

**The Smith Institute for
Industrial Mathematics and System Engineering**

**Report on the
Scottish Industrial Networking Initiative
in Mathematical Sciences (SINIMS)**

by

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EXECUTIVE SUMMARY

This report is the final deliverable of the Scottish Industrial Networking Initiative in Mathematical Sciences (SINIMS). The project was funded by the Department of Trade and Industry as a Special Initiative of the Smith Institute Faraday Partnership. The work was undertaken between October 2001 and April 2002 and was carried out in collaboration with the International Centre for Mathematical Sciences in Edinburgh.

The main aim of the SINIMS project was to identify new opportunities in Scotland for collaborative projects on industrially motivated mathematical problems. A network of contacts with industry, academia and business support organisations was established. Over five hundred companies, all thirteen Scottish universities' mathematics departments and a range of enterprise, technology transfer and other organisations (including several other Faraday Partnerships) were contacted during the project.

Thirty-two companies took part in one-day workshops focussed on applications of mathematics and computing to their industry. Six such workshops were held, targeted at sectors identified as being of significant importance to the Scottish economy: textiles, optoelectronics, medicine & biotechnology, food & agriculture, oil & gas and semiconductors. Forty academics (lecturers, post-doctoral researchers and graduate students) from eight universities took part in the workshops, as well as several other Faraday Partnerships and research organisations. The workshops were used as a mechanism for promoting Faraday Partnerships to industry, for demonstrating through practical examples the relevance of mathematics to these sectors, as a networking opportunity and for capturing companies' requirements for collaborating with academics on mathematical problems identified within their businesses.

The workshops and other networking activities have resulted in a number of opportunities for new industrial-academic collaborations. Several small-scale projects were completed during the initiative. These involved helping a small company validate a design for a proposed broadband internet technology, mathematical modelling of a new device for measuring fluid density in a harsh environment for applications in the oil & gas industry and developing an algorithm to optimise the scheduling of customer orders for a textile company. Several other opportunities are being developed and may give rise to further collaborative projects.

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1 INTRODUCTION

In 2001 the Department for Trade and Industry announced that it would make available to Faraday Partnerships a fund from which they were invited to apply for 'Special Initiative' grants. The choice of projects was left to the individual Partnerships to propose, but the funds were to be allocated and used before the end of the financial year 2001/02.

The Smith Institute for Industrial Mathematics and System Engineering (hereinafter referred to simply as the Smith Institute) is concerned with coupling industry and academia in the key enabling scientific disciplines of mathematics and computing. It was granted Faraday Partnership status in June 2000. By September 2001, it had established relationships with approximately forty companies. These were achieved mainly through personal introductions from academics and other networking activities and were located mainly in England.

The Smith Institute wished to expand its network of industrial and academic contacts in Scotland, and to forge closer links with the International Centre for Mathematical Sciences (ICMS). ICMS is located in Edinburgh at the birthplace of the 19th century theoretical physicist and natural philosopher James Clerk Maxwell. Its aims include the encouragement and exploitation of those areas of mathematics that are of relevance to other sciences, industry and commerce. Hence it was natural for the Smith Institute to seek to develop links with ICMS in order to leverage its contacts with academics and business support organisations in Scotland.

For these purposes, the Smith Institute applied for and was awarded one of the DTI's Special Initiative grants¹ of value £50k. The work was to be carried out by appointing a locally based Technology Translator, ideally a PhD mathematician currently working in industry and with several years' commercial experience. The author was approached and subsequently seconded to the Smith Institute from General Electric. The six-month secondment commenced on the 22nd October 2001.

The project was given the title "Scottish Industrial Networking Initiative in Mathematical Sciences" (hereinafter referred to as SINIMS or the 'initiative' or 'project'). This report documents the main activities that took place during the project and summarises the results, including contacts established and opportunities for new industrial-academic collaborations.

¹ A second Special Initiative grant was awarded to the Smith Institute to construct a 'Roadmap' document, grouping industrial requirements for mathematics around a number of topics, thus helping government to identify broad areas in which investment in mathematics is required to meet the future needs of industry.

1.1 The SINIMS Brief

The proposal submitted to the DTI stated several objectives and deliverables for the initiative. In addition to the recruitment of a technology translator from industry, the funding was allocated:

- to provide office space and administrative support at ICMS in Edinburgh
- to establish links with existing business support organisations including the Scottish Enterprise Network and Technology Ventures Scotland
- to undertake site visits to companies
- to run a series of six sector-based workshops at ICMS (including travelling expenses for academic participants) and produce short reports after each workshop
- to prepare a final report summarising the contacts made and opportunities created (this document)

The overall direction of the SINIMS project was determined by a steering group, convened monthly and chaired by the director of the Smith Institute (Dr. R Leese, to whom the author reported). Membership included the director of ICMS (Ms T Dart), a representative from Scottish Enterprise (Mr W Templeman), academics from Heriot-Watt University (Prof. A Lacey), Strathclyde University (Dr S Wilson), the University of Edinburgh (Prof. E Rees) and an industrialist (Dr K Winters, AEA Technology and chair of the Smith Institute Faraday Advisory Board).

The workshops were to be targeted at the following sectors of the Scottish economy:

- Textiles
- Optoelectronics
- Health, Medicine & Biotechnology
- Food & Agriculture
- Oil & Gas
- Semiconductors

These sectors were chosen because of their importance to the Scottish economy. They are broadly consistent with several of the industrial sectors targeted by Scottish Enterprise's 'Cluster Strategy'². Within the specified sectors, the focus where possible was to be on small and medium sized enterprises (SMEs).

² Scottish Enterprise adopts Michael Porter's approach [MP80] for analysing sectors of economic activity. This provides a metric for determining whether particular sectors qualify as 'clusters'. Evidence suggests that such clusters promote economic growth and thus deserve particular attention from regional policymakers.

Among the more notable exceptions from the SINIMS brief are communication and information technologies, creative industries, tourism and financial services, which are also of considerable importance to the Scottish economy. However, the number of sectors to be targeted was necessarily limited by the relatively short duration of the project. Moreover, it was anticipated that networking, the publishing of promotional material on websites and other publicity might lead to queries from companies within these sectors, from companies operating in different sectors or indeed from companies outside Scotland. Such queries, so far as was reasonable and practical, were not to be turned away.

The ultimate objective for the initiative was to identify new opportunities for collaborative activity between industry and academia in mathematics and computing³. Networking and workshops were the mechanisms by which such opportunities could be identified. It was hoped these activities would give rise to a small number of potential collaborative projects which would be at various stages 'in the pipeline' by April 2002. As the secondment drew to a close, the management and development of these opportunities would be transferred to the permanent Smith Institute staff.

