# EPSRC Analytical Science Review

## $8^{th}$ – $9^{th}$ March 2006

## Park Inn Hotel, Heathrow

**Panel Chair: Prof Saul Tendler (University of Nottingham)**
**Report Prepared by: Dr. Carmine Ruggiero (EPSRC)**

**Acknowledgements**

The EPSRC would like to thank the following for helping with the success of the theme day:

The Panel for their hard work and enthusiasm under the chairmanship of Professor Saul Tendler

The grant-holders and researchers for their posters and discussions with the panel

The speakers for their excellent and stimulating talks:

Professor Bonner Denton (University of Arizona)
Professor AP DeSilva (Queen's University Belfast)
Professor Douglas Kell (University of Manchester)

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**Appendices**

## Executive Summary

The primary objective of the Analytical Science Review was to evaluate EPSRC's Analytical Science portfolio to provide guidance for future investment strategy in this cross cutting, interdisciplinary research area. The main activity to satisfy this objective was the assessment of the current portfolio by an expert panel. The panel formally assessed the research quality, training aspects, impact and exploitability of 20 recently completed or near to completion grants. The panel also received the summaries of an additional 25 grants within the portfolio. Posters detailing the work on all 45 grants were presented at the theme day. The panel also received inputs from a bibliometric study, an evaluation of final reports, and utilized breakout sessions during the review.

The panel used the Quality, People, Impact and Exploitability (QPIE) Framework to evaluate the portfolio. The panel considered that overall the research quality of the portfolio was seen as competitive both internationally and within the EPSRC chemistry portfolio as a whole. While the analytical science portfolio includes grants of the highest quality and impact, the relatively small size of the portfolio was a concern. The portfolio as currently identified contains areas of strength; however there are also gaps, for example it appears there is relatively little research, which require a significant initial investment in equipment. It is unsurprising that the portfolio includes such gaps given its relatively small size.

The panel did note that there appeared to be omissions in the grant portfolio presented in the briefing material, particularly in grants funded through the Basic Technology programme. Correctly identifying additional elements within the portfolio may partially address the concerns regarding the size and completeness of the portfolio. The panel did however agree that the existing funding mechanisms are sufficient to address this.

The second day of the review focussed on industrial engagement in this area and also a review of the EPSRC / RSC studentship scheme. Posters were presented by students funded through the joint scheme, which were assessed informally by the panel. The panel were looking to assess the overall training package received by the students. Overall the panel considered the students to be of high quality focussing on specific areas, with appropriate projects. However the panel did not see that there was any significant difference between the training received by these students and those funded through other routes.

The Panel made the following conclusions and recommendations:

- In order to adequately assess the health of UK analytical science the review should not be focused on chemistry enabling techniques. There is much creative analytical science within the materials, engineering and the biological sciences. A key difference from the last review is the development of post genomic science where analytical science development is particularly crucial. EPSRC should assess how to ensure these additional research areas are included in a coherent portfolio.

- EPSRC should make efforts to better capture the analytical science research which is already being funded through the Research Councils. The data presented to the panel based on current coding appeared incomplete. Examples include the major programmes of work funded through the Basic Technology programme. Panel members were involved in a number of projects which involved analytical technique development; however, the coding of these grants had not recognised the analytical science component.

- The UK has a number of world leading research groups; a significant proportion of these groups are clustered at institutions which could be described as centres of excellence. However, as the number of researchers is often relatively small (2-3 members of faculty), it only requires relatively small numbers of researchers to move to have a major effect on the analytical research at a specific institution. In the case of Analytical Science the leading centres appear comparatively transient. In this context, the panel concluded that there is no specific need for an initiative increasing research capacity in the UK such as through the funding of additional chairs. EPSRC should still be receptive to initiatives from individual institutions to partner in the support of a potential star recruit; however any recruit should be an addition to the UK research base such as from industry or overseas.

- The image of analytical science is not considered as poor as previous reviews have identified. However, there is still an issue in that researchers establishing their careers may not choose to highlight the technique development aspects in comparison to the potentially more attractive application science. Efforts should continue to promote the crucial central role which analytical science has in chemistry and related disciplines. The ESPRC / RSC Analytical Science Chair holders could be a potential focus for this activity in the short term. A coordinated approach between the relevant funders is recommended targeting key groups such as 6$^{th}$ formers or early career academics.

- The multi-disciplinary research contained within the portfolio ensured that researchers had strong connectivity with other areas. A number of the researchers presenting work at the review received funding from a variety of sources with EPSRC often a minority component. It is crucial that as many stakeholders as possible are made aware of potential impact of the research being carried out within the portfolio. Analytical science researchers are in a unique position to influence Government agencies and policy makers through their ability to provide new measurements. There would be some value in establishing how the breadth of analytical research is funded in the UK, which could inform future policy on EPSRC funding.

- The number of proposals which appeared to be submitted to EPSRC was considered low, even if the data presented included only those elements which were directly chemistry relevant. Additional engagement with the community was required to highlight the diverse opportunities available across the Research Councils; however, such promotion must be careful not to simply raise expectations.

- The impact of the formal managed analytical science programme (1995 – 2000) is still unclear. The completed grants funded through the managed activity should be re-examined to assess the outputs from the research portfolio. As all of these grants formally ended 3 – 8 years ago, it may be opportune to capture these outputs both to assess the success of the programme and also capture any highlights for publicity.

- The EPSRC / RSC studentship scheme has had consistently high demand throughout its existence. It is unclear whether the scheme is delivering the underpinning of the training base that was envisaged when the scheme was expanded following the last review. The panel considered that there are a number of routes to securing PhD studentships in this area apart from the scheme itself, which funds only a minor component. The scheme has value as there continues to be training needs; however, the scheme should be redeveloped to take account of this. In order to further develop the training elements, awards should be consolidated to nucleate a number of students at a smaller number of institutions. Awards must require a specific training package to be incorporated either within the institution or in partnership with industry.

- There appeared to be some disconnect between the training requirements of industry and those provided by funders and providers of graduate and postgraduate training. The two main areas appear to be a broad appreciation of analytical techniques and the context of their research both within academe and industry. There should be increased dialogue between stakeholders to seek to address this issue and to ensure that training continues to meet the needs of UK academe and industry. This issue is one where the recently formed Chemistry Innovation KTN would be best placed in taking the lead.

## 1. Introduction

### 1.1. Portfolio Reviews General

The primary objective of a portfolio review is to evaluate the effectiveness of the EPSRC's support for research in an area that cuts across programme boundaries. Such reviews are, therefore, a constituent part of the overall evaluation framework and, along with Programme and Sector evaluation reports, feed into the business planning process. Secondary objectives of such reviews are to provide advocacy by generating information on research achievements and successes that can be used to demonstrate the importance and relevance of research; and to provide an opportunity for individuals within a particular research community to network with others.

These reviews also provide a mechanism for examining topics of research that span programme areas. An independent expert review panel provides opinion on a representative sample of grants from the research theme and draws conclusions about the portfolio as a whole, or major segments of it. These reviews are not concerned with constructing league tables of individual grants or individual research groups, nor are they trying to isolate individual achievements or failures. The Panel's considerations are facilitated by discussion with, and poster presentations by, grant holders. Grants are scored on the basis of these discussions against the agreed QPIE (Quality, People, Impact, Exploitability – see Appendix (1)) evaluation framework. These ratings are then aggregated to consider the quality and impact of EPSRC funded research in the theme.

### 1.2. Analytical Science Grant Portfolio Review

EPSRC’s Analytical Science portfolio was last evaluated at a theme day held in 2000. A number of recommendations resulted from that review including the initiation of 3 analytical science chairs, the EPSRC / RSC studentship scheme and the formation of 4 analytical science networks. It was thus thought timely to review the portfolio to inform future EPSRC policy in this area and also to look closely at how the research has developed in the UK and how it may impact in future.

Prior to the theme day the panel was sent a volume of papers containing a bibliometric study of analytical science, an evaluation report based on the current EPSRC portfolio and the most recent reviews of the area. These papers together with the grant synopses and associated posters were used as inputs to the panel to enable it to review and evaluate the EPSRC research grant portfolio for Analytical Science. The primary objective was to indicate its strengths and weaknesses, highlight the opportunities and threats, and to develop a strategy to deal with these.

Other features of the Analytical Science review were:

Three oral presentations were given by UK and International experts to help set the scene and act as further input to the panel.

The theme day was opened to allow people other than the poster presenters to attend and get a view of the EPSRC's Analytical Science portfolio.

Industrialists and PhD students were invited to a specific element of the review. The industrial representatives examined analytical science postgraduate training requirements from a variety of sectors. The PhD students presented the research funded through the EPSRC / RSC studentship scheme and also examined issues surrounding promotion of the area.

Breakout sessions were also organised based around a number of analytical science challenges both in research and training to glean a wider view of the state of the EPSRC Analytical Science portfolio, the output from these sessions was also used as input to the panel.

The Agenda for the Theme day is given in Appendix (2).

## 2. Conduct of Study

### 2.1 Grant Selection.

Current grants that had been underway for at least two years before March 06 and grants that had been completed within a year prior to March 06 were considered as candidates for the review. Grants were selected which had been classified with a research topic 'Analytical Science'. This gave a population of 63 grant holders who were approached and asked if they would be willing to attend the review event and to supply a grant synopsis if they were. This led to 45 grants being represented by posters at the event. To ensure attendance on the day, emphasis was given to those projects where analytical science was the major component of the research, based on EPSRC grant coding. The panel had a synopsis for each of the grants highlighted at the event. The panel examined 20 posters in detail, the majority of those involved grants where the focus had been on analytical science. The panel also had an opportunity to informally view the remaining posters.

### 2.2 Panel

The full listing of the panel is given in Appendix (3). The panel consisted of scientists and technologists from academia and industry, and was chaired by Prof Saul Tendler of the University of Nottingham. The panel also included an overseas representative to provide an international perspective.

### 2.3 Portfolio review

The main activity for the panel at the review was to evaluate the grants selected against a framework comprising the following criteria:

Quality: *Intrinsic excellence of the research in world terms*

Impact: *The potential for wider impact on other research*

People: *The extent to which the skills of the research staff are in demand from, and meet the requirements of employers*

Exploitability: *The potential to contribute to (UK) wealth creation and quality of life*

Each of the criteria was scored a scale of 1-5 details of the meanings of the score levels is given in Appendix (1).

Two panel members were assigned to assess each grant. Panel members had 15 minutes allocated to each poster for discussion with the relevant researcher. A full listing of the posters presented at the theme day is given in Appendix (8)

2.5 Panel Inputs.

In the breakout sessions attendees were asked to consider the current state of Analytical Science in the UK and then consider what might be the major research challenges for Analytical Science on the 5 and 10 year horizon.

The papers sent to the panel members included:

- a report of the previous Analytical Science Review held in 2000,
- a bibliometric report on Analytical Science citations,
- an evaluation report based on relevant EPSRC grant data,
- A collection of summaries of key documents from outside of EPSRC that had some relevance to Analytical strategy.

These papers together with the grant synopses and associated posters and the posters derived from the breakout sessions were inputs to the panel to enable them to review and evaluate the EPSRC research grant portfolio for Analytical Science.

## 3. Results

3.1 Overall:

The individual scores were combined under each criterion average scores for each theme and the proportion graded as 4 or 5 are given in Table (1).

It should be emphasised that the metrics and graphs were produced as inputs to the panel conclusions and that there has been no statistical analysis as to the significance of differences between scores. The small number of grants would make any statistical analyses difficult and the intention of the scoring was to assist the post panel assessment rather than provide an absolute measure for each criterion.

