NPL National Physical Laboratory

Counting on IT

A National Measurement Newsletter

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Eye in the sky: NPL aids TopSat vision

Courtesy of the Topsat Consortium

Figure 1. A TopSat image of the Thames

Contents:

SS*f*M skills have contributed to the successful commissioning of a new earth observation camera. Last December, the remote sensing, imaging camera used in the TopSat micro-satellite transmitted its first high-resolution images of the earth. The camera was designed, constructed and tested at Rutherford Appleton Laboratory and is a compact low cost imager with a 2.5 metre panchromatic resolution of ground images taken from a distance of 600 km above the earth's surface. It returns high quality images very quickly to fixed and mobile ground stations to be used for natural disaster monitoring, environmental damage assessment and pollution and habitat mapping.

Previous high-resolution cameras have been bulky and required large and expensive satellites. TopSat gets round this by using a camera with a folded optical system using an off-axis mirror. This design necessitates an extremely stable and accurately aligned optical system. SS*f*M staff contributed to:

- mathematical modelling and simulation of the optical system to check the viability of the alignment and mirror characterisation and to estimate the likely uncertainty in the measurements of the geometry of the mirror system,
- the development of models, algorithms and software to convert measurements of the mirror system into settings for the five degrees-of-freedom mirror adjusters to bring about optimal alignment,

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- the analysis of the measurements of the individual mirror forms and the measurements taken during the first phase of the mirror alignment within the camera body.

The measurement of the mirror profiles, the placement within the camera body and the effect of vibration on positioning was carried out at NPL using two high-accuracy CMMs (co-ordinate measuring machines). A small CMM was used to characterise the mirror shapes using a special error separation measurement strategy. A larger CMM was used to determine their placement within the structure, both before and after vibration testing. Three small tooling balls were attached to each of the mirrors providing a datum for the coordinate system used for the measurements. Once the mirror shapes had been characterised, the alignment of the mirrors could be determined from the position of the balls.

After the system had been aligned at NPL, three optical fringes showed across the field of view. RAL were able to reduce this to a final value of approximately half a fringe using an interferometric system. The accurate alignment from the CMM measurements reduced the time required for the interferometric alignment from months to a few days.

TopSat was designed and built by a consortium of British companies led by QinetiQ. The TopSat programme has been jointly funded by the British National Space Centre (BNSC) and the UK Ministry of Defence.

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Popular SS*f*M downloads

The SS*f*M website remains the major outlet for guides, reports, presentations and other documents produced during the programme.

Around 80% of these are publicly available at

www.npl.co.uk/ssfm/download/

and SS*f*M club members can access the remainder. Do visit the site again if you haven't done so recently, as new material is continually being added.

Since May 2005, over 7500 items have been downloaded from the site. The SS*f*M good- and best-practice guides remain ever-popular: around 300 copies each of BPG1 (Validation of software in measurement systems) and BPG6 (Uncertainty evaluation) have been taken during this period.

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Distributed Computing Guide now available (Good Practice Guide No. 17)

The SS*f*M programme has just published a guide to the use of distributed and parallel computing in metrology. The guide is based on NPL's experience in developing applications for its own Grid system and provides practical advice on topics ranging from how to convert serial code to a suitable form for distributed and parallel systems, to systems administration in distributed systems. It aims to provide all the basic information that scientists require when considering the use of DC systems for large metrology calculations.

The NPL Grid itself has been the subject of articles in previous issues of Counting on IT – see issues 16 (Autumn 2004) and 17 (Spring 2005). Download these from

www.npl.co.uk /ssfm/download/newsletters/

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Continuous modelling (Good Practice Guide No. 15)

This guide is aimed at both new and experienced users of continuous modelling techniques who wish to apply good practice to their modelling projects. It may also be of interest to those who want a better understanding of the similarities and differences between various numerical methods for solving models.

A draft version is already available to club members, and the final version will soon be made to all.

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Mathematical Modelling for Metrology at the Nanoscale

More and more measurement applications require modelling at the small scale. A new SS*f*M report considers mathematical modelling at the nanoscale and its application to problems in metrology. The motivation for the report arises from the recognition that modelling at this scale is becoming more important for metrologists working on programmes funded by the National Measurement System Directorate (NMSD). It has been drafted with metrologists from other programmes in mind, and aims to set out the most important issues for metrologists. Its purpose is both to offer advice on how to assess the potential contribution that nanoscale modelling techniques may be able to make and to assist in identifying sources of help with modelling problems. It describes some of the software available and suggests ways in which non-commercial software can be used to gain experience in modelling at the nanoscale.

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Controlling instruments with non-standard interfaces over the Internet

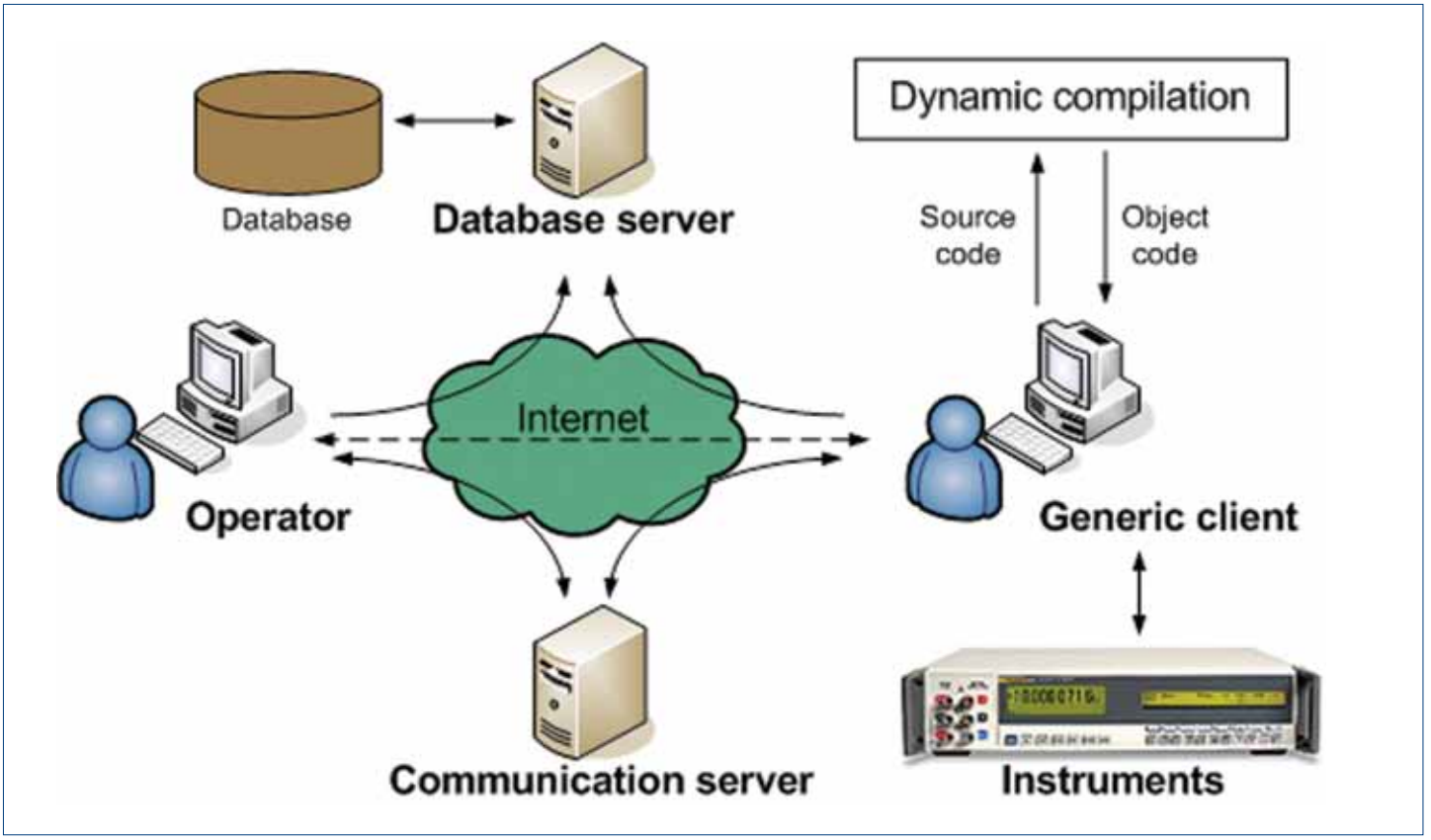

Figure 2. Components for controlling instruments with APIs

NPL has been continuing its investigations into the possibilities of internet-enabled metrology by designing a system that allows instruments with their own Application Programming Interfaces (APIs) to be controlled over the Internet. This is an important step forward from previous Internet enabled calibration systems that have been restricted to using instruments with GPIB or RS232 interfaces.

As all APIs are different, the tricky part of the project was to find a generic way of running them so that new APIs could be added dynamically without the need to change any of the operational parts of the software. This was accomplished by controlling the APIs via dynamically compiled source code, in this case C# .NET. The measurement source code is made available to the project by loading it onto a database running on a public server. The project uses the freeware database software MSDE.

A program known as the "generic client" runs on the computer to which the instrument is attached. This program fetches the measurement software from the database, compiles it at runtime and uses the compiled code to control the instrument. Any instrument can be controlled by the generic client provided that the measurement software is available on the database. The generic client is driven by operator software that can run either on the instrument PC, if local operation is required, or on a remote PC. An operator drives the experiment, causing the instrument to be controlled as required and collecting the results that are sent back. Example generic client and operator programs have been produced in C# .NET, but there is no dependence on this language.

The programs communicate with each other over the Internet via a communications server provided by event driven messaging middleware known as xmlBlaster. XmlBlaster libraries have to be installed on all participating computers.

A recent collaboration between Justervesenet (Norwegian Metrology Service) and NPL resulted in the demonstrator for this project. Åsmund Sand, who implemented the software, has been able, while working in Norway, to use it to control a NetTest instrument kept at NPL (NetTest is an Optical Time Domain Reflectometer with an API).

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Biometric trials

NPL has led another important set of biometric trials. The last such trial was conducted in 2000 [see Counting on IT issue 10]. Since then, there have been a number of innovations and improvements in performance. This latest trial was run under the DTI Measurement for Innovators programme, as a Joint Industry Project involving several industrial partners who provided the equipment and algorithms to be evaluated as well as supporting the running of the evaluation.

A public report on the outcome of the trial is being produced, covering:

- performance of the systems and algorithms tested,
- test methodologies used.

When completed, the report will be posted on the NPL website.

The work benefits the UK Biometric industry and is relevant to the Government's ID cards and e-borders programmes. The participating biometric suppliers benefited through having their products independently evaluated. The data generated during the evaluation is available to assist research on performance models for biometric systems, and multi-modal biometric fusion.

Figure 3. LG iris icam 4000

Testing took place on two sites, one at NPL and the other at **Deloitte** who were one of the partners assisting with the running of the evaluation. Over two hundred volunteers were used in evaluating the systems. Each volunteer had two appointments, separated by two or more months. On their first visit, the volunteers were enrolled in the systems, and biometric reference data was collected and stored to evaluate their identification potential. On their second visit, further recognition data was collected, the combined data being used to evaluate the recognition performance of the enrolment and comparison algorithms provided.

Figure 4. Securimetrics hand held iris recognition camera

Three different types of biometric technology were evaluated in these trials: face recognition, iris recognition and vein patterns.

Face recognition

For 3D face recognition, **A4Vision's** system projects a pattern of light onto a person's face, and the contours of the light in the recorded face image enable a 3D model of the face to be reconstructed. The use of 3D data helps make the system less sensitive to variations in pose and illumination than earlier face recognition technologies.

The latest **Identix** face recognition system combines analysis of 2D local features with skin texture. The system uses flash photography with a standard high-resolution digital camera.

OmniPerception provided a third advanced face recognition system, accommodating the different heights of individuals by using three cameras with no moving parts, and using fluorescent lighting and continuous image capture rather than a flashgun.

The face recognition systems show a considerable improvement in accuracies since our previous tests.

Figure 5. Techsphere VP II hand vascular pattern recognition

Iris recogntion

The new **LG** iris camera photographs both eyes at the same time. The subject looks into a mirror, and aligns an orange spot on the bridge of the nose. The system speaks; advising the subject to move closer or farther away to ensure the image is in focus. This system was easy to use and reliable at identification.

The **Securimetrics** iris camera is a hand-held device that requires some practice to be easy to operate. Once mastered this camera also seems to produce reliable results.

The data collected using these two iris cameras is also being used to evaluate new algorithms for iris recognition provided by **Smart Sensors**

Vein patterns

Techsphere VP II is a hand vascular pattern recognition system. Here the subject locates a hand in the device and activates a switch to record a near infra-red image of the veins in the back of the hand. The system is designed for access control to rooms and buildings, and was liked by many volunteers as being fast and easy to use.

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Figure 6. A4 Vision 3D face recognition

From *PTB* – Industrial Association for Distributed Measuring Systems established in Germany

After the successful completion of the SELMA project (Secure Electronic Measurement Data Exchange), the members of the consortium and other partners established an Association for Distributed Measurement Systems (ADM). ADM members are from industry (the majority), universities and other institutions; PTB is also a member.

The aim of ADM is to initiate and promote research and development in the area of distributed measuring systems, communication and security of measurement data for various areas of measurement. Members are convinced that open communication systems and new communication means are simultaneously a challenge and a risk. Resulting advanced measuring systems need to be accompanied by trustworthy security methods. The association aims to develop methods that can immediately be used in industry.

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The NPL distributed computing grid

NPL presented a poster on its work with Grid computing at The GRID Computing and Web Services event held by The London Technology Network (LTN), in November 2005. The LTN exists to stimulate the transfer of knowledge and innovation between London universities and companies in the local and global community. The event proved to be an excellent platform for showcasing our work in Grid computing, and was a great success.

We created the NPL Grid by tapping into the unused processing capability (typically 80%) of our networked desktop computers. This virtual 'supercomputer' presently uses the spare capacity of 200 PC's, running programs in a co-coordinated and parallel fashion, enabling calculations to be completed in dramatically reduced time. The Grid has been used by a number of teams at NPL undertaking research that would have been impossible to do without it.

Nick McCormick of NPL's Process Materials Team used the grid to do a sensitivity study for the Finite Element Analysis (FEA) of piezoelectric devices. When modelling these devices seventeen material parameters are involved and their uncertainties could, singly or in combination, disproportionately affect the model output. The time needed to perform an input sensitivity study for FEA requires 1.7×10^{14} computer runs, which would take 1 billion years of computer time! However, by independently assessing mount, mechanical and piezoelectric properties, it can be shown that such a calculation would only need 1 million runs (i.e. 6.75 years of computer time). Using the NPL Grid, the calculation was completed up to 112 times faster than is possible with a single machine – and the job was completed in one month.

In another application on the NPL Grid, the speed of the calculation was increased by a factor of 150. Irradiation, the focusing of high-energy particles, is a powerful cancer treatment. However, to ensure the effectiveness of this treatment, clinicians need to be able to determine the total dose of irradiation delivered and its distribution in the body. So, NPL uses the Monte Carlo codes EGSnrc and McPTRAN.CAVITY to model radiation transport through a virtual patient (an ionisation chamber in a water bath). The software simulates the paths of a large number of particles, but the calculation is inefficient and unfeasibly lengthy, because only a fraction of the particles interact with the small volume of the ionisation chamber. The increased speed achievable with the Grid overcomes this disadvantage.

The NPL Grid has also been used in the following research projects:

- loudspeakers and underwater transducer modelling,
- near-to-far field acoustic studies,
- electron transport in quantum dots,
- adiabatic energy transfer in atoms.

If you wish to discuss opportunities for collaboration, please contact The NPL Grid Team Coordinator Trevor Esward.

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Developing advanced spreadsheet applications

Spreadsheets are a ubiquitous part of office and scientific life, but most people use only a fraction of their capabilities. Of those who do use them in more depth, very few consider applying the normal rigours of programming when developing spreadsheet applications.

The SS*f*M team, who have extensive expertise in spreadsheet development and testing, ran a two day course in November 2005, to highlight the need for proper design and testing of scientific spreadsheet applications, and to teach the attendees how to implement this.

The first day of the course showed how to apply software development techniques to spreadsheets using VBA, including:

- replacing formulas with functions,
- layout,
- coding conventions,
- review.

The delegates worked through a number of exercises to understand the relationship between Excel and VBA and hence be able to implement the required solutions.

Testing is a key component of software development, and a method of testing spreadsheet applications based on unit testing technology has been developed under SS*f*M. The second day of the course explained the need for testing and introduced delegates to the method.

Feedback from the course was very positive, and included comments that the hands-on part was very good, with helpful and encouraging technical support from the course tutors, and that the new knowledge would be useful on a daily basis.

There are plans to repeat the course later this year.

An SS*f*M best practice guide "Development and testing of spreadsheet applications" (BPG7), is available for download at

www.npl.co.uk/ssfm/download/bpg.html

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Register now for our next signal processing seminar

SS*f*M held a very successful first signal processing seminar on 30 November 2005. It attracted a wide range of interest from industry, universities and measurement laboratories, including visitors from overseas. The keynote speech was delivered by Dr Andrew Hurrell from Precision Acoustics

www.acoustics.co.uk/

who described the important role that digital signal processing (DSP) plays in his company in the field of medical ultrasound measurement. He set the scene for a range of tutorial sessions, talks on specific DSP applications and software demonstrations. The day ended with a panel discussion involving all the day's speakers, which attempted to define the main requirements for the successful use of DSP in modern metrology applications.

www.npl.co.uk/ssfm/news/events/20051130/

A full report of the seminar is available on the NPL web site.

The next seminar will take place at NPL on 23 June 2006 and will cover topics such as signal estimation, filtering and spectral analysis. The day will combine tutorials, talks about DSP applications, software demonstrations, lunch-time workshops and one-to-one advice sessions with NPL experts. If you would like to offer a talk, a workshop session or software demonstration, please don't hesitate to get in touch. The simplest way to do this is via the NPL web site where you can learn more about the seminar, volunteer contributions and register for the event itself.

www.npl.co.uk/ssfm/news/events/20060623/

The current SS*f*M programme is producing a Good Practice Guide on signal processing and the seminars are a vital part of the process of preparing the Guide, as they allow us to understand exactly what is required by practitioners.

For further information contact:
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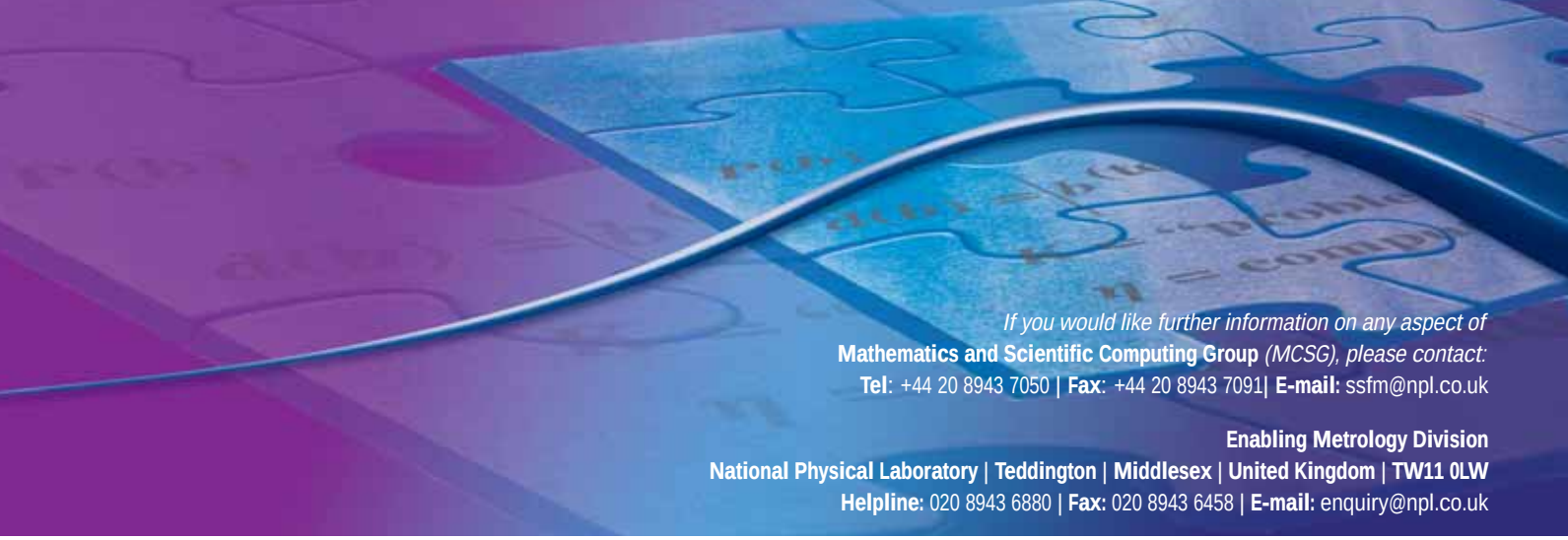

If you would like further information on any aspect of **Mathematics and Scientific Computing Group** *(MCSG), please contact:*
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SS*f*M-4 – your chance to participate

The next DTI funded SS*f*M programme, SS*f*M-4, will start in April 2007 and the process of identifying research and development projects is now underway.
SS*f*M exists to promote and develop the use of mathematics, statistics and software in measurement applications.

In industry and academia, mathematical and software contributions to projects often share a common interest with R&D conducted in support of the national measurement infrastructure.

NPL is keen to collaborate with industrial and academic partners both during the lifetime of SS*f*M-4 and now, while the content of the programme is being finalised. Participate at this stage and you may be able to ensure that SS*f*M is aligned with your current and planned projects and objectives. Collaborate during the programme, and you could deliver your future mathematical and scientific software contributions at no direct extra cost to your projects.

The collaborative mutual co-funding of industry, academic and SS*f*M research will:

- Create larger multidisciplinary project teams which have sufficient expertise and available effort to solve problems
- Share knowledge
- Enable industrial products to be market competitive in a reduced time

On behalf of the DTI, NPL seeks your views and ideas on the direction of the new SS*f*M programme. If you have specific measurement related software/mathematical requirements that could benefit from such collaboration we would welcome the opportunity to discuss them with you.

Visit our website www.npl.co.uk/formulation/ssfm4/ and complete the "Register an Interest" form at the link on the sidebar.

For further information contact:
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Forthcoming events

15 to 16 June 2006,
National Physical Laboratory,
Visualisation of Measurement Data
Contact: joe.bennett@npl.co.uk

2 June 2006,
National Physical Laboratory
2nd Signal processing awareness seminar
Contact: trevor.esward@npl.co.uk

7 July 2006
National Physical Laboratory,
VAM Workshop on Mass Spectrometry
Contact: stacy.skangos@npl.co.uk

www.npl.co.uk/ssfm/news/events/20060623/
Visit www.npl.co.uk/news-and-events/ www.npl.co.uk/ssfm/news/

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

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