³ Here 'computing' is included in so far as it is a mechanism for the delivery of mathematical solutions. It does not include traditional 'computer science'.

2 METHODOLOGY

The methods employed to promote the SINIMS initiative to the industrial and academic communities and subsequently to evaluate their success are described in this chapter.

2.1 Promotion of SINIMS

The first stated objective in the proposal to the DTI for the SINIMS project was to establish a network of industrial, academic and other suitable contacts in Scotland. A combination of general and specific marketing was carried out to promote the project to the various target audiences.

2.1.1 General marketing

A website⁴ and email address for the SINIMS initiative were established in the first week of the project. The physical infrastructure and software were provided ICMS with technical support from computing staff at the Department of Mathematics and Statistics at the University of Edinburgh. Initially the website contained a basic description of the initiative, contact details and links to the main Smith Institute website. Further information was added to the site as the project progressed, including details of forthcoming workshops (with an on-line registration facility). A number of other organisations subsequently agreed to host links to the SINIMS website.

Several press releases were issued in the first two months of the project. Technology Ventures Scotland printed a promotional article in its monthly publication entitled *Spur*. The distribution for *Spur* includes over one and a half thousand Scottish businesses, of which approximately two-thirds are Small or Medium sized Enterprises (SMEs). Scottish Enterprise printed a similar article in their quarterly bulletin 'CommTecho' aimed mainly at businesses in the communications technologies sector. (Communications technologies is not one of the main six sectors targeted by the SINIMS proposal, but the offer was made spontaneously by Scottish Enterprise and was willingly accepted.)

A poster stand was displayed at the "Innovations in Scotland in the 21st Century" one-day conference, hosted jointly by the Royal Society of Edinburgh and the Scottish Executive. The event was attended by representatives from government, industry, academia, venture capital firms and other organisations whose activities relate to technology transfer or commercialisation. Several hundred leaflets describing the SINIMS initiative were produced for the event.

⁴ <http://www.ma.hw.ac.uk/icms/sinims>

2.1.2 Government agencies and other technology transfer organisations

During the first month of the project several visits were made to organisations involved either directly or indirectly with technology transfer or interfacing in one way or another between academia and industry. The purposes of such visits included raising awareness of the new initiative, gaining agreement to host brief descriptive material on their websites (and provision of a direct link to the SINIMS website) and identifying further contacts with specific knowledge of companies that might benefit from the initiative. Among the organisations visited were Scottish Enterprise, Technology Ventures Scotland, the Defence Diversification Agency, the Royal Society of Edinburgh, Foresight, the Lanarkshire Technology Innovation Centre and the Scottish Institute for Enterprise. A short notice describing the new initiative was also posted on the Scottish Microelectronics website.

2.1.3 Academic community

Early in the project the heads of mathematics departments for all thirteen Scottish universities were contacted by letter. The letter explained the background and aims of the SINIMS initiative and gave notice of the forthcoming sector-based workshops. Heads of departments were encouraged to circulate the letter and promote the initiative to their colleagues. Several mathematics departments (Edinburgh, Heriot-Watt and Strathclyde) requested individual visits and presentations to interested academics, at which a fuller discussion of the initiative was provided. As soon as the dates for the workshops were finalised, these were also sent to the Scottish university mathematics departments. At the mid-point of the workshops, a brief summary of the activity and industrial interest generated to date was also circulated.

Non-Scottish universities were not specifically targeted during the initiative. However, the author delivered a short presentation on the project to the Smith Institute Plenary Meeting at the Royal Academy of Engineering, London, on 11th January 2002. The audience included representatives from the Smith Institute Scientific Committee and Faraday Advisory Board, the Department for Trade and Industry and the Engineering and Physical Sciences Research Council. In particular, the Smith Institute Scientific Committee represents mathematicians from across the entire UK university research base, thus providing a mechanism for reaching departments outside Scotland.

Throughout the project, requests were made to individual academics with relevant expertise to attend and give presentations at the sector-based workshops. Graduate students reading for masters' degrees and doctorates and post-doctoral research fellows were also encouraged to attend the workshops to broaden their perspectives on industrial applications of mathematics.

2.1.4 *Industrial community*

The main format for engaging industry during the project was through the organisation of a series of six sector-based workshops. Each workshop was targeted at a particular industrial sector: textiles; optoelectronics; health, medicine & biotechnology; food & agriculture; oil & gas and semiconductors. In total, over five hundred companies were invited to attend the workshops, an average of approximately eighty-five invitations for each workshop. The companies were selected mainly from trade directories or sector specific websites. For example, Scottish Enterprise hosts the Scottish Textiles website⁵, providing the names, activities and contact details for the majority of the Scottish textiles industry broken down into various market segments. Similar websites or directories were used for other sectors.

The sectors were chosen to provide a broad sweep of the Scottish industrial base, with a clear emphasis on manufacturing organisations. Given the limited time available in which to organise and run the workshops, it was felt that running six such events was a realistic and achievable target. Other Scottish manufacturing sectors, for example communication technologies, were not specifically targeted. Nor were the strong Scottish service industries such as tourism or financial services.

In addition to the workshops, a number of suggestions for suitable companies (and, in some cases, named contacts within companies) were provided by Scottish Enterprise (e.g. Optos Plc) and individual academics (e.g. Canongate Technologies). The author also used his own contacts with his current employer (General Electric), previous employer (BAE Systems) and contacts provided from colleagues on the part-time MBA programme at Edinburgh University (e.g. Bank of Scotland, Scottish Equity Partners, GE Capital Woodchester). Several contacts within companies were provided by colleagues from the Smith Institute Scientific Committee and Faraday Advisory Boards (e.g. Intense Photonics).

2.2 Workshops

The organisation of each workshop followed a broadly similar process, though evolved in some respects in the light of experience gained from the first workshops. The process can be broken down into a number of discrete steps corresponding to pre-workshop activity, the day of the workshop and the post-workshop follow-up activity.

⁵ <http://www.scottish-textiles.co.uk>

2.2.1 *Pre-workshop activity*

Company selection

The objective of the selection process was not to form a representative or randomly chosen sample of any one sector, but simply to obtain a sufficient number of industrialists at each workshop to make the event worthwhile. The workshops would go ahead even if only one or two companies agreed to attend, but would clearly have greater value and impact if a greater number participated. Small and medium size enterprises (SMEs) were to be targeted, though not exclusively. Similarly, Scottish companies were the main target market, though some English companies were also occasionally invited when suggested by individuals with relevant contacts in the companies. There was no requirement for the companies to be indigenous Scottish firms. Indeed, many of the firms have headquarters elsewhere.

Approximately six weeks before each seminar the search for appropriate companies to invite was initiated. The internet was used to search for directories of companies within each sector. Other directories, for example the Scottish Biotechnology Source Book [SBSB00], were also used as alternative sources of company information. For those sectors with a relatively small company base in Scotland (e.g. Optoelectronics), almost all the companies appearing in the relevant directories were selected. For sectors with a much larger company base in Scotland (e.g. food & agriculture, textiles, oil & gas), a selection was made. The objective was to invite at least fifty companies in each sector to the workshop. For those sectors where a selection had to be made, the criterion applied was a largely subjective judgement in trying to anticipate which companies were most likely to be receptive to the invitation. This is not always the same thing as selecting those companies who appeared to have the most to gain from such a workshop.

To illustrate the point, consider the Scottish textiles industry. Despite being in decline, the industry is still the fourth largest manufacturing sector in Scotland, accounting for approximately nine per cent of Scottish manufactured exports (by value), eleven per cent of Scottish manufacturing jobs and employing some twenty-eight thousand workers [SCCI00]. The industry can be divided into several sectors, including industrial & technical textiles, spinning, weaving, knitwear, garment manufacture, workwear manufacture, dyeing & finishing, etc. There are over a thousand textiles companies in Scotland. The vast majority of these are small, traditional knitwear manufacturers. Approximately eighty are “technical textiles” companies. Despite the title ascribed to this subsector, technical textiles companies are not necessarily deploying more advanced technology in the manufacturing processes than their peers in other subsectors. However, their end products are used for higher technology end-user applications. Moreover, unlike the traditional knitwear manufacturers, the technical textiles sector is growing and has been targeted by government

policy initiatives as of strategic importance to the overall textiles sector. After consulting with members of the TechniTex Faraday Partnership and the Scottish Textiles Network (a Scottish Enterprise initiative), it was decided that only this sector would be targeted for the textiles workshop. Of course, this does not mean that companies in the other sectors stood to gain any less from applying mathematics in their businesses.

In addition to the Scottish companies selected, a few companies were occasionally targeted from England. Some of these were suggested by colleagues, normally academics or contacts within other Faraday Partnerships who had previously had dealings with the companies. Others were chosen where the indigenous Scottish company base was smaller than the targeted size of sector.

For example, the optoelectronics industry in Scotland contains some sixty companies. The optoelectronics industry is a relatively advanced technology sector. Hence this number of companies was considered a sufficiently large base for generating invitations. However, there is a considerable overlap between this sector and the Scottish semiconductor sector. It was thought to be inappropriate to invite companies to more than one seminar. Hence all the Scottish optoelectronics companies were invited to the optoelectronics workshop but not to the semiconductors workshop. The search for semiconductor companies was then expanded beyond Scotland to include several English electronics companies.

Once companies had been selected, their contact details were transcribed from the appropriate source (usually a website) into a database. The information relating to each company consisted of the following data:

- **Sector**
- **Company name**
- **Postal address**
- **Telephone number**
- **Fax number** (where given)
- **Website** (where given)
- **Description of core business** (where given)
- **Point of Contact** (where given: name and job title)
- **Date invitation sent**
- **Summary of subsequent communication**

For the textiles, optoelectronics, oil & gas and semiconductor workshops the selected companies were contacted by phone in advance of the invitation packs being sent. The purpose of the phone call was to identify an appropriate point of contact within the company. The contact details of the technical director, or head of research & development were sought. These were mostly provided, though some companies refused to give out contact details due to restrictions imposed upon them by the Data Protection Act. In such cases the letters were simply addressed to the Technical Director (or other job title provided by the company). The contact details for the health, medicine & biotechnology and food & agriculture workshops were not checked in advance: a larger number of companies were selected for the latter, which was thought likely to offset any inaccuracies in the data. For the former, the details were taken from a recently published directory (Biotechnology Scotland 2001 Source Book), hence were presumed to be reasonably accurate.

Invitations to companies

Approximately four weeks before the chosen date for a workshop, invitation packs were sent out to the selected companies. The invitation pack contained a letter (usually addressed to a named individual, mostly technical directors or holders of closely related position, e.g. head of research & development), a flyer for the workshop, a reply slip and a list of brief examples of successful applications of mathematics in industry.

The following text was extracted from a typical invitation letter:

I have pleasure in inviting you to take part in the above one-day workshop on Monday 11th March 2002, which will be held at the International Centre for Mathematical Sciences, 14 India Street, Edinburgh. The workshop is being hosted by the Smith Institute Faraday Partnership, which exists to promote collaboration between industry and academia in the areas of mathematics and computing.

The objectives for the workshop are: to raise awareness within industry of how the Smith Institute can help companies access and commercially exploit academic research and expertise in mathematics and computing; to understand how companies in the oil and gas industry and its supply chain use mathematics and computing in their businesses and to identify potential areas of collaboration on new and industrially motivated problems. The Smith Institute can help with the design of collaborative projects, the identification of relevant skills and expertise within academia and in securing financial support where appropriate.

During the workshop some examples will be discussed in which mathematical and computational ideas and techniques have been successfully applied to the solution of problems motivated by the oil and gas industry. Representatives from industry are also invited to give a short company presentation, highlighting any areas in which a mathematical approach to a problem (for example in research and development, design, manufacturing or production) could be of benefit.

After the initial invitations to the textiles workshop were sent out, a poor response rate was noted. In order to try and improve the response rate it was decided that in addition to the letters, flyers and reply slips, future information packs should also contain some 'marketing material' for mathematics. Colleagues at the Smith Institute created a two-page summary of successful collaborations across a range of industrial sectors. This was included in the information packs sent out to companies for the remaining workshops. For the Food & Agriculture workshop, a more targeted list of examples was produced and included, reflecting the great many examples of mathematics having benefited companies in this sector.

Two weeks after the invitations had been sent for a particular workshop, typically very few acceptances or rejections had been received. Those companies that had not responded were then contacted by phone. Usually several attempts were required in order to make contact with the company contact, who would then be asked to confirm whether they had received the information pack and were offered further explanation of the workshop. This would typically consist of a brief summary of the Faraday Partnership scheme, the Smith Institute, the objectives for the workshop, examples from other workshops and, where possible, the kind of areas it was envisaged might be appropriate applications of mathematics within the individual's business. The discussions from that point on took many paths: acceptances (usually conditional on availability or the granting of permission to attend by higher authority); a promise to circulate the information amongst colleagues; requests for the information to be re-sent or declinations.

Where a respondent declined, sometimes a reason was offered. For example, some respondents said they were too busy, or could not see the relevance of the workshop (or mathematics) to their business, or had no immediate requirement for the service. Such responses were recorded in the database. Note that where respondents declined the invitation and did not offer a reason, no attempt was made to extract one. This approach was considered to be more courteous and consistent with the right to 'exit' from an offer.

Invitations to academics

All heads of mathematics departments in Scottish universities had received information describing the initiative at the start of the project. Further information was then sent to them describing the workshops and their dates. Heads of department were requested to circulate the information to their colleagues. The letter extended an open invitation to all mathematicians (and implicitly to graduate students and research assistants as well as lecturers) interested in collaborating with companies to attend. In addition, the author contacted individual academics recommended by staff at the International Centre for Mathematical Sciences or by the SINIMS Steering Group as having relevant experience or interests.

Two academic speakers were sought to give presentations at each of the workshops. These were contacted directly and invited to describe several examples from their own experience in which mathematics had been used to the direct benefit of companies from the relevant sector.

Invitations to other organisations

Faraday Partnerships are actively encouraged by their government sponsors not only to engage with companies and academics in their own area of expertise, but also to establish links with other Faraday Partnerships and research organisations to allow cross-fertilisation of ideas. Thus invitations to workshops were extended to relevant organisations.

For example, the textiles workshop was attended by representatives from the TechniTex Faraday Partnership and the optoelectronics workshop was attended by the Imaging Faraday Partnership and Smart Optics Faraday Partnership. Representatives from these organisations gave short presentations on their respective research programmes and funding opportunities. The medicine & biotechnology workshop was attended by representatives from the Beatson Institute, the Biomedical Sciences Department at the University of Edinburgh and the Roslin Institute. The Roslin Institute also attended the food & agriculture workshop. The Petroleum Institute (based at Heriot-Watt University) attended the oil & gas workshop.

2.2.2 Format of the workshop

Each of the workshops adopted a common format. The author chaired all the workshops and gave an introductory presentation describing the objectives, running order and the general principles and organisation of the Faraday Partnerships. This was followed by a presentation (usually by another representative from the Smith Institute) on how the Smith Institute interprets the 'Faraday principles', its organisation, events, research programmes and methods of engaging with companies. Where relevant, representatives from other Faraday Partnerships would then offer similar short presentations on their organisations. The next two presentations in each workshop were from academics with experience of working on problems motivated within the relevant sector. Typically each speaker would outline three different problems that he or she had worked on and describe the contribution that mathematical ideas and techniques had made to the solution of the problem. Speakers were encouraged to keep the talks at a reasonably conceptual level where possible⁶. The objective was to help illustrate to the industrialists that mathematical ideas were highly relevant to their sector.

⁶ This approach was adopted in order to avoid raising concerns among the industrial participants that the degree of mathematical sophistication required was too high for them to engage in the workshop

After a buffet lunch, the afternoon session was devoted to presentations from company representatives. The speakers were asked to provide a brief introduction of their businesses, to explain how the company used mathematics within the organisation and, if possible, to identify one or two problems motivated from the business in which a mathematical or computational approach might prove beneficial. Each company presentation was followed by a discussion period in which the audience was encouraged to offer relevant experience and suggestions about the problems outlined by the companies.

At the end of each workshop, the author reviewed the objectives and explained that a short report would be generated and sent out to the participants in due course. To protect commercial confidentiality, industrial presenters would be offered an opportunity to review the relevant section of the report describing their presentation, after which a final report would be published on the website. The industrialists would then be contacted to discuss whether they would be interested in taking forward any of the problems as a collaborative project.

2.2.3 Post-workshop follow-up activity

At the time of writing, several companies have expressed a desire to create collaborative projects based on the problems they had outlined during the workshops. These opportunities are described in more detail later in the report. Notably, two of the companies that attended the workshops (Acordis, textiles workshop; Nan Gall Technology, oil & gas workshop) also agreed to take part in the 43rd European Study Group with Industry, held at Lancaster University from 2nd-5th April 2002 and one (Ahlstrom) took part in the MacsiNet Textiles Study Day on 4th April (also held at Lancaster University).

2.2.4 Analysis of workshop data

A total of over five hundred companies and two hundred academics were invited to take part in the workshops. The vast majority of the effort went into persuading industry to take part. By contrast, there was very little difficulty in persuading a sufficient number of academics to attend. The process of organising workshops certainly evolved as the SINIMS project progressed. It is important, therefore, not to read too much into quantitative data that follows. To illustrate the point, the first workshops were somewhat difficult to predict. This resulted in strenuous attempts to persuade as large a number of companies as possible to attend the first two workshops (textiles and optoelectronics). However, it was felt that possibly too many companies had attended, resulting in too short a time to allow adequate discussion of the problems they had presented. Hence for the remaining workshops, the attempts to persuade companies to attend continued until three or four had agreed to attend. This gave rise to a smaller workshop, but a longer and more effective discussion following each company presentation.

3 ANALYSIS OF MARKETING EFFECTIVENESS

In this section the analysis of data relating to the sector-based workshops and other activities undertaken to market the SINIMS initiative is presented. The data from individual workshops are treated first separately, then collectively. Conclusions from the analysis and possible interpretations are presented.

3.1 Workshop data

Each invited company was categorised according to its response to the invitation:

- A – Attended
 - A1 – attended the workshop and presented
 - A2 – attended the workshop but did not offer a presentation
- B – Did not attend
 - B1 – either the company did not reply to the invitation or did not communicate a decision after subsequent correspondence
 - B2 – the company declined without offering a reason
 - B3 – the company declined, stating that they did not think the workshop or mathematics was relevant to their business
 - B4 – the company declined, stating that they were too busy to attend
 - B5 – the company declined, offering a different reason to B3, B4.

Companies in A2 did not offer presentations either because they could not think of any problems to present, or did not want to present in front of potential competitors. At the outset the limitation associated with commercial confidentiality was discussed. However, the benefits associated with running sector-based workshops were thought greater, and hence some degree of reluctance to participate was an inevitable consequence. Most companies that attended did present, and either kept their presentations fairly unspecific, or else seemed not to be unduly concerned with confidentiality and described problems in considerable detail. Companies in B1 usually did not reply to the invitation. For those that were subsequently contacted, usually several times, either the invitee was unavailable, or did not communicate a final decision after discussing the workshop. Companies in B2 were not pursued to offer a reason when they had declined the invitation. It is difficult to distinguish those companies in B4 who were honestly stating that they were too busy (but otherwise interested) from those who saw no relevance for the workshop but were simply being polite. If it were possible to identify the latter, they would have been placed in category B3. Several companies gave different reasons for declining the invitation. For example, some had existing relationships with academics and regarded their needs as being already serviced. Others did not have existing relationships, could not see an immediate need, but envisaged a time when they might develop such a need and requested to be notified of any future events. Such responses were placed in category B5.

3.1.1 *Textiles workshop (16th January, 2002)*

Category	Total	Percentage
A1 – Attended & presented	6	7.7%
A2 – Attended, did not present	2	2.6%
Total Attended (A = A1+A2)	8	10.3%
B1 – Did not attend – no reply / decision received	50	64.1%
B2 – Did not attend – declined, no reason cited	12	15.4%
B3 – Did not attend – declined, not relevant	4	5.1%
B4 – Did not attend – declined, too busy	3	3.8%
B5 – Did not attend – declined, other reason	1	1.3%
Total Not Attended (B = B1+B2+B3+B4+B5)	70	89.7%
Total (A+B)	78	100%

Table 3.1: Textiles workshop – industrial response rates

Source of company information: Scottish Textiles website (part of Scottish Enterprise’s Textiles Cluster): (<http://www.scottish-textiles.co.uk>) and the TechniTex Faraday Partnership (<http://www.technitex.hw.ac.uk>). Only Technical Textiles sector companies were selected.

Industrial representation

- Acordis UK Plc (2 representatives)
- Ahlstrom Plc (1 representative)
- Assistive Technologies Ltd (2 representatives)
- Divex Ltd (1 representative)
- Don & Low Ltd (1 representative)
- Pail Containers Ltd (1 representative)
- SGL Technic Ltd (1 representative)
- WL Gore & Associates Ltd (1 representative)

Academic representation:

- Heriot-Watt University (5 representatives)
- Strathclyde University (2 representatives)
- UMIST (2 representatives)
- University of Oxford (1 representative)
- University of Edinburgh (1 representative)

Other organisations

- International Centre for Mathematical Sciences (1 representative)
- Smith Institute Faraday Partnership (2 representatives)
- TechniTex Faraday Partnership (2 representatives)

3.1.2 *Optoelectronics workshop (30th January, 2002)*

Category	Total	Percentage
A1 – Attended & presented	7	12.5%
A2 – Attended, did not present	3	5.4%
Total Attended (A = A1+A2)	10	17.9%
B1 - Did not attend – no reply / decision received	23	41.1%
B2 – Did not attend – declined, no reason cited	4	7.1%
B3 – Did not attend – declined, not relevant	3	5.4%
B4 – Did not attend – declined, too busy	11	19.6%
B5 – Did not attend – declined, other reason	5	8.9%
Total Not Attended (B = B1+B2+B3+B4+B5)	46	82.1%
Total (A+B)	56	100%

Table 3.2: Optoelectronics workshop – industrial response rates

Source: Scottish Optoelectronics Association website (<http://www.optoelectronics.org.uk>)

Industrial representation

- BAE Systems Plc (2 representatives)
- CRL Opto Ltd (1 representative)
- EMC Compliance Services Ltd (1 representative)
- Intense Photonics Ltd (1 representative)
- Alcatel Plc (formerly Kymata Ltd) (1 representative)
- Light Networking Ltd (1 representative)
- Optos Plc (1 representative)
- ST Microelectronics Ltd (1 representative)
- Terahertz Photonics Ltd (2 representatives)
- Thales Optronics Ltd (1 representative)

Academic representation

- Heriot-Watt University (4 representatives)
- Strathclyde University (4 representatives)
- University of Edinburgh (6 representatives)

Other organisations

- Imaging Faraday Partnership / UK Astronomy Technology Centre (2 representatives)
- International Centre for Mathematical Sciences (1 representative)
- SMART Optics Faraday Partnership (1 representative)
- Smith Institute Faraday Partnership (3 representatives)

3.1.3 *Medicine & biotechnology workshop (13th February, 2002)*

Category	Total	Percentage
A1 – Attended & presented	3	4.0%
A2 – Attended, did not present	1	1.3%
Total Attended (A = A1+A2)	4	5.3%
B1 – Did not attend – no reply / decision received	18	23.7%
B2 – Did not attend – declined, no reason cited	9	11.8%
B3 – Did not attend – declined, not relevant	19	25.0%
B4 – Did not attend – declined, too busy	20	26.3%
B5 – Did not attend – declined, other reason	6	7.9%
Total Not Attended (B = B1+B2+B3+B4+B5)	72	94.7%
Total (A+B)	76	100%

Table 3.3: Medicine & biotechnology workshop – industrial response rates

Source of company information: Scottish Enterprise Biotechnology Source Book 2001. (website: <http://www.biotech-scotland.org>) and the Medical Device Institute Scotland (<http://www.mdis.org>).

Industrial representation

- Aquapharm Technologies (1 representative)
- BioSil Ltd (1 representative)
- Hycor Biomedical Ltd (1 representative)
- Inverness Medical Ltd (1 representative)

Academic representation

- Heriot-Watt University (7 representatives)
- Nottingham University (1 representative)
- Strathclyde University (3 representatives)
- University of Edinburgh (7 representative)
- University of Glasgow (1 representative)

Other organisations

- Biomedical Sciences Unit, Edinburgh University (1 representative)
- Cancer Research UK (1 representative)
- Centre for Mathematical and Computational Sciences in Medicine (3 representatives)
- International Centre for Mathematical Sciences (1 representative)
- Roslin Institute (1 representative)
- Scottish National Blood Transfusion Service (1 representative)
- Smith Institute Faraday Partnership (3 representatives)

3.1.4 Food & agriculture workshop (25th February, 2002)

Category	Total	Percentage
A1 – Attended & presented	2	1.6%
A2 – Attended, did not present	1	0.8%
Total Attended (A = A1+A2)	3	2.4%
B1 - Did not attend – no reply / decision received	103	82.4%
B2 – Did not attend – declined, no reason cited	8	6.4%
B3 – Did not attend – declined, not relevant	3	2.4%
B4 – Did not attend – declined, too busy	7	5.6%
B5 – Did not attend – declined, other reason	1	0.8%
Total Not Attended (B = B1+B2+B3+B4+B5)	122	97.6%
Total (A+B)	125	100%

Table 3.4: Food & agriculture workshop – industrial response rates

Source of company information: FoodFirst website: (<http://www.foodfirst.co.uk>). Producers and suppliers only, not wholesalers or retailers.

Industrial representation

- Biomar Ltd (1 representative)
- Canongate Technologies Ltd (2 representatives)
- Simply Organic Ltd (1 representative)

Academic representation

- Heriot-Watt University (5 representatives)
- Strathclyde University (2 representatives)

Other organisations

- Biomathematics and Statistics Scotland (BioSS) (1 representative)
- International Centre for Mathematical Sciences (1 representative)
- Roslin Institute (3 representatives)
- Smith Institute Faraday Partnership (2 representatives)

3.1.5 Oil & gas workshop (11th March, 2002)

Category	Total	Percentage
A1 – Attended & presented	3	3.1%
A2 – Attended, did not present	1	1.0%
Total Attended (A = A1+A2)	4	4.1%
B1 - Did not attend – no reply / decision received	58	59.2%
B2 – Did not attend – declined, no reason cited	11	11.2%
B3 – Did not attend – declined, not relevant	12	12.2%
B4 – Did not attend – declined, too busy	9	9.2%
B5 – Did not attend – declined, other reason	4	4.1%
Total Not Attended (B = B1+B2+B3+B4+B5)	94	95.9%
Total (A+B)	98	100%

Table 3.5: Oil & gas workshop – industrial response rates

Source of company information: Scottish Enterprise Energy Group website:

(<http://www.se-energy.co.uk>).

Industrial representation

- Digital Geology Ltd (1 representative)
- Edinburgh Petroleum Services Ltd (1 representative)
- Halliburton Plc (5 representatives)
- Nan Gall Technologies Ltd (1 representative)

Academic representation

- Heriot-Watt University (6 representatives)
- University of Edinburgh (6 representatives)

Other organisations

- International Centre for Mathematical Sciences (1 representative)
- Petroleum Institute (1 representative)
- Smith Institute Faraday Partnership (2 representatives)

3.1.6 *Semiconductors workshop (24th April, 2002)*

Category	Total	Percentage
A1 – Attended & presented	3	4.2%
A2 – Attended, did not present	0	0
Total Attended (A = A1+A2)	3	4.2%
B1 - Did not attend – no reply / decision received	40	55.6%
B2 – Did not attend – declined, no reason cited	6	8.3%
B3 – Did not attend – declined, not relevant	10	13.9%
B4 – Did not attend – declined, too busy	6	8.3%
B5 – Did not attend – declined, other reason	7	9.7%
Total Not Attended (B = B1+B2+B3+B4+B5)	69	95.8%
Total (A+B)	72	100%

Table 3.6: Semiconductors workshop – industrial response rates

Industrial representation

- Analog Devices (1 representative)
- Cadence Design Systems (1 representative)
- Motorola Plc (1 representative)

Academic representation

- Heriot-Watt University (4 representatives)
- Napier University (1 representative)
- Strathclyde University (1 representative)
- University of Edinburgh (4 representatives)
- University of Glasgow (1 representative)

Other organisations

- International Centre for Mathematical Sciences (1 representative)
- Smith Institute Faraday Partnership (2 representatives)

3.1.7 *Analysis*

At least one member of the SINIMS steering group attended each of the seminars and provided feedback on the evolving format. Informal feedback was also received from other industrial and academic participants after each event. Several interesting remarks can be made based on these observations. In particular, the workshops which were generally considered to have been the most successful were on textiles, food & agriculture, oil & gas and semiconductors. Some possible factors that may have contributed to this, and other observations, are outlined below.

Workshop size

Fewer people attended the textiles, food & agriculture, oil & gas and semiconductors workshops (26, 18, 24 and 17 respectively, compared with 33 at the optoelectronics workshop and 34 at the medicine & biotechnology workshop). The attendance at each of the seminars, categorised according to whether the participants were from industry, academia or other organisations (e.g. Faraday Partnerships or research organisations) is summarised in the following table.

	Textiles	Opto-electronics	Medicine & Biotechnology	Food & Agriculture	Oil & Gas	Semi-conductors	Total
Industry Representation	10	12	4	4	8	3	41
Academic Representation	11	14	19	7	12	11	74
Others	5	7	11	7	4	3	37
Total	26	33	34	18	24	17	152

Table 3.7: Summary of workshop participation

Workshop intensity

Those workshops which had a smaller audience also had slightly fewer presentations. The presenters had all been asked to provide a brief introduction to the company and to spend more time outlining problems where a mathematical approach may benefit. However, most presenters still spent considerable time on the introduction. The presentation slots at the largest workshops were thirty minutes each. The slots were extended to forty or forty-five minutes for the workshops with fewer presentations. Thus those presenters who spent substantial time on the introduction at the busier workshops did not have sufficient time to describe and discuss their problems. For the smaller workshops, each presenter was able to explain to the audience his background and perspective and to describe one or more problems in greater detail. This gave rise to more effective interaction between the speaker and the audience during the presentations and resulting discussions. It seems likely also that delegates felt more willing to contribute to the discussion simply by virtue of there being fewer people in the room.

Technology background

A third possible insight into the relative success of the different workshops arises from the “closeness to technology” of the different sectors. For example, the textiles and food sectors employ less sophisticated technology (broadly speaking) than the optoelectronics and semiconductor sectors. To be specific, the industrial participants at the optoelectronics workshop all employed mathematics regularly in the design, modelling and simulation of optical devices. However, the sophisticated mathematics used in such processes is largely unseen to the design engineer and takes place “behind the scenes” via off-the-shelf commercial software packages. Industrial representatives from these sectors easily recognised the importance and relevance of mathematics to their business, but also seemed to suggest that the software packages largely met their needs. So much so that the smaller optoelectronics companies relied entirely on these packages and thus did not employ any mathematicians at all. The larger optoelectronics companies (BAE Systems, Thales Optronics) did employ a number of qualified mathematicians, though largely for algorithm development and systems engineering rather than optical device modelling.

By contrast, most of the representatives from companies that attended the textiles workshop were certainly not used to thinking about mathematics as being relevant to their business. (Acordis is the main exception, having submitted numerous problems to mathematics ‘Study Groups’ over several years.) Thus prior to the workshop, most of the textiles industry representatives were unable to think of areas of their business where mathematics might have a role to play. In effect, they attended the workshop more out of speculation than belief. They tended to approach the question of finding opportunities for mathematical input to problems from an opposite (though equally valid) viewpoint. Rather than trying to identify industrial applications from a very small mathematical knowledge base (usually school rather than university level sophistication), they presented instead examples of everyday industrial problems within their businesses and challenged the academics to identify any that were mathematically tractable. More often than not, such problems could indeed be identified.

Case studies

Several industrialists commented during and after the workshop that the examples described during the morning session and the enthusiastic academic response to the problems they had outlined in the afternoon session had been both surprising, and had opened their eyes to the relevance of mathematical techniques to their business. In particular, the insights offered by mathematical modelling of manufacturing processes were acknowledged to be both very powerful and relatively cost effective compared with the usual ‘destruction testing’ alternative.

Company size

The representation from SMEs versus large organisations is summarised below:

	Textiles	Opto-electronics	Medicine & Biotechnology	Food & Agriculture	Oil & Gas	Semi-conductors	Total
SME	3	6	2	3	3	0	17
Large / Multinational	5	4	2	0	1	3	15
Total	8	10	4	3	4	3	32

Table 3.8: Summary of participation versus company size

Most of the workshops had at least half of the industrial representation from SMEs, the exceptions being textiles and semiconductors. Overall, 53% of the total number of companies that attended the workshop were from SMEs, thus satisfying one of the original objectives. However, care should be taken not to misinterpret the statistics, as far more SMEs were originally invited than large companies, reflecting the composition of industry in Scotland (and elsewhere).

Representatives from larger companies across the sectors normally had a centralised research and development facility, almost invariably overseas in the cases of a foreign parent company. Companies from the relatively high-tech sectors of optoelectronics, oil & gas, medicine & biotechnology and semiconductors maintained relationships with universities, though none with mathematics departments. The textiles and food & agriculture companies had fewer relationships with university departments, and none with mathematics departments.

Sector comparison of industrial response rate

The response rates from companies across the different sectors are summarised below:

Sector	Response Rate (acceptances as percentage of invitations sent)
Textiles	10.3%
Optoelectronics	17.9%
Medicine & Biotechnology	5.3%
Food & Agriculture	2.4%
Oil & Gas	4.1%
Semiconductors	4.2%
Average	6.3%

Table 3.9: Sectoral comparison of industrial response rates

The average acceptance rate of 6.3% is based on a total of 32 companies attending the 6 workshops from a total of 505 invitations. The lowest response rate was from the food & agriculture sector (2.4%). The optoelectronics sector exhibited the highest response rate (17.9%).

The above statistics were influenced by the evolving process as the SINIMS initiative progressed. Once the optimal balance of industrial and academic participants and the overall size of the workshop were estimated, the author tried to aim for this target in the remaining seminars. Hence it would not be fair to read too much into the apparent poor response rates for medicine & biotechnology (5.3%), food & agriculture (2.4%), oil & gas (4.1%) and semiconductors (4.2%) compared with the textiles (10.3%) and optoelectronics (17.9%), which were the first two workshops to be held.

Finally, a small number of companies that declined invitations to workshops indicated that they were unable to attend due to resource or time constraints, or for reasons of commercial confidentiality, but were otherwise interested in the initiative. Such companies were contacted again after the workshops to discuss possible site visits. As an example, Carlsberg-Tetley was unable to attend the food & agriculture workshop, but was subsequently visited to discuss problems relating to heat distribution through large vessels of green beer. Other companies did not have any immediate requirement, but asked to be kept informed of future events.

3.2 Other data

Apart from the workshops, the other forms of marketing the SINIMS initiative were largely unsuccessful. Two press releases were issued during the project, both describing the SINIMS initiative and its objectives. Technology Ventures Scotland printed a promotional article in the December edition of its monthly publication entitled *Spur*. Scottish Enterprise printed a similar article in early 2002 in their bulletin 'CommTecho', aimed mainly at businesses in the communications technologies sector. Neither of these led to any enquiries to the project office. The poster stand at the 'Innovations in Scotland in the 21st Century' Conference, held in Glasgow in November 2001 produced relatively few enquires and no follow-up activity. No serious enquires resulted from the SINIMS or Smith Institute websites (other than offers to redesign them from web consultancies), or from links to it hosted by other organisations (Technology Ventures Scotland, Foresight, the Royal Society of Edinburgh and scottishresearch.com). Finally, very few personal introductions were facilitated by these organisations, though Scottish Enterprise provided some useful contacts.

The posting of a brief description of the SINIMS initiative on the Scottish Microelectronics Organisation website led to an enquiry from QinetiQ to assist on a due diligence exercise on a proposed design for a new broadband internet communication technology. This resulted in a short consultancy contract (see next section).

3.3 Prospects for new collaborative activity

The SINIMS initiative resulted in several small collaborations between industrialists and academic mathematicians. These, and further opportunities still being developed, are summarised below.

3.3.1 Completed / ongoing collaborations

Vesian7

Vesian7 is a small company (2 employees, based in Lanarkshire) developing a communication technology to increase data transfer rates over traditional copper wires. Vesian7 have received grant assistance from Scottish Enterprise to prepare a business plan for the next phase of funding and have contracted with QinetiQ (the former industry arm of the Defence Evaluation and Research Agency) to perform a technical due diligence exercise. QinetiQ staff seconded to the Scottish Embedded Software Centre in Livingston contacted the SINIMS office seeking assistance with validation of signal processing algorithms. This led to a five-day consultancy contract for an academic at the University of Edinburgh. At the time of writing the consultancy is ongoing. If the design is successfully validated, Vesian7 intend to license its development to manufacturing partners in the communications industry.

Nan Gall Technology

Nan Gall Technology is a small company (15 employees) based in Aberdeenshire and operating in the Oil & Gas sector. The company designs and manufactures a range of transducers to operate in down-well environments. The products must withstand extremes of temperature and pressure. The company is developing a new product to add to its range of sensors, incorporating a device to estimate fluid density and viscosity. Traditional methods are inaccurate or involve hazardous materials. Nan Gall's method uses an alternative technology based on a resonating tuning fork. A representative from the company attended the oil & gas workshop and requested assistance with mathematical modelling or simulation of the device to determine the optimal operating conditions; to quantify the performance degradation due to the proximity of metal housing to the tuning fork; and to simulate the effect on device performance of different fluid mixtures and geometries. The problem was identified as being particularly suitable for submission to the 43rd European Study Group with Industry at Lancaster University (2nd-5th April 2002). The problem received attention from a group of eminent academics over the course of the study group, and produced satisfactory answers to two of the three questions posed by the company.

Acordis

Acordis is a multinational organisation in the textiles sector, with UK offices in Grimsby. Acordis has previously collaborated with the Oxford Centre for Industrial and Applied Mathematics

(OCIAM) and submitted numerous problems to study groups. Representatives from Acordis attended the textiles workshop and presented a new problem concerning the scheduling of customer orders for the manufacture of non-woven fabrics. The temporary shutdown of production lines to alter machine settings (e.g. for colour changes) incurs considerable cost. It is thus desirable to minimise the number and duration of shutdowns required by the careful scheduling of customer orders. At present this process is performed by machine operators based on their accumulated experience. Acordis requested assistance with the design of an algorithm that could automatically schedule customer orders so as to minimise costs due to stoppages. The problem was considered suitable for the study group at Lancaster University (2nd-5th April) and subsequently presented there. The collaboration produced significant insights into the problem. The solution will be further developed as an MSc project for the Operations Research Masters programme at Lancaster University.

Ahlstrom

Ahlstrom is a textiles company based in the Scottish Borders. It is part of a multinational organisation headquartered in Finland. Representatives from the company attended the textiles workshop. The manufacturing facility in Duns, Berwickshire, produces wrappers for meat products (especially sausage skins). It is a key requirement of Ahlstrom's customers that the wrappers exhibit uniform elasticity characteristics. Excess variability results in wastage and unnecessary costs. The current production process does not produce uniform elasticity, and Ahlstrom would like to understand the mechanism by which the non-uniformity is introduced during their manufacturing process. The problem was subsequently submitted to the MacsiNet textiles day at Lancaster University on 4th April 2002, resulting in a number of possible directions for future research projects. In particular, knowledge of similar problems in the paper industry (but with different end-user applications, e.g. corrugations in tracing paper) may allow for a research project involving more than several such organisations.

In addition to the elasticity problem described above, Ahlstrom also required a deeper understanding of data processing relating to a facility for measuring the basis weight of a textile. The estimates are currently produced and analysed as time series data. In order to be able to provide further insights into the data, in particular to identify dominant frequencies which can then be matched to faulty rollers on the production line, consultancy is currently underway to provide an algorithm by which the time series data can be converted and analysed in the frequency domain. This work is being carried out by the author and an academic at the University of Edinburgh.

3.3.2 *Other prospects for collaborative projects*

In addition to the collaborative projects described above, which are either complete or substantially underway, a number of other opportunities for creating new collaborative projects are being developed. These opportunities arose from problems presented at the workshops. The companies concerned are summarised below.

Optoelectronics:

- CRL Opto
- Terahertz
- ST Microelectronics

Food & agriculture

- Canongate Technology
- Carlsberg Tetley

Oil & Gas

- Halliburton Subsea

Semiconductors

- Analog Devices
- Motorola

The author's original period of secondment to the Smith Institute under the DTI Special Initiative expired in April 2002. However, the author has agreed to continue in post until October 2002 to develop these remaining opportunities further. This activity is being funded by the Smith Institute.

4 CONCLUSIONS

- Relationships with government agencies, enterprise and technology transfer organisations were established during the initiative, including Scottish Enterprise, Technology Ventures Scotland, the Scottish Institute for Enterprise, Foresight, the Royal Society for Edinburgh, the Scottish Embedded Software Centre, QinetiQ and the Defence Diversification Agency.
- Over five hundred companies were contacted directly during the SINIMS project. Most of the companies were small or medium sized enterprises based in Scotland, though some of the larger firms had headquarters outside Scotland. Thirty-two companies attended one of six sector-based workshops (textiles, optoelectronics, medicine & biotechnology, food & agriculture, oil & gas and semiconductors) held at the International Centre for Mathematical Sciences in Edinburgh.
- All thirteen university mathematics departments in Scotland were contacted during the project. Forty academics (lecturers, post-doctoral researchers and graduate students) attended one or more of the six sector-based workshops.
- Four collaborative projects involving companies and academics took place during the six-month initiative, benefiting companies in the oil & gas, textiles and communications technology sectors. Several more opportunities that arose during the project are still being actively pursued. This has resulted in an extension to the SINIMS project for a further six months beyond the original period of the DTI Special Initiative. (The project extension is being funded by the Smith Institute.)
- For companies with little experience of interfacing with academia or in using mathematics in their businesses, especially low-tech companies, the proposition can be somewhat difficult to market and is most easily described by way of case studies. In particular, it would be highly desirable to build up a small database of case studies in which mathematical or computational approaches to problems - from a variety of industrial sectors – had proved beneficial to companies.

REFERENCES

- [AIRTO] **The contribution of Faraday Partnerships to growth in innovation intensity in the UK economy**, Association of Independent Research & Technology Organisations (2001)
- [Dav91] **The SIAM Mathematics in Industry Project Report 1:Some Views of Mathematics in Industry from Focus Groups**, Society for Industrial and Applied Mathematics (1991)
- [FP01] **Faraday Partnerships: Best Practise Guidelines**, Faraday Partnerships (2001).
- [GUN97] J. Gunawardena, **Basic Research in Mathematics Collaboration between Industry and Academia**, Working Paper for Discussion Meeting at The Isaac Newton Institute on 4th November 1997.
- [JRO95] J.R. Ockendon, **The Moving Interface Between Mathematics and Industry**, Proc. International Congress on Industrial and Applied Mathematics, pp. 307-316. (1995)
- [MII98] **The SIAM Report on Mathematics in Industry**, Soc. for Industrial and Applied Mathematics (1998)
- [MP80] **Competitive Strategy: Techniques for Analysing Industries and Competitors**, M E Porter, New York Free Press (1980)
- [RSA98] **Report of the Senior Assessment Panel of the International Assessment of the US Mathematical Sciences**, US National Science Foundation (1998)
- [SBSB00] **Scottish Biotechnology Source Book** (2000)
- [SCCI00] **Briefing paper on the Scottish Textiles and Clothing Industry**, Scottish Executive Enterprise and Lifelong Learning Department and Scottish Textiles Network (2000)
- [SIRD02] **Mathematics: Giving Industry the Edge**, Smith Institute Roadmap Document (2002)
- [WC00] **Mathematics and Statistics**, M. Wright & A. Chorin, US Nat. Sci. Foundation (1999)

Web sites:

http://www.dti.gov.uk/	Department of Trade and Industry
http://www.ecmi.dk	European Consortium for Mathematics in Industry
http://faradaypartnerships.org	Faraday Partnerships
http://www.foresight.gov.uk	Foresight
http://www.epsrc.ac.uk	Engineering and Physical Sciences Research Council
http://www.ma.hw.ac.uk/icms/	International Centre for Mathematical Sciences
http://www.maths.ox.ac.uk/ociam	Oxford Centre for Industrial and Applied Mathematics
http://www.ma.hw.ac.uk/icms/sinims	Scottish Industrial Networking Initiative
http://www.pims.math.ca	Pacific Institute for the Mathematical Sciences
http://www.siam.org/	Society for Industrial and Applied Mathematics
http://www.smithinst.ac.uk	Smith Institute

A. WORKSHOP REPORTS