Table (1) Average Metrics for 2005 Theme day.

| | Quality | People | Impact | Exploitability | Overall |
|---|---|---|---|---|---|
| **Average score** | 3.45 | 3.20 | 3.00 | 3.35 | 3.40 |
| **% graded 4 & 5** | 45% | 45% | 30% | 40% | 45% |

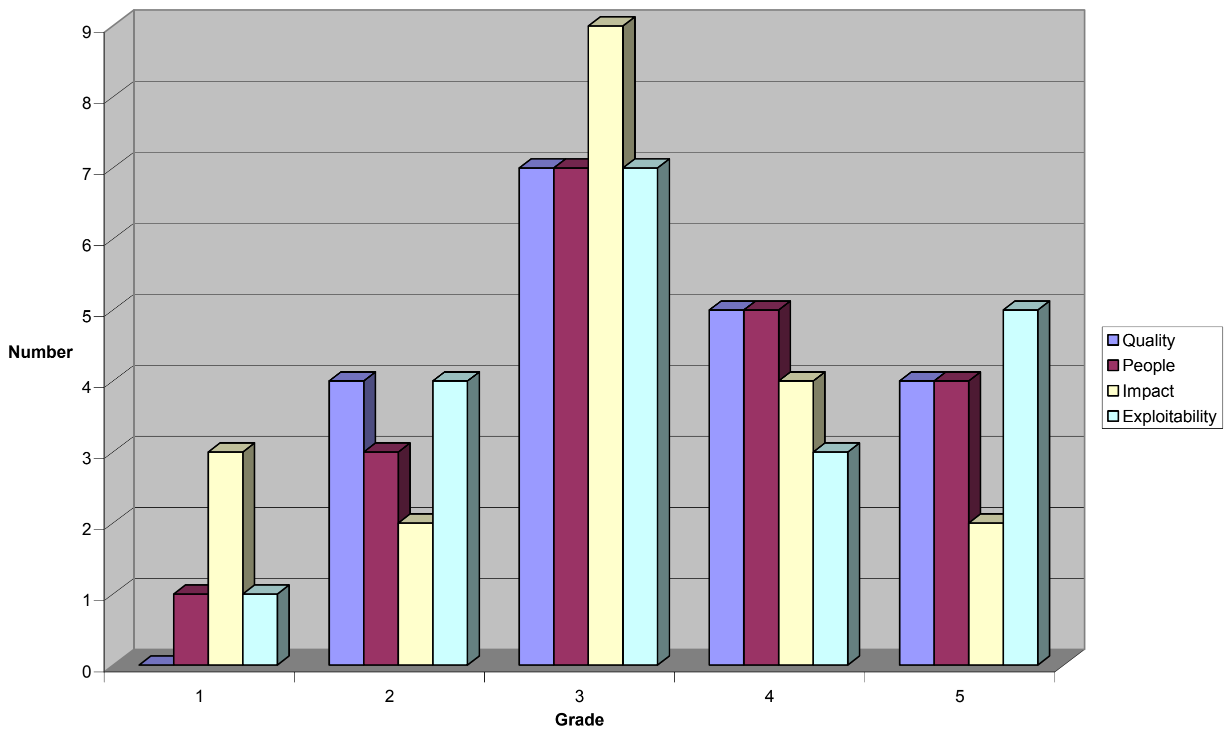


**Figure 1 Number of grants graded against the specific QPIE criteria**

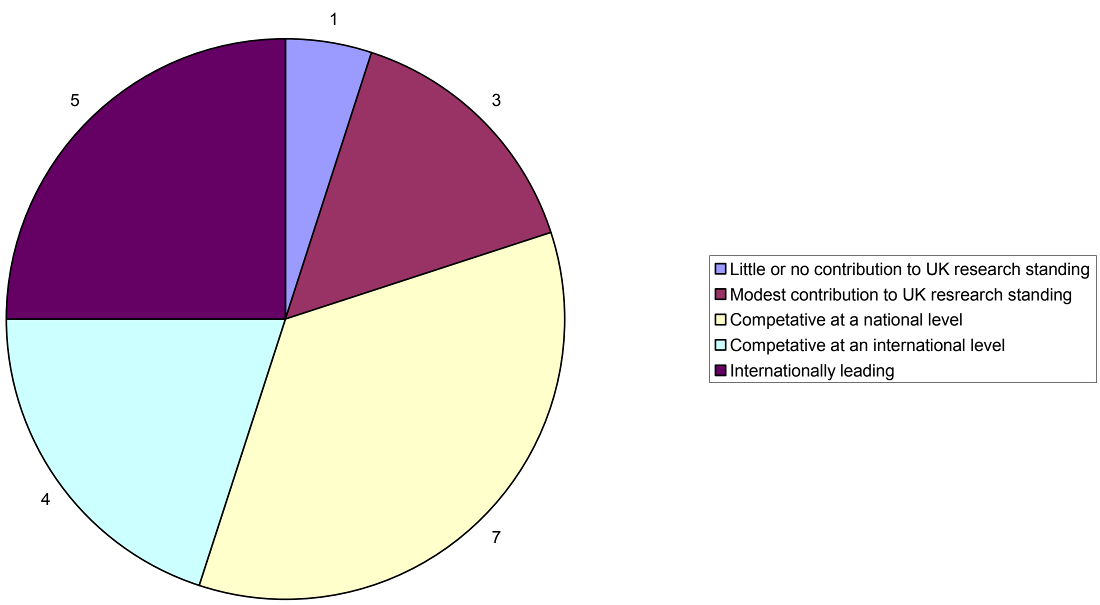


**Figure 2 The number and proportion of overall grades for the grants assessed**

Quality

The overall average quality was 3.4 with the proportion of grants that were graded 4 or 5 at 45%. There was no evidence for strengths and weaknesses in any particular research areas with research quality varying within all areas. The overall levels of research quality appear consistent with similar reviews within chemistry and the Final Report scores of grants across the chemistry programme.

People.

Nearly all the grants assessed were considered to have provided good to excellent training opportunities, both for PDRAs and PhD students. This is reflected in the grades, with 45% achieving 4-5 grades and only 4 grants being assessed at 1-2; the lower scores reflected specific issues which occurred during the project rather a lack of additional training opportunities. The training provision tended to be project specific, though one PDRA has subsequently been involved in the generation of a spin out company.

Impact.

The scores for impact appear slightly lower than the other criteria; however, as this represents only slight differences in the scores it should not be considered statistically significant. The majority of projects appear to be integrated with potential beneficiaries of the research.

Exploitability.

Analytical science is an area where there should be great potential for exploitation of the methodology or technology developed. A number of the projects have links with industry either through formal collaborations or have generated exploitation after the grant has been awarded. A variety of industrial sectors are engaged with the portfolio including the pharmaceutical and security sectors. This is at least partially reflected in the score of 3.35, which compares well to those areas of the chemistry programme that have also been assessed through a theme day, most recently in catalysis. The proportion of grants assessed as having a 4-5 grade also compares favourably with the remainder of the portfolio. While comparable to the remainder of the portfolio given the nature of the discipline it is perhaps surprising that the average score was not higher (though this criterion did have the highest number of grants with the highest score).

3.3 Breakouts:

The breakout session focussed on two of the primary issues relating to analytical science. The academically focussed breakouts examined a number of grand challenges in analytical science. All delegates were invited to submit what in their view was a current grand challenge in analytical science. The panel examined all the submitted grand challenges and collated them into 5 thematic challenges in analytical science. The 5 challenges presented to delegates are listed below along with short summaries of the main areas of discussion:

1) **Analysis of soft wet matter at high resolution**
Environmental Forensics – multidisciplinary approach to characterising changes in the environment. Combining imaging techniques to allow high resolution non destructive characterisation.

2) **Large Parameter Spaces: Omics, Sensors, Screening**
To characterise and measure interactions of 100,000 components at a dynamic range $>10^{10}$ and to model the dataset generated.

3) **Chemical Imaging: Time Spatial Resolution, Information Content**
Fast, high resolution, multidimensional chemical imaging of real systems focussing on materials and biological applications.

4) **Non Invasive Techniques: Remote Sensing, Pharmaceuticals, Physiological Sensors, Chemical Processes**
To obtain information about the health/disease status of an individual by a method which does not cause pain or damage. To find new contrast mechanisms eg different frequencies may reveal/detect items/chemicals etc or interest. The development of core science and engineering systems (instruments) that are high resolution and low power.

5) **Transient Phenomena: In Cells, Catalytic Systems, Interfaces**
Structural information (molecular) at high spatial and temporal resolution within complex systems.

The topics were kept purposefully broad to allow delegates latitude to develop the specific research areas and objectives around these challenges as they wished. It was hoped that as the challenges had been submitted by delegates and not developed by the panel, that delegates would have increased ownership of any outputs from the workshop. The sessions were only briefly introduced by EPSRC staff to ensure that there was no steering from the office on any of the outputs. Some groups were able to progress further in developing objectives than others; however all groups have been offered the opportunity to submit a consortia building proposal around the challenge. The outputs from the workshop are summarised in appendix 4.

## 4. Panel Analysis and Comments on Results

The panel wish to thank colleagues from the EPSRC for their professional preparation of the background information, high-level support at the meetings and for the excellent running of the theme day itself.

Analytical science is a broad subject and can be interpreted in several ways. Analytical science spans the entire EPSRC portfolio and covers, for example, DSC for polymer analysis, electron microscopy, X-ray diffraction, synchrotron techniques. Analytical science can also be defined more narrowly as analytical chemistry. In this study, the data provided and portfolio assessed appeared to focus on analytical chemistry. If EPSRC wishes to examine analytical science more broadly it should make increased efforts to ensure that appropriate and robust coding is given to proposals. Any future assessment could also have added value if it was conducted in collaboration with other Research Councils.

While the volume of Analytical Science grants is a relatively low component of the EPSRC Chemistry Programme, the panel were impressed by the palpable level of enthusiasm for research that was displayed by grant holders, researchers and postgraduates alike. The presented assessment indicates that the analytical science portfolio includes grants of the highest quality and impact, however, the relatively small size of the portfolio was a concern. The panel was also concerned about gaps within the portfolio, most notably in the area of the development of next-generation instrumentation. At the same time, the panel was clearly of a view that significant additional analytical science was funded by the EPSRC in a range of other programmes including Engineering, Materials and Basic Technologies. In this regard, this analysis covers only a small fraction of total analytical spend. Given the current portfolio of funding that is operated by EPSRC the panel could not discern the need to create a new funding scheme that was specifically for analytical sciences.

Analytical science appears to still have a relatively poor perception in UK chemistry departments, though there has been improvements due to recent initiatives by the EPSRC and RSC. The International Review noted that in UK chemistry departments there is still only a small role for analytical chemistry as a distinct research area. There is still a perception that analytical science simply exists to provide analysis tools for chemistry research, rather than providing its own research challenges that may lead to the opening up of new areas of investigation.

The panel spent a significant amount of time exploring the EPSRC / RSC studentship scheme. In the limited number of cases where more than a single student had been awarded, there was evidence that there was much added value in clustering the students within centres in terms of the overall training and research outputs. There was concern that the scheme was failing to deliver added value to the students and did not help in developing critical mass. To address these concerns it is proposed that the scheme is consolidated to support a number of themed analytical science centres which might be co-funded by industry. There appears to be much value in modelling such centres on Doctoral Training Centres and include a robust four year training programme. It was also considered important to include industry in developing training packages more broadly, which could possibly be achieved in a coordinated fashion.

