Publishable JRP Summary Report for JRP NEW 04 Uncertainty

Novel mathematical and statistical approaches to uncertainty evaluation

Background and Need for the Project

Measurement uncertainty evaluation is fundamental to metrology. Without it, measurement results cannot be compared, either among themselves or with reference values given in specifications and standards.
Metrological traceability requires the propagation of reliable uncertainty values from primary standards provided by national metrology institutes (NMIs) to industrial end users. Unreliable evaluation of uncertainties has a vast negative economic impact.

New mathematical and statistical approaches are required to address uncertainty evaluation in many modern metrology applications, which are not explicitly covered by existing GUM guidelines. For example, uncertainty evaluation in many emerging or rapidly growing metrology applications, such as biochemical measurements and nanometrology, often poses challenging mathematical and statistical problems. There exists an unnecessarily high risk of incorrect decisions without reliable measurement uncertainty analysis. Many applications demand guidance for conformity assessment beyond current standards. The specific needs in problems demanding inverse methods and regression or computationally expensive systems require a co-ordinated effort to cope with these challenges, to ensure harmonisation and to develop a consistent application framework throughout Europe.

Objectives

The project is developping novel approaches to measurement uncertainty evaluation and aims to enable their consistent application, illustrated by appropriate case studies. The dissemination of these methods will be ensured by providing input for future revisions of the Guide to the Expression of Uncertainty in Measurement (GUM), its supplements and other relevant documents and by providing algorithms and software. It focuses on three areas where new uncertainty analysis methods are needed: inverse and regression problems, computationally expensive model functions, conformity assessment and reliable decision-making.

In addition, the project focuses on applying these methods to challenging applications where a strong need for new uncertainty evaluation methods has been identified. These include new analytical technologies for biochemistry and biotechnology (ELISA, PCR), transport processes (fluid flow, thermophysical properties of materials), industry and regulation (scatterometry, fire safety engineering, conformance testing for healthcare products). Case studies addressing these important areas are carried out in such a way that their solutions generate a large immediate impact. They will also provide template solutions that will be easy to use for other applications. Outputs from work packages include software, best practice guides, scientific papers and reports, articles in trade journals, conference presentations, and reference data sets.

The project builds on the existing network of mathematical experts active in the *EURAMET Focus Group Mathematical and Software Tools for Metrology* project and will lay the foundation for a virtual *European Centre for Mathematics and Statistics in Metrology* that will disseminate state of the art methods to European industry and organisations and ensure that the momentum developed by the project is carried forward and that impact can be realised beyond the end of the project.

EMRP European Metrology Research Programme
Programme of EURAMET
The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union

Impact

This project aims at a substantial extension of the mathematical infrastructure for metrology in Europe. Collaboration between European NMIs with mathematical and statistical expertise is essential to ensure wide take-up of the project outputs and to maintain Europe's current leading role in mathematics for metrology. The results of this project will strengthen European capabilities for innovation by enabling traceability for modern metrology and measurement techniques. Product testing, safety regulations, medical diagnosis and drug testing will be significantly improved by the procedures for reliable uncertainty evaluation, decision-making and conformity assessment to be developed in this project. Training courses provided by the *Creating Impact* work package will allow European NMIs and DIs that are not part of the project consortium to develop their capacity in the application of mathematics and statistics to challenging uncertainty evaluation problems. The planned virtual *European Centre for Mathematics and Statistics in Metrology* will be based in the first instance on the members of the current JRP-Consortium.

Application Partners and Stakeholders

At the international level JCGM Working Group 1 (JCGM/WG1) on the Expression of Uncertainty in Measurement, which represents BIPM, IEC, IFCC, ILAC, ISO, IUPAC, IUPAP and OIML, has identified the need for research in the areas of Monte Carlo methods, regression and inverse problems, conformity assessment and the application of expert and prior knowledge. Many national professional societies of engineers and accreditation bodies have recognised the need for further development of uncertainty evaluation methods. These bodies maintain specialised committees dealing with the topic of uncertainty evaluation that regularly seek advice from NMI experts. European and international associations dealing with best-practice guides to the use of computationally expensive models have started to address questions of uncertainty.

23 stakeholders have expressed their strong interest in this project. The list includes industry, universities, professional societies, regulatory bodies, international organisation and NMIs outside Europe. The stakeholders will form an *Application Partner and Stakeholder Committee* whose role of will be to ensure that the outputs of the product have clear relevance to NMI experimentalists and to industrial stakeholders and end users. Committee members will also have a key role in testing and establishing the usability of software produced by the technical work packages.

JRP start date and duration:	1 August 2012, 36 month
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