NPL
National Physical Laboratory

Counting on IT

A National Measurement Newsletter

Issue 20

Figure 1. Software is increasingly used in safety systems. The IEC 61508 standard reduces the risk of disaster by ensuring that software achieves the required Safety Integrity Level.

Contents:

No second chance

When it comes to safety-related systems, it's vital that a dangerous situation is recognised and that the appropriate corrective or preventative actions are taken. When lives are at risk, there is no room for error.

International standard IEC 61508 provides a framework in which all parties involved in implementing and operating a safety-related system can work together to achieve the desired level of safety. By following the life-cycle approach specified in the standard, safety measures commensurate with the risks can be designed and maintained to provide cost-effective protection of people, plant and the environment. While the standard specifically addresses electrical, electronic and programmable electronic systems, the principles can be applied to any functional safety system.

A key part of the standard is the concept of a Safety Integrity Level (SIL), which is applied to a safety function to indicate the degree of risk reduction that it must achieve. The target SIL needs to be set by the user of the safety system to meet the acceptable risk level in his operations. It is then up to the suppliers of the system and its component parts to demonstrate that the required SIL can be achieved under the specified operating conditions. Once the system has been installed, it must then be operated and maintained in the specified manner, to preserve its safety integrity.

One of the driving forces behind the creation of IEC 61508 was the

increasing use of software in the safety systems used in sectors as diverse as power generation, chemical processing, factory automation and railway transport systems. Part 3 of the standard is dedicated to the measures that must be taken to achieve the required safety integrity capability of the software used in elements of the safety system such as sensors, logic solvers and actuators.

Setting out to design a safety system or one of its elements to achieve a particular SIL capability is difficult enough, but providing evidence that the integrity claims have been met to the satisfaction of the user or the regulatory authority can be a problem. The CASS Scheme (Conformity Assessment of Safety Systems) has been developed to provide a conformity assessment process that achieves integrity, transparency and consistency in the end result. SS*f*M is contributing to this work and its Best Practice Guide No. 1 *Validation of Software in Measurement systems* provides helpful information for those involved in assessing safety-related measurement software. (www.npl.co.uk/ssfm/download/bpg.html)

IEC 61508 is still in the early stages of implementation and there is a growing understanding of the standard and its potential usefulness around the world. CASS is helping to provide the confidence that all those involved in the safety system lifecycle need in order to demonstrate that the necessary level of safety is being achieved.

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Evaluation of software in alarm annunciators

Alarm Annunciator Units (AAUs) are used to indicate, through lights or sounds, some malfunction of a system.

Figure 2. Typical Alarm Annunciators from *Delta-controls* (see www.delta-control.com).

AAUs are being used in safety-critical systems to deliver safety functions; and safety-critical systems in turn are being asked to comply with the international functional safety standard IEC 61508.

An evaluation was carried out by NPL to determine how closely a selection of AAUs matched the requirements of IEC 61508. The core parts of AAUs are now being implemented in software, and the evaluation concentrated on the software as this was believed to be the most challenging area of IEC 61508 compliance. A questionnaire based on Best Practice Guide No 1, *Validation of Software in Measurement Systems* (www.npl.co.uk/ssfm/download/bpg.html) was used to collect information on the quality of the developed software from telephone and face-to-face interviews.

Five AAUs being used by members of Evaluation International were selected for evaluation, one from each of five different suppliers: Selco, Delta-controls, Ametek, RTK Instruments and Omniflex.

The evaluation concluded that the software in AAUs is straightforward to implement and, with some further work on the part of the suppliers, could be certified to IEC 61508 SIL 1. Further details are available in a report, which is free from Evaluation International. (www.evaluation-international.com)

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SS*f*M training courses

The popular course ***Developing Advanced Scientific Engineering Spreadsheet Applications*** is being repeated on 14 -15 June 2007. The course looks at the advantages and disadvantages of using spreadsheets in measurement systems. Spreadsheets present issues that often make validation difficult. The course emphasises the use of sound software engineering principles in the development of spreadsheet applications and includes hands-on exercises using Excel. See *Counting on IT* issue 19 for a report on the course.

For information on SS*f*M, event details and contacts visit the website: www.npl.co.uk/ssfm

Signal processing

The new SS*f*M programme that began in April 2007 has a signal processing project entitled 'Quantitive approaches to digital signal processing in measured systems'.

We are looking for potential collaborators for metrology-related signal processing case studies. Please contact us if you are interested in working with us on these leading edge solutions.