A summer school could provide a complement to existing or new training centres. Such a school could provide a coherent package of training in analytical science techniques and also expose students to the breadth of current research. A summer school could be developed in association with the RSC Analytical Forum, though the school should remain separate to it. This annual research forum is a successful way of bringing the majority of the students funded through the scheme together to present their research. The meeting is very broad in scope and provides an opportunity for students to discuss their research with academic and fellow students and assists in providing a broader perspective. Industrial CASE allocation in this area might also be an appropriate mechanism to deliver innovative and goal related research in this area.

Instrument development is a key area where there appears to be a lack of suitably trained individuals. The development of increasingly computerised instrumentation means research groups rarely do their own repairs on complex instruments and the UK is producing relatively few individuals capable of building new instruments with new capability. There is the possibility that in the future this could be a real limitation for the UK. Research funding bodies should examine whether an initiative to develop PhD students with instrument building skills is appropriate or potentially prioritising studentships in this area. There is potential overlap with activities in the engineering programme; this should be explored with the possibility of encouraging Engineering Doctorates in this area. There is also potential overlap with activities with in other Councils such as BBRSC's Tools and Resources initiative.

The individual areas of the grand challenges are considered to be important and all have the characteristic of being intrinsically cross-disciplinary. Examining the outputs of the grand challenge workshop, many of the groups appeared to focus on the same basic challenges such as imaging and high throughput. The leading edge of analytical science research at present is nearly always occurring at the boundary of disciplines. The importance of researchers at all levels being able to work across boundaries should be highlighted.

## 5. General Comments and Conclusions

The research presented during the review was considered to be of high quality with elements which are internationally leading. The portfolio presented probably represents only a fraction of the entirety of the EPSRC portfolio. The grants which were presented were the ones which were most relevant to the chemistry community; however, it should be recognised that this is only one of the drivers in analytical technique development. In the post genomic era the biological drivers should be specifically recognised. Future reviews of this of analytical science should be as inclusive as possible and not be limited by EPSRC programme or Research Council boundaries.

The size of the chemistry portfolio in analytical science does appear low, even taking into account the issues discussed above. There appears to have been a significant decrease since the end of the managed activity in 2000. It is still unclear why this should be, though certainly there has been a diversification of drivers in analytical science in recent years. The level of chemistry programme funding appears to have stabilised in recent years and there is no evidence that analytical science proposals have lower success rates compared to other elements of the chemistry portfolio. As there are a number of funding opportunities available for analytical technique development, the panel judged that there is no requirement for an additional specific initiative to fund research projects.

The EPSRC / RSC studentship scheme appears to be delivering innovative PhD projects in analytical science. However, the students appear to be receiving the same standard training elements as those students funded through Doctoral Training Grants or other funding bodies. Little added value was identified to be provided by the scheme, an element identified was the participation of students at the annual Analytical Research Forum. A dedicated scheme should deliver additional benefits to students and employers. In addition, there is a disconnect in the analytical specific training received and that required by employers. The industrial representatives at the review raised potential training issues on breadth of knowledge of analytical techniques and contextual awareness of research. This in tandem with the preliminary destination data presented in this report raises a potential issue for stakeholders.

Where multiple studentships had been allocated around the same research programme, the panel considered that the output appeared to be of higher quality and anecdotally from discussions with the students their experiences and breadth of interaction appeared to be better. This also supports the view that critical mass of students / researchers are particularly required surrounding multi-disciplinary research.

Analytical science research has significant connectivity with industry, in both the level of partnership on EPSRC grants and direct collaboration. This connectivity with industrial and other stakeholders is a significant strength of the discipline. Analytical research has a potential impact across a number of industrial sectors and this diversity is reflected in the research and studentship projects presented. There is potential scope for the other stakeholders to become increasingly involved in both research partnerships and training provision.

## 6. Panel Recommendations

- EPSRC should make efforts to better capture the analytical science research which is already being funded through the Research Councils. The data presented to the panel based on current coding appeared incomplete. Examples include the major programmes of work funded through the Basic Technology programme. Panel members were involved in a number of projects which involved analytical technique development; however, the coding of these grants had not recognised the analytical science component.

- The image of analytical science is not considered as poor as previous reviews have identified. However, there is still an issue in that researchers establishing their careers may not choose to highlight the technique development aspects in comparison to the potentially more attractive application science. Efforts should continue to promote the crucial central role which analytical science has in chemistry and related disciplines. The ESPRC / RSC Analytical Science Chair holders could be a potential focus for this activity in the short term.

- The multi-disciplinary research contained within the portfolio ensured that researchers had strong connectivity with other areas. A number of the researchers presenting work at the review received funding from a variety of sources with EPSRC often a minority component. It is crucial that as many stakeholders as possible are made aware of potential impact of the research being carried out within the portfolio. Analytical science researchers are in a unique position to influence Government agencies and policy makers through their ability to provide new measurements. A survey of where analytical science groups in the UK received funding for their research programmes would also be valuable.

- The number of proposals which appeared to be submitted to EPSRC was considered low, even if the data presented included only those elements which were directly chemistry relevant. Additional engagement with the community was required to highlight the diverse opportunities available across the Research Councils; however, such promotion must be careful not to simply raise expectations.

- The impact of the formal managed analytical science programme (1995 – 2000) is still unclear. The completed grants funded through the managed activity should be re-examined to assess the outputs from the research portfolio. As all of these grants formally ended 3 – 8 years ago, it may be opportune to capture these outputs both to assess the success of the programme and also capture any highlights for publicity.

- The EPSRC / RSC studentship scheme has had consistently high demand throughout its existence. It is unclear whether the scheme is delivering the underpinning of the training base that was envisaged when the scheme was expanded following the last review. The panel considered that there are a number of routes to securing PhD studentships in this area apart from the scheme itself, which funds only a minor component. The scheme has value as there continues to be training needs; however, the scheme should be redeveloped to take account of this. In order to further develop the training elements, awards should be consolidated to nucleate a number of students at a smaller number of institutions. Awards must require a specific training package to be incorporated either within the institution or in partnership with industry.

- There appeared to be some disconnect between the training requirements of industry and those provided by funders and providers of graduate and postgraduate training. The two main areas appear to be a broad appreciation of analytical techniques and the context of their research both within academe and industry. There should be increased dialogue between stakeholders to seek to address this issue and to ensure that training continues to meet the needs of UK academe and industry.

## Appendix (1) EVALUATION SCORING CRITERIA

QUALITY
***Intrinsic excellence of the research in world terms:***
5 = predominantly world leading
4 = predominantly competitive at an international level
3 = predominantly competitive at the national level
2 = modest contribution to the UK's research standing
1 = little or no contribution to the UK's research standing

PEOPLE
***The extent to which the skills of the research staff are in demand from employers:***
5 = exceptional demand from employers
4 = high demand from employers
3 = moderate demand from employers
2 = limited demand from employers
1 = no output or no demand for the skills provided

IMPACT
***The potential for wider impact on other research:***
5 = very high potential
4 = high potential
3 = moderate potential
2 = limited potential
1 = no potential discernible at present

EXPLOITABILITY
***The potential to contribute to (UK) wealth creation and quality of life:***
5 = very high potential for exploitation
4 = high potential for exploitation
3 = moderate potential for exploitation
2 = limited potential
1 = no potential for exploitation discernible at present

## Appendix (2) ANALYTICAL SCIENCE REVIEW AGENDA

### Timetable for the EPSRC Analytical Science Review

### 8th March 2005

| | |
|---|---|
| 0930 - 1000 | Registration - with Coffee |
| 1000 - 1015 | Welcome (EPSRC and Panel Chair) |
| 1015 – 1100 | Keynote Presentation by Professor Douglas Kell<br>- University of Manchester |
| 1100 – 1245 | Poster Presentations |
| 1245 – 1345 | Lunch |
| 1345 - 1600 | Breakout Sessions |
| 1615 – 1645 | Feedback via a marketplace |

### 9th March 2005

| | |
|---|---|
| 0930 - 1000 | Registration |
| 1000 - 1015 | Welcome (EPSRC and Panel Chair) |
| 1015 – 1100 | Keynote Presentation by Prof M Bonner Denton<br>– University of Arizona |
| 1100 – 1230 | Poster Presentations |
| 1230 – 1330 | Lunch |
| 1330 – 1350 | Professor AP De Silva – Queens University Belfast<br>2006: A Small Space Odyssey with Luminescent Molecular Devices |
| 1350 – 1600 | Parallel Workshop Sessions<br>i) Public Engagement<br>ii) Training and Knowledge Transfer |
| 1600 – 1630 | Feedback from Workshops |

## Appendix (3) PANEL MEMBERS

**Professor S Tendler, (Chairman), Nottingham**
**Professor B Denton, Arizona (USA)**
**Professor S Haswell, Hull**
**Dr P Lyne, Laboratory of the Government Chemist**
**Professor J Scrivens, Warwick**
**Professor G Leggett, Sheffield**

## <u>Appendix 4 Summary of Breakout Sessions.</u>

<u>GRAND CHALLENGES IN ANALYTICAL SCIENCE</u>

### 1) ANALYSIS OF SOFT, WET MATTER AT HIGH RESOLUTION

Delegates:
Chris Jeynes – Surrey IBC
Lorna Dawson – Macaulay Institute
Jamie Hobbs – Uni Sheffield
*Gari Harris – U of Dundee*

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**ENVIRONMENTAL FORENSICS**

1. Provide a scientific basis for policing environmental quality

2. A multidisciplinary approach to characterising changes in soil chemistry/biology, air, water, groundwater

3. Analytical chemistry, biology, genetics hydrology, methodology, atmospheric chemistry remote sensing, chemo informatics, law

4. Polluter pays

   Cleaner, safer environment
   Improved environment policing
   Improved public health

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**COMBINING/REFINING IMAGING TECHNIQUE FOR SOFT WET MATTER**

1/2. High resolution non-destructive characterisation, eg at molecular resolution of biology, and systems

3. Microscopy, spectroscopy, optical physics

4. Ability to study functional structures of individual cells/applications in systems biology

## 2) LARGE PARAMETER SPACES: OMICS, SENSORS, SCREENING

Delegates:
Peter Fielden
Douglas Kell
Simon Gaskell
David Goodall
Ewan Blanch
Phillip Wright
David Perrett
David Ferguson
Stuart Fancey
*Derek Stevenson*

**Issue: TO IDENTIFY**

- Characterise
- Measure interactions
- Relatively quantitative
- Absolutely quantitative
- Over time, reliably

At least 100,000 components of a dynamic range of $>10^{10}$ and model the data set generated

**SKILLS/SPECIALISED**

- Separation science
- Mass spectrometry
- Bioinformatics
- Other spectroscopic techniques
- Cell/molecular biologist
- Life scientists
- Sampling science

**INDIVIDUAL OBJECTIVES**

- New and/or improved techniques for
  - Separation and
  - Detection
  - Datahanding/datamining
  - Improved speed

**SKILLS NEEDED TO MEET CHALLENGE**

- Varied – completely multi-disciplinary
- Chemists
- Biologists
- Engineers
- Physicists
- Mathematicians
- Computer scientists

**IMPACT AREAS**

- Metabalomics
- Proteomics
- Pollutant profiling

- Diagnostics
- Toxicology

**HOW WOULD THE WORLD BE DIFFERENT?**

- Personalised medicine
- Better diagnostics
- Improved treatment
- Less dependence on drugs
- Better drugs

**COMMENTS**

- Does/could this correspond to taking large numbers of simple measurements (resistivity, refractive index,…) to characterise a material (identify and quality(!)) and hence avoid complex separation/detection? Chemo metrics used to assemble/interpret data. Application: any analysis of complex materials

## 3) CHEMICAL IMAGING : TIME, SPATIAL RESOLUTION, INFORMATION CONTENT

Delegates:
Mark Bradley
Hugh McCann
Mark Barrow
Tom Drewello
A Craven
Imran Khan
Ewen Smith
Jon Cooper

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**1. HIGH RESOLUTION, FASTER, MULTIDIMENSIONAL, CHEMICAL IMAGING OF REAL SYSTEMS (MATERIALS/CELLS)**

**2. OBJECTIVES**

- Smaller
- Faster
- Less damaging (does not perturb systems)
- More informative
- Quantitative
- Greater dynamic range
- Single molecule level
- Portable device
- Spatial and temporal resolution
- Atomic structure
- Reactions and binding
- Study under real conditions
- Even (in situ)
- More informative

**3. SKILLS BASE**

- Engineers (inc. Electrical and software)
- Chemistry

- Physics
- Biology
- Management team

*Synthetic and Spectroscopic
Spectrometric skills
Microscopy

**4. WHY?**

- More details understanding of systems
- More efficient technology
- Less pollution (lower carbon emissions)
- Reduced energy consumption
- Medical advances

**COMMENTS**

- Does this extend to chemical imaging of intact materials eg multilayer/multi-component materials? Drug product would be an example. Fast analysis with fast data proc. could give improved mfg.

**CHEMICAL IMAGING OF BIOLOGICAL SYSTEMS**

- Fluoroflows/spectroscopic methods Raman
- Label proteins
- Low levels of detection
- High throughput
- Cell scale – metabolites
- Concentrations
- Cellular processes on a molecular level
- Dynamic and structural resolution
- Protein structure analysis
- Analysis of amorphous systems
- Portable

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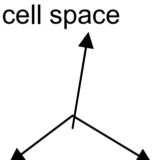
Reaction systems

- Spectroscopic
- Spectrometric
- Microscopy

**Biological data**

High resolution information in
A cell space



Time conc

**Surface data**

**Particle – particle interactions**
**EPS**
**SEM**
**SIMS**
**STM**

| **Rate of processes** |
|---|

**CHEMICAL IMAGING OF MATERIALS**

- Special distribution of atoms at interfaces (solid state) or surfaces
- Local chemistry

**Current limitation – stability of samples**

- Less powerful beams – more sensitive detection
- Portable

## 4) NON-INVASIVE TECHNIQUES : REMOTE SENSING, PHARMACEUTICALS, PHYSIOLOGICAL SENSORS, CHEMICAL PROCESSES…...

Delegates:
David Cowan
Paul Monks
Ian Watt
Paul Ewart
Giles Davies
David Littlejohn
P Zioupos
Margaret O'Hara
Ivana Evans
Paul Hodgkinson
Jim Tucker
Mike Hughes

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**Non-Invasive**

**(THE GRAND CHALLENGE THAT EPSRC FACES IS TRUE MULTI-DISCIPLINARY RESEARCH THAT BRIDGES DIFFERENT AREAS)**

Resource Base – Multi Disciplinary

Facilitating Technology

- Real time
- Sensitive/specific
- Easy/low cost systems

- Rapid/low cost/artefact – free
- Quality of information
- Data analysis tool (chemcometric)
- Role of proxies

People

**Research Question?**

What analytic area required to be monitoring non-invasively?

This has a system dependency

**So What?**

Cost-effective, quicker, more accurate

Medical diagnosis/therapy

Process control/developments

Crime screening/abuse

Use as a diagnostics

Air quality/quality of life

More useful markers

which area of application
Would be marketable?

narrow down this list
Be more targeted

**COMMENTS**

1. The So What List - needs to be more targeted
2. The areas of application need to be realistic and marketable – will people buy it and use it?
3. Many techniques are available – it is using them in an applied way that need addressing
4. Interested in quality determinations (eg of drug substance) rather than just I.D. (handheld devices for ID already exist!)

**A MEDICAL CHALLENGE**

**BIOMARKERS ON BREATH**

Stable
Isotope
(or minimal)

gas v analysis
↓
sensitivity/specificity
↓

exhaled breath compensate
(liquid)

Data analysis

?particulate

**TECHNOLOGIES**

- Laser spectroscopy
- DEP
- CIRMS (chemi-ionisation)
- Electrochemistry
- DOAS
- Accoustic spec.
- Resonance imaging
- LIDAR/RADAR
- NIR
- Polarimetry
- $TH_z$
- Microscopy

*************

**System**

- System diagnostics
- Medical diagnostics
- Inferential analysis from signal attenuation or passive sensing of system output
- Obtaining information about the health/disease status of an individual by a method which does not cause pain/damage
- Cells or people?

**New Technology**

- Find new contrast mechanisms eg different frequencies may revel/detect items/chemicals etc or interest
- Develop new imaging and spectroscopy equipment eg new solid state laser
- Development of core science and engineering systems (instruments) that are low cost, high resolutions, low power, small (remote measurements at low cost)
- Ensuring that the data obtained gives the intended information ie doesn't just tell you that one patient is hotter /fatter/taller/more female etc than another

**Non-invasive**

- Characterisation of substances and changes without the need for sampling or perturbation
- Sensing molecules with no disturbance of target system
- Observation of system without grouping it
- Label – free cell analysis
- Non-destructive characterisation of materials
- Does not perturb concentra5ions
- Does not involve destructive sampling
- Analytical device(s) that will be non-destructive, point of collection, able to identify (selectively) and quantify substances

- Analytical device(s) that will provide spatial and temporal information
- Sensing molecules in-vitro rather than in-vivo?
- Making measurements in real-time (non-invasive or insitu) to get timely relevant information from systems (Industrial, Environmental, Biological)
- Detection/measurement of species or processes without affecting the concentration or process

*******************

**A Challenge**

Non-invasive “sensing” of liquid/heterogeneous systems
Spatial structure
Single molecule eg diffraction in solution
Population of molecules

## 5) TRANSIENT PHENOMENA : IN CELLS, CATALYTIC SYSTEMS, INTERFACES…..

Delegates:
Roger Webb
T Raymont
Frank Martin
Edmon Tsang
Mike Hughes
Ritu Kataky
Annette Taylor
Peter Weightman
Joanne Elliott
Sillas Hadjiloucas
David Russell
Ben Horrocks

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**Grand Challenge**

- Structural information (Molecular)
- High spatial resolution
- High temporal resolution
- Low concentration/gradients
- Within complex systems:-
    - Wet/noisy/difficult to interface } insitu
    - Heterogenics/sensature
- “Dynamics of interfaces which change as a result of a reaction”
- Stable over seconds
- Over distances of CM

**Results**

- Great advances in pharmaceuticals
- Engineering of complex systems
- Improve energy efficiency/$CO_2$ absorption
- Optimising efficiency of molecular machines
- Spatial/temporal model of cell and cell dynamics

- Natural/Artificial surface interactions
- Bio-CAD tools
- Self assembly
- Chemo response
- Inter/intro cell communication
- Membrane Biology

**Tools**

- Central facilities
- Central, specialist Bio facilities

- Surface science/interfaces away from UHV
    - Relevant environment

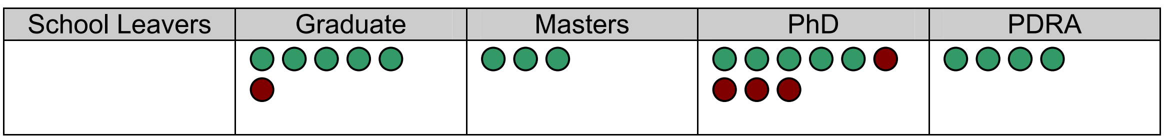
**Skills**

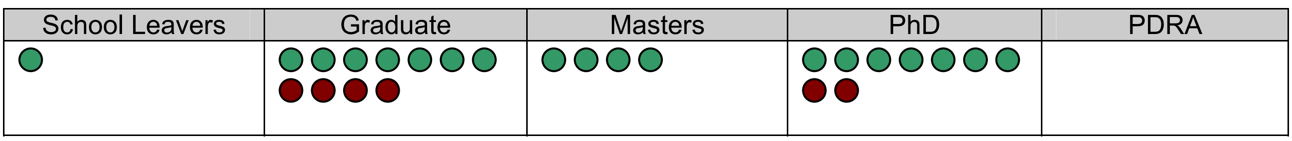
- Range of techniques
- Signal processing
    - System identification
- Surface science
    - Bio/artificial interfaces
- Sensors
- Nano/micro fluids
- Bio-physicists and cell biologists /organic chemistry/physicists/engineers
- Imaging/bio photonics
- Instrument design and miniaturisation
- Data mining

## <u>POSTGRADUATE TRAINING REQUIREMENTS IN ANALYTICAL SCIENCE</u>

### 1) Levels of recruitment

Two groups of industrial representatives were asked specific questions relating the their training requirements. Initially they were asked to indicate at what level they recruited analytical scientists. Delegates were asked to put a green dot where they recruited but had few problems in securing appropriate individuals. Delegates were asked to place a red dot for levels where they attempted to recruit but encountered difficulties securing appropriate individuals. The results are represented graphically below. Both groups indicated that they had problems recruiting at graduate and PhD levels.




### 2) Specific competencies required by industry

- Evidence of activity/leadership

- Key competence. Applied focus
- Evidence that he/she can apply knowledge to broad application areas (lateral thinking!)
- “Broad” knowledge area w.r.t. their expertise (wider applications)
- A general understanding of a broad area of analytical chemistry
- Broad knowledge of analytical science
- Broad knowledge in anal science or specific as required
    - Problem solving experience
- Problem-centred approach (not intent on developing a particular technique as own ends) (artificial thinking)
- Manipulative Skills
- Key competence Common Sense!
- Proactive
- Analytical thinking skills (Generalist + specialist)
- Problem solving skills
- Key competence: Problem solving skills
- Numerate fund IT skills. Aware of chemometrics
- Some experience of industry or evidence that they know what industry is + does.
- Awareness of industrial practices
- Previous experience in industry
- Industry experience
- Key competence. Communication kills.
- Communication Skills
- Fund communication
- Specific skills (in-depth knowledge of a specific area: chromatography or (?)
- Relevant research skills
- Technical competence! (?) level of expertise
- Relevant technical expertise (specialist)
- Specialist knowledge
- Specialist technical skills
- Key competence: scientific an technical knowledge
- Team working (Generalist and specialist)
- Team approach
- Interpersonal skills
- Other skills (e.g. communication or competencies) or potential for e.g. people management
- Proven team worker
- Team skills
- Good communication and interpersonal skills (team worker)
- Communication and people skills

***Key competencies for recruitment***

1. Soft skills → Communication interpersonal / Written + Verbal
2. Broad base understanding of science → not project specific experience
3. Technical skills → Data Analysis
    → IT skills
    → Analytical thinking

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## 3) How can industry work with training providers to provide innovative training packages?

| **Key competencies for recruitment** | | **Industry Role** |
|---|---|---|
| Specialist technical skills | → | Should have when they arrive |
| Broad Knowledge of analytical science | → | Expect if recruiting a specialist to give extra timing here |
| Communication skills | → | 50/50 need basics but can be improved e.g. RSC courses |

| | | |
|---|---|---|
| Team Working Skills | → | Need basics but can be improved 40/60 |
| Problem solving skills | → | Should have already 80/20 |
| Industry experience | → | Industry provide e.g. year out or PhD projects with CASE award. |
| Proactive | → | Have to have it themselves |

Industry Experience
- → Sandwich year v. valuable → 2/3 year typical for companies present N.B. 12 months placements much more valuable than short placements
- → CASE awards, DTAs
- → MSc students (overseas students) doing there MSc with industry Could learn from French system – they work on a particular project, get a thesis out of it, a problem is solved so industry benefits. Don't see MSc level students in industry in the English system
- → Industry should be more proactive in seeking out MSc students e.g. identify suitable MSc courses they could take students from to do projects.

- Industry can work with specialist organisations chromatographic society, British mass spectrometry society to develop specialist training courses → courses can then be accredited by these societies.
- RSC courses are being promoted

- Soft skills placements, Through in house training.

- [More industrial CASE + consistency in allocation any good notice of them from funders] – for EPSRC to do.

- Direct linking with schools
- Web based seminars
- Conferences (CASE+)
- Develop communities of interest → Gearing and sharing burdens. VFM
- Use societies ES RSC courses or SCI + RSC for e.g. science competitions
- Use grad school mentories as a training opportunity for the mentors
- Virtual cabs
- Offer industrial lectures on real world applications
- Produce DVD/Videos of how A/S has been used in different situations Different probs.
- Sponsor training tool kits
- Be clear about requirements – numbers of people + skill requirements

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### 4) How can EPSRC help bring industry and academia together to provide such training?

- Grad schools → More of them + students should go to more than one
  → Better information sent to industry about it.
- Give better information about providers of PhDs + what else is going on in CASE.
- More industrial CASE → More steering of them
  → Consistency of allocations
- RCs should stipulate training requirements for students and regulate the delivery of them – particularly in year one.
- Bring together the players – in particular BBSRC LGC MPL
- Facilitate exchange of information RCs what industry needs → inf sheets etc (RSC)
- IE act as conduct of good practice look at what other countries do. Learn from experiences
- More dialogue with industry → understanding of each others requirements. 1 day workshops good format.
- Encourage universities to be more proactive in seeking out industry → where can they send their students to do projects?

- Make information available to industry on what training is available (NB RSC has a website that does this already)
- N.B. RSC should be working more closely with specialist groups like the chromatographic society etc (They are already starting to do this)
- Process analysis PhDs are needed – what can EPSRC do about this? [Specialist call needed – proposals don't do well in general peer review
- (NB How would there be a big response? Lack of novelty in proposals Is a problem in proposals? It is development + application rather than research but it is needed.
- If this is addressed will help with recruitment – people are needed with PhDs in process analysis
- More industrialists on peer review college
- Criteria in peer review cause problems for these types of proposals (adventure etc)
- NB process analysis is multidisciplinary, so has these problems
- Encourage long term effort in an area – these areas take time.
- "applied", "economically relevant" as criteria instead of "adventure" ("training PHD students" – for analytical studentships it should on referee form)
- Move emphasis on new applications of existing technologies. Industries + EPSRC need more communication in this area to see if they can work together.
- BMS and centre at Swansea to work together in future?
- NB very few women in industry. Hard to recruit

**5) How can EPSRC best work with stakeholders to make careers in analytical science more exciting to young people?**

- Find + Support champions (DeSilva factor)
- Demonstrate Value, Excitement + Impact
- Find sexy exemplars + communicate (?)
- Ensures representation of analytical science in executive structures of EPSRC → visibility
- Work in EU/commission to raise profile → influence FP content etc
- Explore what is done in other countries (Nano bus etc)
- Biometrics/Security/Orwell
    - Too Sensible? (Unless they're boring/watch news)
- CSI – Type "Sexy Science" "Extreme labs" ie. Not white coat – RSC rip-off
- Sports involvement
    - formula 1
- Environment
    - New energy sources. (?)
    - NASA/Beagle (shhh)
- Food
    - Preservative testing (Not Dairylea Lunchables)
    - Health supplements etc
    - Eating well?
- Max Power/FHM type thing

**Appendix 5 EPSRC ANALYTICAL SCIENCE PORTFOLIO DATA**

# Analytical Science Theme Day Panel Briefing

January 2006

Engineering and Physical Sciences Research Council

Author: Carmine Ruggiero
carmine.ruggiero@epsrc.ac.uk

EPSRC
Polaris House
North Star Avenue
Swindon
SN2 1ET

# Analytical Science Review

## *Summary*

Analytical Science is a relatively small component of the chemistry programme portfolio both in number of grants and overall level of funding. Only a minority of grants are funded through responsive mode, despite the fact that there has been no dedicated managed programme since 1999. The majority of EPSRC funding for this area comes from a variety of managed programmes, only one of which is lead by the chemistry programme. This movement away from measurement techniques solely for the chemical sciences is reflected by key research groups often not being located within major chemistry departments. Research in technique development is often single application focussed such as for environmental or pharmaceutical analysis.

The main research centres that engage with EPSRC are at Manchester, York, Sheffield, Oxford and Strathclyde. However the portfolio of funded grants is disparate with many institutions having a single grant in the area. In an attempt to develop the area, EPSRC and the Analytical Division of the RSC funded three research chairs in analytical science at UMIST, York and Sheffield. EPSRC continues to work in collaboration with the RSC to underpin the discipline; the annual call for analytical science studentships is the major collaboration at present.

*Introduction*

# Context

Historically the primary route for EPSRC funding has been through a broad analytical science managed programme, which ran from 1995 to 1999, with earmarked funding of £1M per annum. At the end of the programme the EPSRC view was that it was considered constraining rather than protective and that mainstream funding should come through responsive mode. The hope was that analytical science would be able to compete for greater funds through responsive mode based on quality of science.

In retrospect, despite efforts to reassure the community, the main perception appears to have been that EPSRC was withdrawing funding and commitment to the area. The number of proposals submitted significantly reduced and have only recently begun to increase. Success rates have varied but this is probably a consequence of the relatively low numbers of proposals; however, it does not appear that analytical proposals are being significantly less successful at panel.

Following the end of the dedicated managed programme, EPSRC earmarked funding was targeted at encouraging new researchers into the area. This was to be achieved in the short term by establishing 3 research chairs and in the longer term through earmarked funding for PhD students. EPSRC is engaged with Analytical Division of the RSC in funding both the chairs and studentships. The chairs were considered important in attempting to generate a critical mass of leading researchers in analytical science. In order to maintain the numbers of PhD analytical scientists, since 2000 EPSRC and the RSC have jointly funded at least 14 studentships per annum, rising to 20 in the last call. The studentships from EPSRC are funded through the Doctoral Training Grants; the remainder are directly funded by the RSC and are not captured in this portfolio data.

There have also been managed calls in specific application areas where analytical development could have a significant impact, such as; Analytical Techniques for Atmospheric Chemistry and Metrology for Life Sciences. Due to the commercial importance of analysis there have been two LINK programmes in the area, ‘Lab-on-a-chip’ and ‘Measuring up to the environment’.

There have been a number of assessments of the current state of analytical science in the UK including the EPSRC / RSC International Review of Chemistry. Previous reviews have all focussed on the importance of analytical science and instrument development in underpinning research being carried out within chemistry, biology and physics. However there is possibly still a perception that analytical science is applied and incremental with little scope for creativity; this has been propagated partly by the confusion between it as an area of research as opposed to a service.

The UK is considered world leading in areas such as microfluidics and electrochemical analysis; however the community has been perceived as conservative and slow to identify new drivers such as high throughput technologies, and integration with computational and chemometric methodologies. There is also still concern regarding the number of researchers active in this field and whether the UK still needs to strengthen the research base with a number of international recruits.

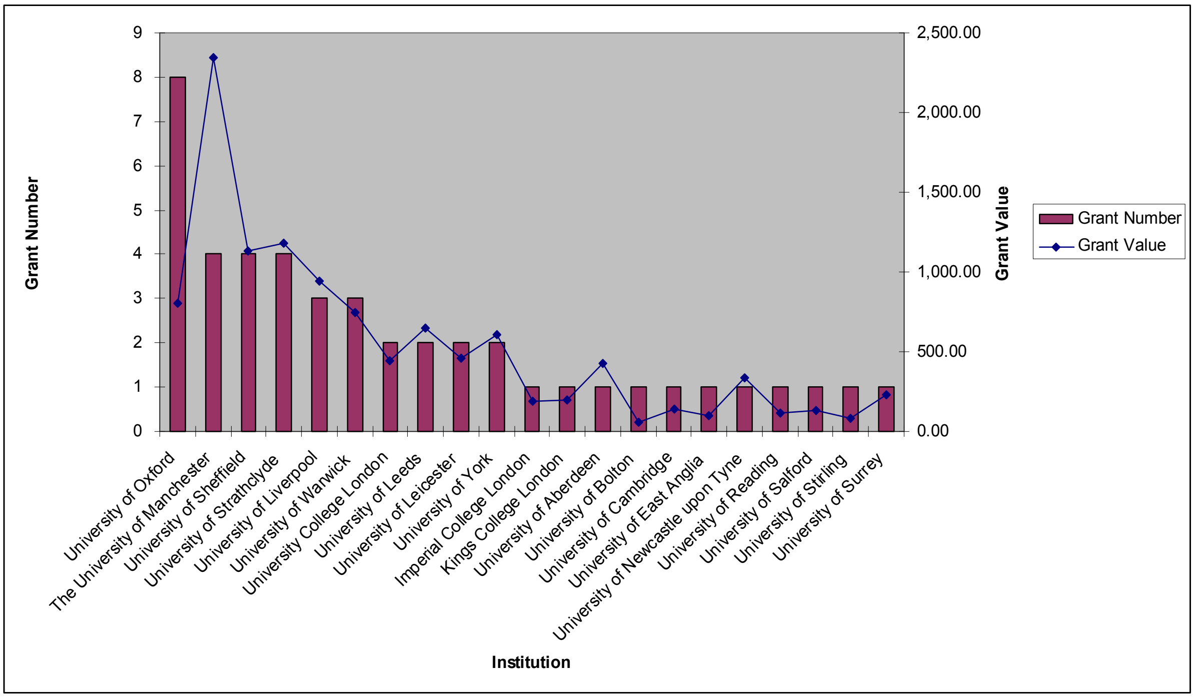
A recent Chemistry Leadership Council report also highlighted the importance of the area to all technically based industrial sectors. The report also highlights the disparate way that analytical science has developed and been deployed.

### *Current EPSRC portfolio*

**Introduction**

Within EPSRC, analytical science is considered as part of the chemistry portfolio as historically it was primarily a tool for chemical analysis. However the changing research landscape means EPSRC is no longer the sole Council in funding such development; BBSRC, NERC and PPARC are also engaged in technique development.

**Current EPSRC portfolio in Analytical Science**




The above figure illustrates the number and value of grants distributed across institutions where analytical science is the primary focus of the research. The Analytical Science portfolio contains 44 current grants, distributed amongst 21 institutions, approximately half with only a single grant. The total value of this portfolio is £11.2M; it appears that the majority of this funding is through relative small awards. Oxford appears to have the extreme with a large number of small awards (8 current grants but totalling less than £1M). Within the portfolio there is only a single example of the larger 'critical mass' type grant, funded at Manchester, the above figure illustrates the significant effect it's had on the value funding at the institution.

A more specific estimate of the total spend specifically on analytical science can be made by examining and totalling only the analytical science component of the grants, as coded by EPSRC. Totalling the percentage component of analytical science in all grants across the chemistry portfolio, there are 26.4 equivalent grants, which have some analytical science component. These grants have a total equivalent value of approximately £6.6M, which represents approximately 5% of the total chemistry portfolio.

The portfolio of 26.4 equivalent grants is widely dispersed amongst 44 institutions, the majority of institutions having less than 1 grant equivalent. The same key institutions appear within this data though UEA and York appear to have larger portfolios using this metric. The disparate nature of the community is illustrated by only two investigators holding more than one current grant in the portfolio.

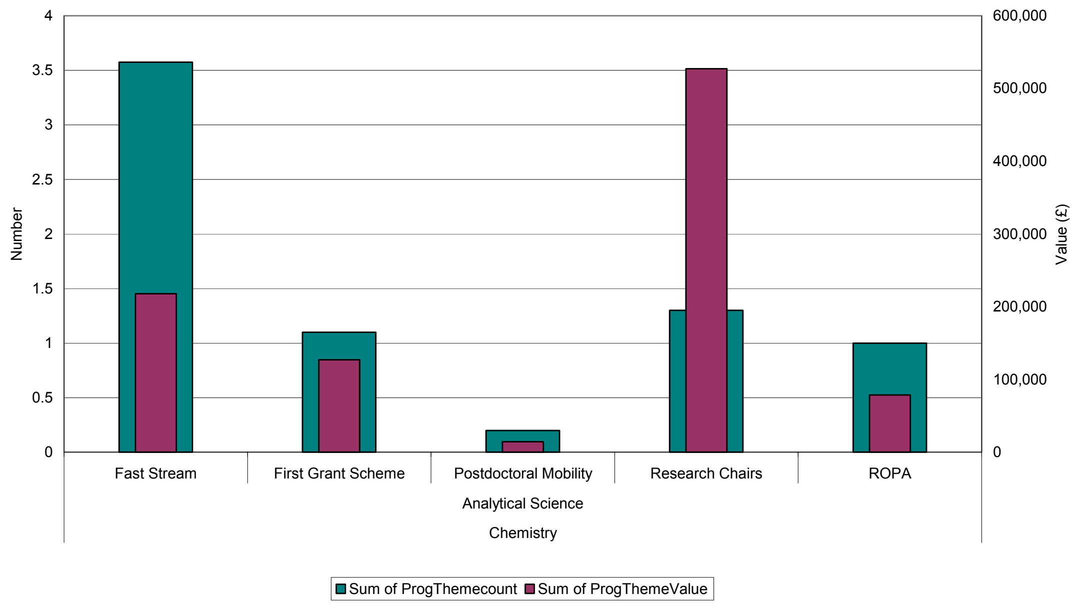
**Connectivity**

By examining the data contained within the grant portfolio, it is possible to examine where EPSRC funded analytical science research has the greatest connectivity with other disciplines. As would be expected analytical science is strongly linked to other chemistry areas such as physical chemistry and catalysis. The biotechnology driver for instrumentation and measurement science is reflected with approximately a third of responsive mode grants jointly funded with the Life Sciences Interface Programme. Two of the three research chairs are also jointly funded with LSI. The physics programme also joint fund a small fraction of grants, primarily for gas phase studies. A small proportion of the portfolio has an engineering lead through chemical engineering in development of on-line process analytics.

## Schemes

In March 04 approximately half of grant funding in Analytical Science was through responsive mode, including first grants. This was in stark contrast to the remainder of the chemistry portfolio where responsive mode funding dominated. Funding through other schemes is shown in the graph below. The main point from the graph is the predominance of the funding for the 3 research chairs, which demonstrates the relatively small portfolio. Realising Our Potential Awards (ROPAs) were also a relatively successful scheme for the analytical community. Funding through schemes such as fast stream and ROPAs has now ended, with the only majority of funding coming through standard responsive mode.

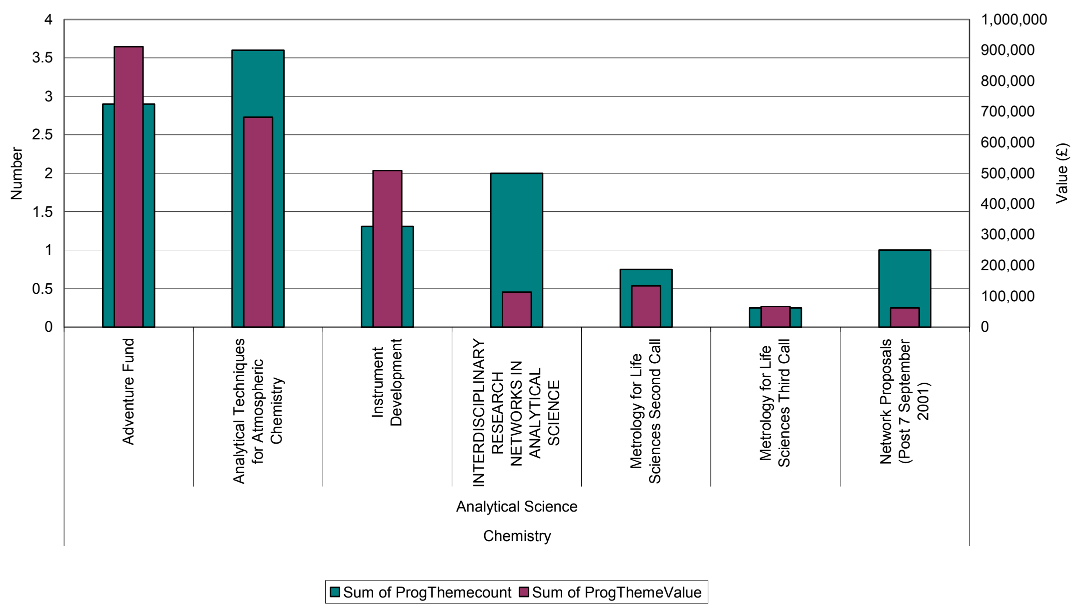
### Schemes which have funded elements of the analytical science portfolio



# Current Managed Programmes

While there is no longer a specific managed programme in analytical science, the community has been very successful in levering funding form various managed programmes. The Cross Council Adventure Fund increased the funding within this area by nearly £1M in a single call; of the 19 grants funded in the call, 6 had components of analytical science. The other two major managed programmes which contribute to the portfolio were application based; Analytical Technologies for Atmospheric Chemistry and Metrology for Life Sciences.

**Managed activities which have funded components of Analytical Science**




There are two key omissions in the above figure. The four calls in Technologies for Crime Prevention and Detection programme has funded novel analytical science with applications in forensic science and chemical / biological detection. There are currently 19 grants (value: £3.8M) where analytical science is a component of the research programme (equivalent value: £1.6M). A full list of analytical science grants funded through the Think Crime programme is included in Annex 1. In addition there is the RCUK Basic Technology programme, which has funded large programmes of broad underpinning technique development. There are currently 8 grants that have a component of analytical science (value: £9.4M) in the research programme (equivalent value: £3.4M); a full list of relevant Basic Technology grants is included in Annex 2. Within the chemistry programme analytical science has also been funded through the high throughput technologies call.

In order to increase the analytical research base 4 networks were also funded through a single call for proposals.

## Networks and other community groups

There are four networks which were funded through a specific call; all have now come to the end of their funding, it is not apparent that any are still active. No subsequent networks in this area have been funded through responsive mode. The four networks funded were:

| Principal Investigator | Institution | End Date | Network |
|---|---|---|---|
| Prof ML Colemam | University of Reading | 31 Dec 04 | Network to develop applications of stable isotope mass spectrometry in forensic science and crime detection |
| Prof AJ Morris | University of Newcastle | 31 Dec 04 | Interdisciplinary network in process analytics |
| Dr AJ Drake | Kings College London | 3 March 05 | In situ particle analysis network |
| Dr TR Hull | Bolton Institute | 31 July 05 | Flame retardant innovation through flame and residue analysis |

The UK analytical Partnership was formed funded through the DTI and RSC to coordinate efforts in the area of education, regulation and innovation. UKAP came to an end in 2004; to date the innovation group has had only limited impact in generating new Research Council proposals.

## Studentships and training activities

The Doctoral Training Grant data is not coded on announcement as with standard research proposals. The DTGs are block grants to institutions, their value calculated algorithmically based on EPSRC grant income. Institutions are requested to supply details on the students and projects supported on an annual basis. The studentships are then coded by the office based on the data supplied by institutions. It is estimated that up to 04/05 the data is approximately 90% complete, the data for 04/05 is only 80% complete consequently the numbers appear lower.

In March 04 there were 38 DTG students identified as working within this area, there were also 7.9 project studentships supported through research grants. The data in the table below updates this; however, it has been possible only to show the total number of equivalent students. Included in this total are fractions of studentships where analytical science is only a minor component of the research.

Within theses figure should be the EPSRC funded analytical studentships (administered through the DTG); however the 7 annually funded by the RSC are not included.

| Research Topic | 2001 / 2002 | 2002 / 2003 | 2003 / 2004 | 2004 / 2005 |
|---|---|---|---|---|
| **Analytical Science** | 19.1 | 27.25 | 10.25 | 13.1 |
| **Catalysis and Applied Catalysis** | 29.6 | 34.05 | 35.71 | 24.95 |
| **Computational and Theoretical Chemistry** | 11 | 15.4 | 24.5 | 7.5 |
| **Chemical Synthetic Methodology** | 92.75 | 107.15 | 80.38 | 77.6 |
| **Solid state Chemistry** | 6.5 | 10 | 10.58 | 3 |

In order to provide some context for the studentship numbers, data are also shown for a sample of areas of the chemistry portfolio. Analytical Science appears to be comparing favourably with numbers of students with other areas of the chemistry. The only main area that it is significantly lower than is chemical synthetic methodology, which encompasses synthetic organic chemistry; however, this area dominates all others in terms of student numbers.

Annex 3 lists the studentship projects funded through the analytical science scheme, with annex 4 providing some final destination data. It appears that 15 students (approximately half) have entered the academic research base at the PDRA level; however, the scheme does not appear to directly support the industrial sector with only 2 students being directly employed in related industries. The small number of students entering the industrial base is surprising given the broad industrial demand for analytical technologies. Of the remaining students 10 had either not completed or were seeking employment and 4 had been employed in non-related areas.

Due to the industrial relevance of analytical science there were 4 Masters Training Packages funded within the area:

| Institution | MTP Title |
|---|---|
| Loughborough | Analytical and pharmaceutical science |
| Warwick | Instrumental and analytical methods for biological and environmental chemistry |
| UMIST | Bioanalysis and post genome science |
| UMIST | Masters in chemical informatics |

The funding for masters training has been incorporated into Collaborative Training accounts. Similar in flexibility to the DTG, institutions can use this funding to deliver training elements in line with their priorities. At present, it is still unclear how devolved funding through CTA will affect the number of masters programmes funded within the area.

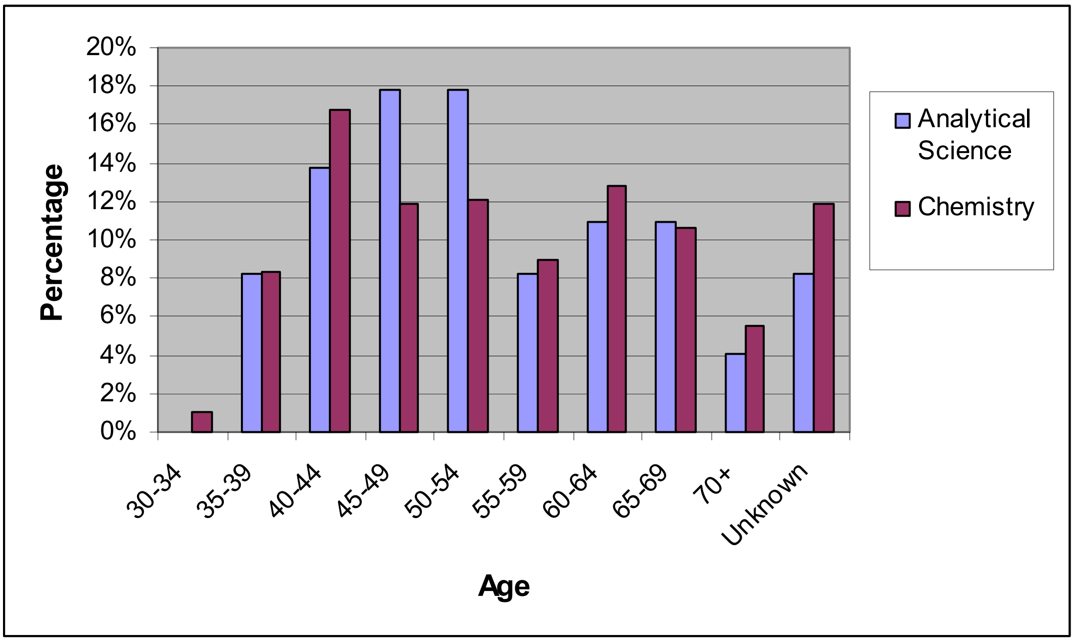
# People Supported

The last analysis of analytical science in 2004, highlighted that there were the equivalent to 18.2 PDRAs then funded by EPSRC in this area. A longer-term perspective is illustrated in the table below, which lists the number of people supported through research grants within analytical science and chemistry as a whole. The level appears consistent with the proportion of grant funding going into the area. It is unclear as to how this relates to the numbers directly supported by industrial or other 3rd party funding.

| | Projects Students | PDRA | Technical |
|---|---|---|---|
| **Analytical Science** | 23 | 42 | 36 |
| **Chemistry** | 465 | 951 | 910 |

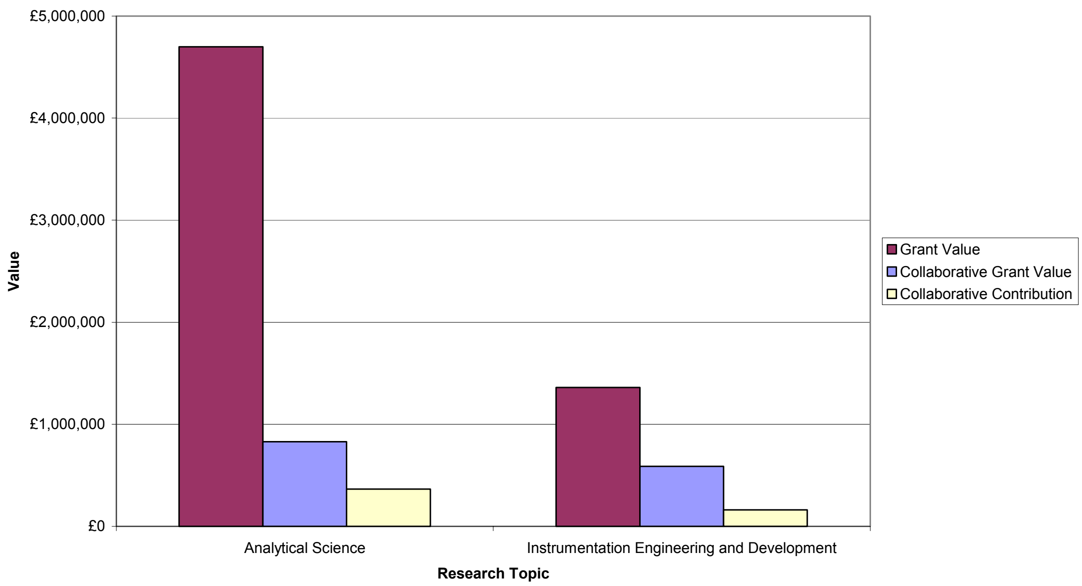
The age profile within analytical science is illustrated and compared with chemistry as a whole in the figure below. The academic research community appears relatively young; however, this only represents a small subsection of the community directly funded by EPSRC. The picture may also be distorted, as researchers may not highlight their work in this area as a key component of their research.

## Age Profile of Researchers in Analytical Science and Chemistry




**Collaboration with Users**

Across the analytical science portfolio, 22% of grants have user collaboration. While relatively high compared to other areas within the chemistry programme, considering the connectivity of the research community, the level of 3rd party involvement is surprisingly low. This is probably due to the analytical and instrument development community receiving funds directly from industry and other government agencies. The fact that many groups also work in specific user areas would also increase the potential of direct funding. This lack of third party involvement also appears to extend to DTA studentships none of which are coded as being collaborative. This is unlikely to be the true picture, as a number of industrial CASE awards have been placed in this area.



While not explicit in the data, collaboration is also fostered through the INSIGHT Faraday Partnership in high throughput technologies. The area of high throughput appears to be a major driver in instrumentation and novel analytical measurements.

The research portfolio is also coded with relevance to industrial sectors; the sectors associated with the analytical science portfolio are listed in the table below. Grants are simply coded against industrial sectors, therefore those grants relevant to two or more sectors would appear multiple times in the table. The underpinning nature of the discipline is illustrated that the majority of grants are coded against more than one sector. It appears from this data that the chemicals and pharmaceutical sectors continue to be the primary drivers; however healthcare is also significant.

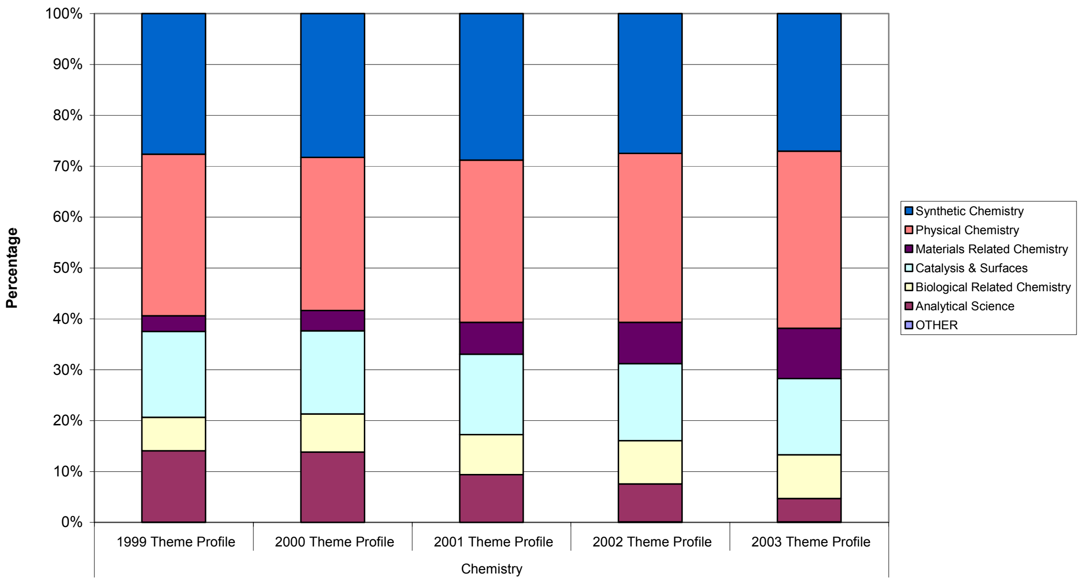
## Sectors related to the analytical science portfolio

| Industrial Sector | No. of Grants | Total Value | Equivalent No. of grants | Equivalent Value |
|---|---|---|---|---|
| Bulk Products and Materials | 5 | 2,201.50 | 2.06 | 632.34 |
| Chemicals | 25 | 5,845.76 | 17.67 | 4,119.43 |
| Electronics | 4 | 854.25 | 2.06 | 559.16 |
| Environment | 2 | 288.02 | 1.90 | 261.93 |
| Food and Drink | 3 | 562.33 | 2.46 | 455.56 |
| Healthcare | 14 | 4,921.88 | 8.10 | 2,593.46 |
| No relevance to Underpinning Sectors | 5 | 1,309.00 | 3.17 | 1,008.36 |
| Pharmaceuticals and Biotechnology | 25 | 5,808.13 | 13.68 | 3,439.63 |
| Power | 1 | 154.57 | 0.75 | 115.93 |
| Software | 1 | 85.44 | 0.60 | 51.26 |

*Trends and Final Report data*

# Funding Trends

Profiled spend in Analytical Science has decreased since the end of the managed programme in 1999. This primarily appears to be the community no longer seeking funds from EPSRC, rather than a significantly lower success rate. The number of proposals in this area has stabilised at approximately 30, and it remains to be seen if numbers of proposals continue at this level success rates can be maintained in order to increase their proportion of the portfolio.




**Success rates in Analytical Science since the final year of the managed activity**

| Financial Year | Number of proposals | Number of proposals funded | Success rate (%) |
|---|---|---|---|
| 99/00 | 47 | 22 | 47 |
| 00/01 | 17 | 6 | 35 |
| 01/02 | 22 | 9 | 41 |
| 02/03 | 30 | 6 | 20 |
| 03/04 | 33 | 17 | 52 |
| 04/05 | 30 | 10 | 33 |
| 05/06 | 32 | 9 | 28 |

**Number of grants announced in analytical science and in chemistry as a whole**

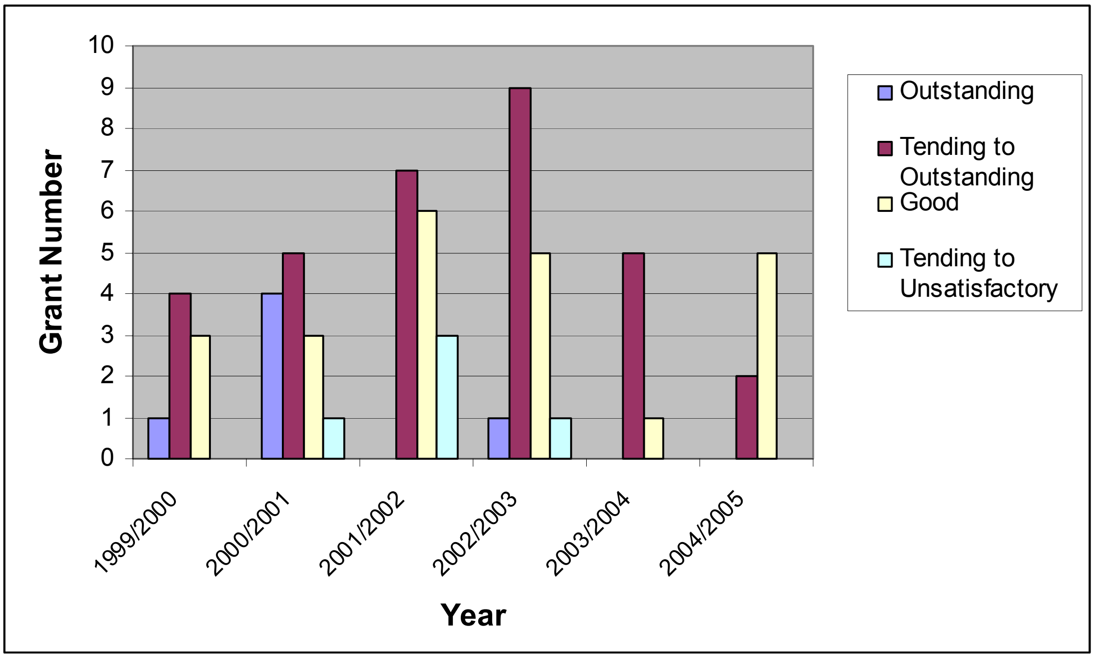
| Number of grants announced | 2003 / 2004 | 2004 / 2005 | 2005 / 2006 (up to Feb 06) |
|---|---|---|---|
| Analytical Science | 17 | 10 | 9 |
| Chemistry | 167 | 182 | 176 |

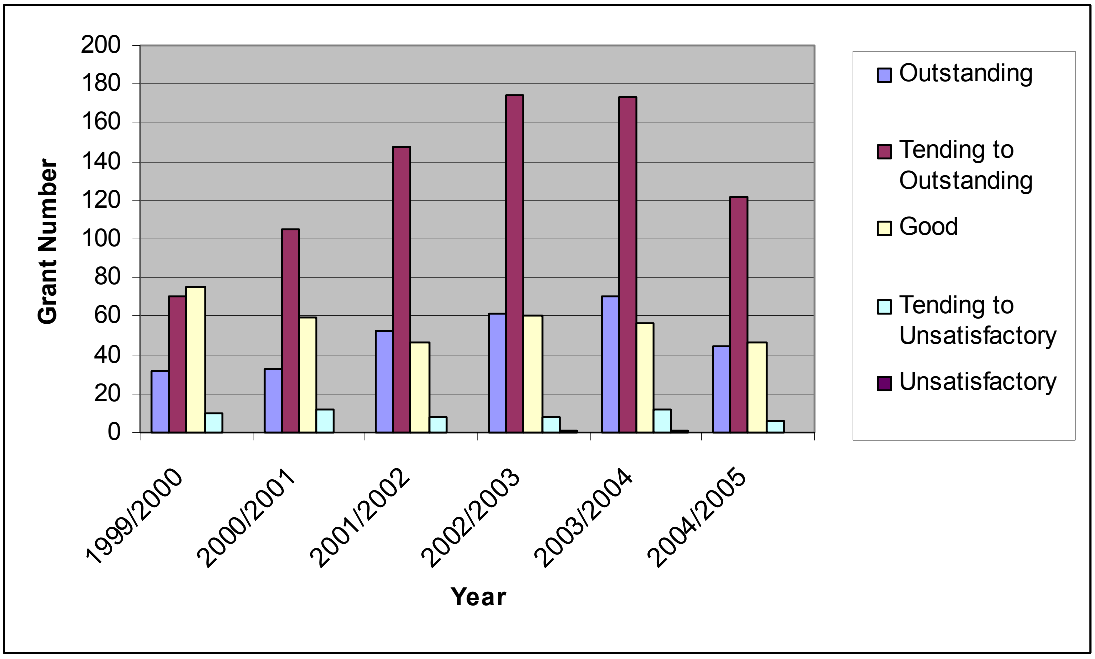
Examining the portfolio for grants awarded in the past three years. The numbers of grants funded has been reasonably consistent. There appears to have been a relatively high number funded in 03-04, which is also reflected in the high success rates in that year. Success rates have fluctuated but this is a consequence of the relatively low numbers of proposals. Apart from those years with very high success rates, those for analytical science do not appear significantly different to the chemistry programme as a whole.

**Final Report Data**

EPSRC collects final report data after 3 months from the end of a grant. Final reports are sent to external assessors and receive final grading at a chemistry prioritisation panel meeting. Final reports are graded against a number of assessment criteria; however only the overall grades will be examined here. The overall grades for grants within the analytical science portfolio are shown in the figure below.

## IGR and FR Overall Scores in Analytical Science by Calendar Year



Final report scores have varied significantly; however, this may be a consequence of the small number of proposals in the statistics. An additional factor may be the managed programme maturing with a reduction in the number of proposals ranked either ‘outstanding’ or ‘tending to unsatisfactory’ between 2001-04. There is a mirrored increase in the number of grants receiving a grading of ‘tending to outstanding’. This variation is in contrast to the chemistry portfolio as a whole (illustrated in the figure above) where the overall gradings appear to be reasonably constant. It should be remembered that the numbers of final reports across the chemistry portfolio is approximately 20 times larger than for the analytical science component.

### *Commentary*

As noted by the International Review, Analytical Science research in the UK appears to be at a crossroads. There appears to be a lack of confidence in responsive mode being a potential route for funding; however the community is willing to submit to a variety of managed calls in specific applications areas. The age profile of the community compares well with other areas of chemistry, but there still remain barriers to recruiting new researchers into mainstream chemistry departments. The recruitment issue could be a symptom of the relatively low regard of technique development by the ‘user’ community.

Attaining a critical mass of researchers has been central to efforts to underpin and develop the area. The funding of three analytical research chairs has been seen as positive, though it did not bring an international recruit into the UK. The international review again highlighted recruitment as an issue and bringing in key players internationally or from industry continues to be a priority.

The area of technique development has broadened from one that primarily underpins the chemical sciences and industry. There are a variety of drivers including the biological and medical sciences. It is clear that an examination of the EPSRC portfolio of grants within this theme should be done in the context of other Research Council support. It continues to be a priority to work with other funding bodies in further developing this area.

### Strengths, Weaknesses, Opportunities, Threats

A SWOT analysis was carried out internally within EPSRC, it is presented here as a basis for discussion.

| | |
|---|---|
| **Strengths**<br>Strong interactions with industry and other agencies | **Weaknesses**<br>Lack of key people<br>Isolation from institutions with established chemistry departments |
| **Opportunities**<br>Numerous sources of funding including Research Councils, industry and other government agencies | **Threats**<br>Lack of collaboration on grants<br>Appear conservative and slow to uptake new developments<br>Lack of critical mass |

## Appendix 6 BIBLIOMETRIC STUDY.

### REVIEW OF ANALYTICAL SCIENCE

1. You have indicated that a bibliometric analysis of papers in analytical science would help to inform a review of the field. I have used Thomson ISI Web of Knowledge and Essential Science Indicators to look at:

I. The number of citations against papers with 10 or more citations from 1981 to present (which covers the full period for Thomson ISI data). Source: Thomson ISI Web of Knowledge.

   - In retrospect this was too large a period to cover in a single analysis, as it is not possible to see any trend data, the decision to perform the initial analysis in this fashion was due to resource and time factors. Ideally it would be useful to examine rolling 5 year periods to see the trends through time and specifically observe the UK position relative to others. The highly cited and hot papers should provide a clearer picture of such trends.

   - A number of topics were omitted due to the large amount of returns submitted from the query. In sampling a number of these it was clear that a large proportion of the returns we publications where the technique had been used. An advantage of moving to a shorter period would be to have a smaller set to examine where it would be possible to manually clean the data. No topics were omitted for the highly cited and hot papers as the smaller sample allowed for annual cleaning of the data.

II. Highly Cited Papers published over the last 10 years, limited to a count of papers within the top 25 highly cited papers in each sub-field (in most cases the number of highly cited papers is below 25). Citation rates vary by field and older papers are cited more than recent papers. The selection procedure for Highly Cited Papers takes these factors into account. Citation thresholds are based on the distribution of citations, selecting the specified top fraction of papers for each year and field. Source: Essential Science Indicators.

III. The number of collaborative papers across analytical science subjects (drawn from the top 25 (max) highly cited papers in each sub-field).

IV. Hot papers in analytical science subjects. Hot papers are papers that receive citations soon after publication, relative to other papers of the same field and age. Hot papers are drawn from the most highly cited papers in the field over the last 2 years

V. The top institutions across analytical science subjects, based on the number of published papers, drawn from the top 25 (max) highly cited papers.

2. A breakdown of analytical science subjects has been provided by David Ferguson. This list is attached at Annex 1. However, within the 'Web of Knowledge' search against those papers with 10 or more citations, the vast number of records returned against some subjects was not manageable in terms of reviewing them for relevance to analytical science. In these cases, we agreed to omit the data from that particular analysis. (With more time, I could conduct an analysis based on a smaller period of, say, 5 year rolling windows, which might present a more manageable dataset).

3. Data on 'highly cited papers' against these same subject fields in 'Essential Science Indicators' was more manageable, since I looked only at those papers within the (max) top 25 for each field. On this

basis, the analysis of highly cited and therefore more recent (over the past 10 years) papers covered all the sub-fields defined in David Ferguson's list.

4. Looking at the 'Highly Cited Papers' in Essential Science Indicators (ESI) there are 267 highly cited papers across all the sub-fields, drawn from the top 25 in any one sub-field, over the period 1995-2005/6. I have ranked them by the number of citations per paper to ascertain the top ranked papers in the field. These represent the most recent and highly cited papers in the field.

Highly-cited papers represent the top 1% in each field.

**National performance**

5. The following table indicates world ranking of the top 8 countries across analytical science subjects on papers published over the period 1981 – present, drawn from 'Web of Science'' and measured by the number of citations. A full breakdown across analytical science sub – fields and country ranking within sub-fields is at Annexes 2(ii) and 2(iii).

| Country Ranking | No. Citations | No of papers | Citations per paper |
|---|---|---|---|
| 1 USA | 118435 | 3695 | 32 |
| 2 UK | 38568 | 1372 | 28 |
| 3 Germany | 33178 | 1208 | 27 |
| 4 Japan | 30137 | 1192 | 25 |
| 5 Spain | 15141 | 671 | 23 |
| 6 France | 13695 | 528 | 26 |
| 7 Italy | 13461 | 576 | 23 |
| 8 Sweden | 12728 | 407 | 31 |

6. The following table shows the top sub-fields in analytical science measured by **the number of highly-cited papers** (drawn from the top 25 in any one sub-field). Full data, showing a breakdown by sub-field and by country, can be found at Annex 3.

| ISI Field | No of papers |
|---|---|
| Capillary Electrophoresis | 25 |
| Capillary Electrochromatography | 25 |
| Electrophoresis | 25 |
| Gas Chromatography | 25 |
| Tandem Mass Spectrometry | 25 |
| Atomic Absorption Spectrometry | 24 |
| Infrared Spectroscopy | 20 |
| Raman Spectroscopy | 19 |
| Solid Phase Extraction | 11 |
| High Performance Liquid Chromatography | 9 |
| Voltammetry | 9 |
| Affinity Chromatography | 7 |
| Thermal Analysis | 7 |

**Country Strengths against Disciplines**

7. An analysis of the top publishing countries against the highly cited papers in the top sub fields (see above table) shows, not surprisingly, that the USA publishes more against the majority of these sub fields. Exceptions are in atomic absorption spectrometry, where Brazil is significantly ahead; and voltammetry and thermal analysis where the UK is marginally ahead. Following the USA lead, Germany shows a strength in Electrophoresis; Germany, Canada and the Netherlands show a strength in gas chromatography; Germany, the UK and Canada in Tandem Mass Spectrometry; and the UK a marginal strength in solid phase extraction.

8. World ranking against highly cited papers over the last 10 years shows a shift in the ranking of some countries, and the emergence of others, compared with overall position from Web of Science data since 1981. This analysis is based on a count of the number of published papers. Notable is the emergence of Canada, the Netherlands, Switzerland, Brazil, Belgium and Denmark, and the decline of

Japan and Spain.

The following table also shows the number and percentage of collaborative papers. The USA is the collaborator of choice for other countries.  Although the UK ranks 3rd overall, its level of collaboration, as measured by joint publications, is noticeably low.

| Country | No of Papers | No of Collab Papers | %age Collab Papers |
|---|---|---|---|
| USA | 119 | 23 | 19% |
| Germany | 33 | 13 | 39% |
| UK | 22 | 4 | 18% |
| Canada | 17 | 7 | 41% |
| Netherlands | 12 | 6 | 50% |
| France | 10 | 6 | 60% |
| Switzerland | 10 | 4 | 40% |
| Italy | 9 | 1 | 11% |
| Sweden | 9 | 3 | 33% |
| Brazil | 8 | 3 | 37% |
| Belgium | 8 | 2 | 25% |
| