the Guide to Uncertainty in Measurement (GUM)

# Applications and supporting techniques

- Data curation
- Good practice in signal processing
- Filtering and feature detection
- Internet-enabled metrology



# Software development, testing and validation

1. Software development best practice
2. Testing numerical algorithms and software
3. Measurement system validation

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# Software development best practice

- A new 1-day training course on development and testing of spreadsheet applications
- An updated 2-day training course on development of scientific software
- A report on 2 case studies
- Revision of Best Practice Guides

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# Data generator for algorithm testing

**NPL** The UK's National Measurement Laboratory  
National Physical Laboratory

## Data Generator for Straight-Line Least-Squares Regression

A Java Applet is provided for generating reference data sets and corresponding reference results for straight-line least-squares regression. The user supplies values for a number of inputs to the Applet, which then generates output in two windows. One window contains the reference data set and the other the reference results and auxiliary information used in the comparison of reference and test results. Guidance on using the Applet is given below.

A [procedure](#) giving instructions on how to use the output of the Java Applet for testing software for straight-line least-squares regression is provided.

Please read the [disclaimer and copyright](#) statements carefully before using the applet.

### Ordinary Straight-Line Regression (1.1)

Dataset centroid abscissa (xc)

Dataset centroid ordinate (yc)

Angle to the x-axis (alpha)

Number of points required (m)

Interval length L

Measurement error (sigma)

Random number seed (S)

#### Procedure for Straight-Line Least-Squares Regression

**Specification**

Given the data set  $\{(x_i, y_i); i = 1, \dots, m\}$  and a straight-line model  $f(x; b)$  defined by parameters  $b$ , e.g.,

$$f(x; b) = b_1 + b_2 x, \quad b = (b_1, b_2)^T,$$

the straight-line least-squares regression problem is to solve

$$\min_b \sum_{i=1}^m d_i^2,$$

where

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# Software development, testing and validation

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# Measurement System Validation

- Revision of Best Practice Guide on Measurement Systems Validation
- An updated 1-day training course on Software Validation in Measurement Systems
- An accredited software validation service to support product certification
- Workshop on safety-critical measurement software validation
- A report on 2 case studies on the application of the the guide to different metrology areas

# Knowledge transfer: a key part of SSfM

- SSfM club meetings
- Publications
- Conferences and workshops
- Website with downloadable materials
- Advice service
- Links with universities



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# Measurement for Emerging Technologies

## Primary objective

**‘To address the measurement requirements of those emerging technologies that will facilitate the introduction of new products and processes, where the UK can be competitive in a global market’**

# The MET programme

- Has a multidisciplinary approach
- Has a longer term outlook
- Is designed to have an impact on the NMIs and on UK Industry
- Identifies core target audiences

# The MET programme - themes

- Medical theme
- Advanced materials
- Manufacturing
- Energy and the environment
- Communications

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# New challenges in metrology of networks

- Increasing use of distributed measurement and distributed computing
- How does a network measurement differ from a measurement with a single instrument?
- Need to develop new methods for calibrating distributed measurement systems, especially wireless systems
- DTI's new MET programme is funding £0.5M (¥90M) project on this topic

# Network issues

- Can results be relied upon?
- Can networks be made self-validating and self-calibrating?
- Can network performance be modelled as part of validation process?
- Can we define quality of service in networks?
- We are looking for collaborators with networks which we can use as demonstrators for the new project.

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