The second signal processing seminar in the previous SS*f*M programme took place in June 2006 at NPL. It attracted an audience of 50 from a wide range of organisations, including representatives from outside the UK. The seminar concentrated on filtering, signal estimation and specific application examples. The keynote address was given by Dr Klaus-Dieter Sommer, Director of the Thuringian State Authority for Metrology and Verification, Ilmenau, Germany, and now head of the Chemiacl Physics and Explosion Protection Division of the PTB, who emphasised the importance of a model-based approach to the quantification of uncertainties arising from signal acquisition, conditioning and analysis. Peter Hessling of the SP Technical Research Institute of Sweden also spoke on the synthesis of digital correction filters. (www.npl.co.uk/ssfm/news/events/20060623)

Slides from the first seminar in November 2005 can be found at: www.npl.co.uk/ssfm/news/events/20051130

The two seminars formed part of the signal processing theme in SS*f*M-3, which also aims to produce a good practice guide on signal processing for metrologists. The intention is to make this entirely web-based, to allow us to provide links to a wide range of Internet resources that will be of use to metrologists. The new format will ensure that the guide can respond quickly to feedback from users and to new developments in signal processing. The web pages will allow users to submit questions about signal processing topics to SS*f*M staff and make suggestions for new content for the guide.

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SS*f*M publications

www.npl.co.uk/ssfm/download/ is a repository of SS*f*M publications. The table below lists the most recent documents that have been made available for download.

Title	Abstract
SS*f*M Best Practice Guide No. 6: Uncertainty Evaluation	Provides best practice in the evaluation of uncertainty within metrology, and in the support to this topic given by statistical modelling. It covers use of the *Guide to the expression of uncertainty in measurement (GUM)*, including validating the current usage of the GUM in circumstances where there is doubt concerning its applicability.
SS*f*M Good Practice Guide No. 13: Data Visualisation	Concerns good practice in the use of visualisation techniques applied to metrology data. Shows the benefits of visualisation, and gives practical advice on how to perform visualisation.
SS*f*M Good Practice Guide No. 15: Continuous Modelling	Aimed at users of continuous modelling techniques. Explains the similarities and differences between different numerical methods for solving models.
SS*f*M Good Practice Guide No. 16: Testing Algorithms and Software	The success of test methodologies is shown by the errors that have been found in widely-used packages, which can be traced to implementations of numerical routines. It covers testing software for discrete and continuous modelling, and the underlying algorithms.
SS*f*M Good Practice Guide No. 17: Distributed computing for metrology applications	Facilitates the effective use of distributed computing methods and techniques. Helps metrologists to take maximum advantage of the significant improvements in computational speed that are offered by cost-effective distributed computing.
Testing The Numerical Correctness of Software (CMSC 34/04 Revised)	Describes applying a methodology for testing numerical correctness to functions for calculating mean and sample standard deviation, straight-line regression and polynomial regression. Contains the results of testing functions from Matlab, LabVIEW, Microsoft Excel, Origin and Mathcad.

Club Members' Page

From *NMi* – Evaluating the self-adjustment routine of a commercial LCR meter

LCR meters are flexible meters for measuring complex electrical impedance over a large range of values and frequencies.

Because of their extended capabilities, calibrating them by conventional means using external standards is a challenge that is presently not met by any calibration laboratory – including the national metrology institutes. This prompted NPL and the NMi Van Swinden Laboratorium to embark on a project for evaluating the self-adjustment procedure of a specific commercial LCR meter. The aim was to find out to what extent this self-adjustment could be used in the realization of traceability. The evaluation concerned both the (metrological) hardware and the embedded software of the LCR meter. The main finding of the evaluation was that the adjustment procedure has a good potential for being the basis of a traceable calibration of the instrument, but that several elements in the software need to be improved upon. The hope is that the manufacturer will use the findings of the study to develop an improved version of the instrument.

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From *The Measurement Standards Laboratory of New Zealand* – `Assert`: a spreadsheet testing and validation tool

Many spreadsheet errors can be found and corrected by early and frequent testing during development.

The `Assert` add-in, a compiled C++ extension for Microsoft Excel, has been developed to help an author, or checker, incorporate dynamic tests and verification code into a spreadsheet. The tool makes it easy to embed the testing of programming assumptions within a spreadsheet, thereby enhancing confidence in the correctness of calculations whenever the spreadsheet is used. `Assert` provides worksheet functions to test cells and to report any failures that occur. Individual cells, or cell ranges, can be tested for logical truth, for exact equality (non-numerical values) and for numerical closeness (given a tolerance). Tests can be documented with Excel comments, which are included in the error messages. `Assert` is available at the Measurement Software Toolkit website. (http://mst.irl.cri.nz)

Editor's note: Download SS*f*M Best Practice Guide No. 7, *Development and Testing of Spreadsheet Applications* from www.npl.co.uk/ssfm/download/bpg.html

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From *SP Swedish National Testing & Research Institute* – Optimised measurement uncertainty and decision-making

In conformance assessment, a decision has to be made on whether a pre-assigned specification has been met.

Wherever there are uncertainties, there are risks of incorrect decision-making in conformity assessment associated both with sampling and measurement. A decision theory approach, earlier used in analytical measurement, where the costs of testing are balanced against the costs associated with the consequences of incorrect decision-making, is extended to more general measurements, especially legal metrology.
Examples cover the measurement of energy, fuel and environmental emissions – exemplified in the type testing and initial and subsequent verification of electricity meters, petroleum dispensers and CO exhaust gas analysers; all areas of increasing societal importance where rising costs are accompanied by the introduction of more stringent accuracy requirements. The present work is described in a journal article *Exhaust gas analysers and optimised sampling, uncertainties and costs*. (http://dx.doi.org/10.1007/s00769-006-0163-3)

The work illuminates procedures for setting and specifying tolerances and associated uncertainties, and explains common rules in conformity assessment, including the maximum permissible uncertainties and attribute sampling quality limits. It also facilitates, in general, the acceptance of conformity by both customer and supplier.

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Standard News

SS*f*M brings expertise in best practice in uncertainty evaluation, to benefit relevant metrology standards development.

British Standard Institution (BSI)

SS*f*M provides convenor and secretary to BSI committee SS/6, P*recision of Test Methods*, and SS/6 Panel 3, *Measurement Uncertainty*. A main item of SS/6 work was the initial development of a new ISO Technical Specification concerning the determination and use of straight-line calibration functions. It will provide approaches for establishing and using such functions for a variety of commonly occurring uncertainty structures associated with measurement standards (stimulus values) and instrument response. It will test the validity of a determined calibration function and predict stimulus values for unknown samples, with associated uncertainty evaluation. Such guidance will provide better-founded results than hitherto, and will benefit suppliers and users of measuring instruments. NPL and Eurachem (www.eurachem.ul.pt/) are carrying out the work jointly, under the BSI/DTI Consultancy Drafting Scheme.

International Standardization Organization (ISO)

SS*f*M provides a UK representative on ISO/TC 69, *Applications of Statistical Methods*, and provides the convenor for ISO/TC 69/SC 6/WG 7, *Statistical methods to support measurement uncertainty evaluation*. SC 6 is the subcommittee entitled *Measurement methods and results.*

Committee work included:

- Development of standards concerned with capability of detection. Search for 11843 at www.iso.org/iso/en/ISOOnline.frontpage
- Considerations relating to the progression of two Technical Specifications to full standards. These are a *Guide to the use of repeatability, reproducibility and trueness estimates in measurement uncertainty estimation* and *Measurement uncertainty for metrological applications—Simple replication and nested experiments.* Search for 21748 and 21749 at www.iso.org/iso/en/ISOOnline.frontpage
- Provision of reviews of GUM Supplement 1 (see below) Detailed consideration of a draft of the above straight-line calibration Technical Specifications.

Joint Committee for Guides in Metrology (JCGM)

JGCM promotes the use of the GUM, prepares summlemental guides for its broad application and revises and promotes the use of the *International Vocabulary of Basic and General Terms in Metrology* (VIM).

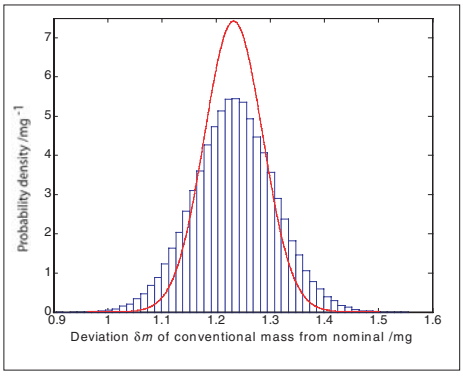
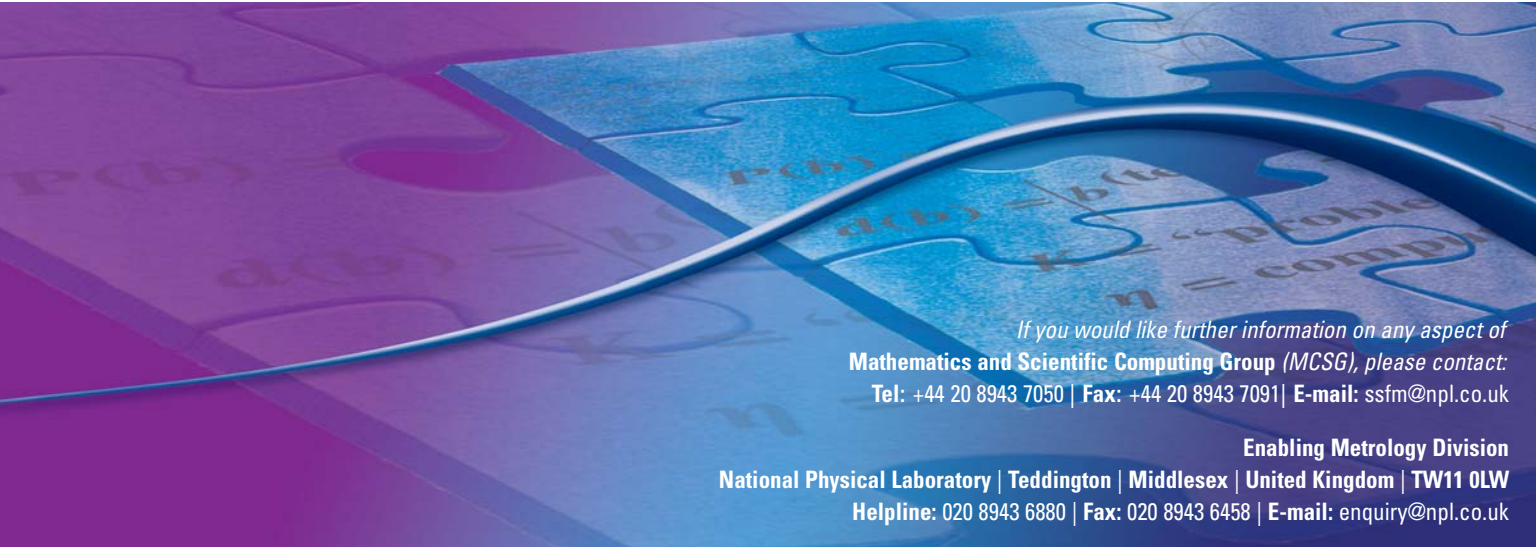


Figure 3. Approximations to the probability density function (PDF) for deviation δm from nominal mass in a mass calibration obtained using the GUM uncertainty framework (curve) and the Monte Carlo method of GUM Supplement 1 (scaled histogram). In this instance, the former approach provides too narrow a PDF.

SS*f*M provides a member to JCGM Working Group 1, *Measurement Uncertainty*, who leads the work on the development of four documents:

- A web-based introduction to the GUM and related documents
- GUM Supplement 1—Propagation of distributions using a Monte Carlo method. See figure 3.
- GUM Supplement 2—Models with any number of output quantities
- GUM Supplement 3—Modelling.

The Group plans to publish the first two of these documents in 2007.



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Software

SS*f*M is preparing software to support both the straight-line calibration functions Technical Specifications and Supplement 1 to the GUM, which it hopes to release following their publication.

Knowledge transfer

Three papers were published in a special issue of Metrologia entitled Statistical and Probabilistic Methods for Metrology, volume 43. 2006. (www.iop.org/EJ/abstract/0026-1394/43/4/E01)

These were:

1. W. Bich, M. G. Cox, and P. M. Harris. Evolution of the 'Guide to the Expression of Uncertainty in Measurement'.
2. M. G. Cox and Bernd R. L. Siebert. The use of a Monte Carlo method for evaluating uncertainty and expanded uncertainty.
3. M. J. T. Milton, P. M. Harris, I. M. Smith, A. S. Brown, and B. A. Goody. Implementation of a generalized least-squares method for determining calibration curves from data with general uncertainty structures.

A more detailed report is available to SS*f*M Club Members at www.npl.co.uk/ssfm/download

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New DTI mathematics and software R&D announced

After a process of consultation, the themes and priorities for the new programme have now been defined and are available at www.npl.co.uk/formulation/ssfm4/prioritisation.html

SS*f*M exists to promote and develop the use of mathematics, statistics and software in measurement applications. Some of the examples of the possible work in the new programme include:

- Sensitivity and uncertainty in continuous modelling
- Molecular modelling
- A framework for uncertainties in measurement
- Model fitting and machine based decision making
- Digital signal processing
- Software and data integrity
- Knowledge transfer

We are interested in collaborating with industrial and academic researchers who could benefit by helping to align the work of the NMS SS*f*M programme with their own projects and programmes, or with projects that they intend to bid for via other research programme funding sources. We see these collaborations as important since they ensure that our work is focussed on the needs of the customer. If you can see scope for collaboration with SS*f*M we would be delighted to discuss this with you. A *Register an Interest* link is provided in the sidebar when you visit the website.

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