

# METROS

## A web site for mathematical software for metrology, and associated materials

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20 June 2001

### 1 Introduction

In this paper we describe the METROlogy Software web site (METROS) that was produced by NAG and NPL as part of the Software Support for Metrology programme. We describe the content of the web site, how contributions are made and validated, and efforts at internationalisation. The METROS URL is [www.npl.co.uk/ssfm/metros](http://www.npl.co.uk/ssfm/metros).

The UK's National Measurement System first three-year programme on "Software Support for Metrology" (SSfM) was completed in March 2001; the second programme will run for three years from April 2001. The aim of the programmes is to support UK industry and the other National Measurement System programmes in the use of software for measurement. The METROS web site was an output of a project in the first SSfM programme on re-usable software. METROS will be a key delivery mechanism for technical output of the second programme — algorithms, software, reference data sets, as well as information on software packages and libraries, and guidance material.

### 2 METROS

#### 2.1 Contents

METROS exists to promote best practice in the design, development, use and re-use of software for metrology. The web site is primarily a means of accessing information about functions and their implementations, which form the Metrology Software library. There are separate web pages for the different components of METROS, the information for each component being provided in a tabular form. The overall structure and content of METROS at the end of the first SSfM programme is described in the METROS user guide [1].

The current version of the web site was populated by function and implementations from NAG and NPL, but contributions from elsewhere are necessary for METROS to mature. Any contributions of software are welcomed but the emphasis is on software based on sound numerical analysis, reflecting best practice in mathematical modelling, which is well written and which has undergone thorough appropriate testing. Contributed software will include an indication of its status: whether or not it has been tested/validated and by whom. The METROS user guide includes procedures and criteria for the acceptance of contributions. NPL will be setting up a service for testing and reviewing contributed software.

METROS will also include guidance material; initially this will be best practice guides, reports and case studies from the SSfM programmes. The intention is to include material that is relevant to the application of modelling, algorithms, uncertainty estimation, numerical analysis, software development, and testing and validation to software for metrology.

## **2.2 Key functions**

Central to METROS is the key function, a mathematical specification of a piece of functionality required by metrologists, the specification gives the input and output parameters and the computational aim (equations describing the relationship between the input and output parameters). The key function definition can also include the algorithms to be used in implementing the key function.

On the web site the key functions are grouped by mathematical category: polynomial, spline and other series evaluation and fitting; geometric elements and fitting; statistical functions, distributions, and routines; numerical solver routines; and functions giving properties of materials (e.g. refractive index and density of air) that are given by empirical mathematical formulae.

The main items of software in METROS are the implementations of key functions. The description of the implementations shows how they relate to the key functions, their input and output parameters, with pointers to the documentation and the code. Software may be supplied free or as commercial software: free software implementations can be downloaded directly from the web site, commercial implementations will include information about how the software can be obtained. It is intended that commercial software included in METROS should be available for download from the appropriate commercial e-commerce site.

## **2.3 Reference data sets**

The METROS approach to software testing is based on the use of reference data sets, as developed and promoted by the SSfM programme. The reference data sets are sets of inputs for a particular function together with the reference result; implementations of the function can be tested by applying them to the input data set and comparing the output with the reference result. Methods of generation of reference data sets, based on null-space methods, allow the data

set to be generated for a predetermined result. METROS includes reference data sets for a number of key functions and will be extended to include more data sets during the second SSfM programme.

These data sets will be used in the testing and validation of software contributed to METROS and other software. By making the testing data sets available on METROS we hope to demonstrate the openness of the process of accepting and validating contributions to METROS. Data sets available in METROS (not necessarily with reference results) can be used for comparing the efficiency of different algorithms and implementations of the same function.

### 3 Accessibility

There are a number of issues to be addressed in making the algorithms and software in METROS accessible to all those who could use them. These issues are both technical (to do with the web technology that is used to support METROS) and promotional (to do with getting people to access METROS).

#### 3.1 Mathematical notation

The main technical issue for METROS is the use of mathematical notation. Currently mathematics for the key function specification is written in  $\text{\LaTeX}$  [3] and converted to HTML, using a  $\text{\LaTeX}$  to HTML tool (HEVEA [4]): this produces mathematical layout using HTML tables. The result is remarkably good but the quality of displayed mathematics varies from one browser to another. As part of the re-implementation of the web site, we hope to move to using MathML [2]. The current  $\text{\LaTeX}$  to HTML tool can produce MathML output, so it should be possible to recreate the existing pages with the HTML tables replaced by MathML.

Of course, MathML is not yet widely supported and we will lessen the accessibility of METROS if we use MathML. But MathML is clearly the right technical solution, which we would like to adopt as soon as possible. The main issue is whether we should use just MathML from some point, or whether we should provide MathML and non-MathML versions of the web site. As MathML becomes more supported by editors and browsers, there will be various options for the inclusion of mathematics in documentation for contributions to METROS. We expect to continue to support  $\text{\LaTeX}$ , but also to accept contributions in MathML directly (output by an equation editor, for instance). There are other options for the mathematics, it can be a graphical image (output from an equation editor), or it may be appropriate for the documentation containing mathematics to be a stand-alone page in PDF.

#### 3.2 Maintenance

The METROS web pages are currently static, each produced manually. This means that when new functions or implementations or other components are added, which need linking from existing pages, there are several pages that

must be edited. As the number of components of METROS grows, this maintenance effort will get onerous and error-prone. We are working to re-implement the web site by storing details of the components and generating the web pages automatically, dynamically on demand. This will allow changes of style and re-configuration of the web site to be implemented simply and painlessly.

### **3.3 Awareness**

If METROS is to be useful and successful it needs a to reach a wide audience that will provide a large user community. Only from a large user base, can we expect sufficient contributions to allow METROS to grow and to become more relevant to its users. The users are measurement scientists and, equally importantly, the software developers who produce software and systems for measurement. Measurement scientists and their software developers are largely unaware of the particular issues to be addressed in software for metrology and tend to use common algorithms and software components that may not be fit for purpose in measurement. Therefore, they are not going out to look for support in developing software for metrology and we must find them.

There is a project in the current SSfM programme aimed at the promotion of METROS. We will use the NPL and SSfM web sites to draw people in to METROS and publicise METROS through NPL's network of industrial clubs (organisations aimed at a particular industrial sector or field of measurement).

### **3.4 Internationalisation**

METROS already has an international dimension through the European Metrology organisation (EUROMET): there is a EUROMET project to encourage contributions to METROS, as EuroMETROS. We have also received offers of software from Canada and New Zealand. As well as encouraging contributions from the rest of the world, we are also keen to avoid conflicts with similar web based software libraries. It is important that we liaise and integrate sensibly with other related activities or web sites, so as not to duplicate effort nor develop pointless rivalries.

## **4 Conclusion**

The basic components of METROS are the key functions and their implementations. Reference data sets are included in METROS and will be used to validate software that is contributed to METROS. The site also contains information on software packages and libraries, and contains guidance material related to software for metrology.

There are technical issues in making the METROS web site easy to maintain and making the mathematical content of the web pages accessible to all browsers. We expect to solve these issues in the reimplementaion of METROS later this year. There are also issues of awareness and promotion of METROS so it will reach all those measurement scientists and software developers, in the UK

and internationally, who can benefit. METROS needs to build a critical mass of user and contributors who will enable METROS to grow.

Through the work of the current SSfM programme, and with increased internationalisation, we intend that the METROS web-site becomes a focal point for all aspects of software for metrology.

## References

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