

**Report to the National
Measurement System
Policy Unit, Department
of Trade & Industry**

**TESTING SPREADSHEETS AND
OTHER PACKAGES USED IN
METROLOGY**

**REPORT ON DISCUSSIONS WITH
OTHER NATIONAL MEASUREMENT
INSTITUTES (1998/1999)**

BY

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1. Introduction

The NMS Software Support for Metrology Programme (April 1998 to March 2001) is a UK government-supported programme designed to tackle a wide range of generic issues arising from the use of software in measurement science. One of the issues addressed in the programme is the numerical correctness of software used in metrology: it is recognised that a poor software implementation can lead to inaccuracy that could have been avoided, and as a consequence the accuracy of measurement results is compromised. Spreadsheets are widely used in the day-to-day operation of many measurement and calibration laboratories, and yet the facilities they provide are usually taken on trust without any testing or validation.

Project 2.1 of the Software Support for Metrology (SSfM) programme is concerned with the use of spreadsheets and other software packages in metrology. The project will develop a methodology for qualifying metrology software using, for example, reference data sets and results. An activity within the project is to discuss with other National Measurement Institutes (NMIs) the developed methodology, and to account for work undertaken by other NMIs in this area.

The purpose of this report is to inform those interested in the NMS SSfM programme about discussions and interactions between NPL and other NMIs relating to this project. Three such reports are to be produced, one at the end of each year of the programme, and this report is the first of these covering the year 1998/1999.

The main aims for the first year of the project were to

- a) establish appropriate contacts at a number of (key) NMIs,
- b) understand the extent to which spreadsheets and other software packages are used by NMIs in metrology,
- c) identify existing work undertaken by NMIs in the area of testing spreadsheets and other software packages used in metrology.

These aims have been achieved through the surveys reported in [1] (undertaken as part of Project 2.1, Testing spreadsheets and other packages used in metrology) and [2] (undertaken as part of Project 5, Status reports in each metrology area). The results of these surveys are summarised in Section 2. Section 3 of this report indicates planned activity for the remainder of the programme. In Section 4 we acknowledge those people from NMIs who provided information to us, and Section 5 contains references.

2. Activity for the Year 1998/1999

2.1 Survey Report

The purpose of the survey report was to inform the NMSPU and the MAC Software Working Group for the NMS SSfM programme about existing work world-wide on spreadsheet quality and reliability with recommendations on its applicability in the metrology field. Initially, the survey took the form of a restricted report provided to the NMSPU and the MAC Software Working Group. However, with the approval of those who contributed to the survey, the report is now available as the open report [1].

Information for the survey was gathered by contacting a variety of people and organisations, including BIPM and the following NMIs:

1. PTB (Berlin and Braunschweig, Germany),

2. IMGC (Italy),
3. DFM (Denmark),
4. Van Swinden Laboratory (The Netherlands),
5. NIST (United States).

BIPM, PTB, DFM and NIST all provided input to the report.

BIPM wished to be kept aware of the project because of its relevance to BIPM work in putting together an operational and administrative system to support, maintain and record a world-wide mutual recognition agreement (MRA) related to national measurement standards. We note, however, that the concern in the BIPM work is principally with database packages rather than with spreadsheets. Calculations of relevant quantities, such as those of key comparison reference values and their uncertainties, as part of interlaboratory comparison activity, will be carried out by spreadsheets. It is expected that these spreadsheets will be linked to the databases.

PTB reported that their use of spreadsheets is not widespread. We are aware of PTB activity in the area of dimensional metrology where reference data sets and results are used for testing software for fitting best-fit geometric elements to data. Their approach to generating reference data sets and results is to use reference software, whereas we propose in this project to use wherever possible data generation software. Data generators are used to construct data sets with solutions that are known *a priori*, and the development of data generation software is considerably easier than the development of reference software.

DFM reports that their use of spreadsheets is increasing. Testing of spreadsheet applications is generally not performed in a systematic way.

NIST is very interested in the numerical accuracy of statistical software. They have developed the Statistical Reference Datasets (StRD) Web service that provides reference data sets with certified computational results for a variety of statistical problems. Their approach is also to use reference software.

It will be appropriate to have discussions with PTB and NIST regarding the relative merits of using reference software and data generators to establish data sets and results for testing numerical software (Section 3).

2.2 Software Status Report

The purpose of the status report [2] was to describe the status of SSfM related activity world-wide, and to survey international concerns in SSfM related issues. It covers all the themes and projects addressed by the SSfM programme: we are concerned here with only those parts impacting on the software testing project.

Survey questionnaires were sent to 41 correspondents in metrology institutes outside the UK, and formal replies were received from the following NMIs:

1. CSIRO (Australia),
2. BEV (Austria),
3. DFM (Denmark),
4. PTB (Berlin, Germany),
5. EIM (Greece),
6. KIM-LIPI (Indonesia),
7. BIPM (International),
8. NML (Ireland),

9. IMGC (Italy),
10. NRLM (Japan),
11. NMC (Singapore),
12. NML, CSIR (South Africa),
13. ITRI (Taiwan).

While spreadsheets and other mathematical software packages are widely used in metrology, it is rare to find a generic project addressing their validation. (The exception being the Software Practices Group at NML (Australia) which is at an early stage of reviewing spreadsheet usage within metrology.) Where there is activity in this area, it is invariably focused on internal requirements and third-party certification.

The list of key metrology software packages used by the NMIs indicated above is not substantially different from the list for NPL [3]. It includes:

- a) Office suites, particularly Microsoft Office and Microsoft Excel,
- b) general mathematical packages, including MATLAB, Mathematica and MathCAD,
- c) statistical packages, including SPSS and Sigmaplot,
- d) data acquisition packages, including LabVIEW,
- e) bespoke packages, including those developed using C/C++ and Visual-Basic.

There is a general view that more advice concerning the “quality” of scientific software is required. Users of scientific software invariably rely on the claims made by software suppliers (this is true also of organisations other than NMIs) because resources are not always available to carry out comprehensive testing of the software. There is some awareness concerning deficiencies with spreadsheet functions: the standard deviation and inverse- t distributions are often highlighted as requiring care with their use. In such cases, some formal testing of the functions may be undertaken, although the level of detail of testing varies.

3. Future Activity

There are some technical differences between the approach proposed within this project and that employed elsewhere (notably at NIST and PTB). These differences relate to the way that (a) reference data sets and results are produced (using reference software or data generators), and (b) the comparison between reference and test results is undertaken (with or without taking account of factors including problem conditioning). It will be important to discuss these issues with other NMIs.

During the second year of the project a number of working papers and draft deliverables will become available, describing

- methodologies for testing software used in metrology (including the design of reference data sets and results),
- the use of reference data sets for testing metrology software (including the results of testing particular functions within software packages),
- guidelines on testing spreadsheet models against user-provided specifications, and
- guidelines on selecting software for metrology applications.

These will be provided to BIPM and a number of (key) NMIs, including PTB, IMGC, DFM and NIST, for their comment. In this way it is hoped to address some of the issues indicated above, and to ensure that other NMIs are aware of activity undertaken within this project.

In addition, links will be maintained with Project 6.5, EUROMET and Framework 5 Projects. In this regard, NAG Ltd has indicated interest in being involved with NPL and appropriate European partners in a project on software testing.

4. Acknowledgements

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5. References

- [1] M G Cox, M P Dainton, P M Harris and B A Wichmann. *Survey Report on Testing Spreadsheets and Other Packages Used in Metrology*. Report to the National Measurement System Policy Unit, Department of Trade and Industry, from the UK Software Support for Metrology Programme. NPL Report CISE 22/99, March 1999.
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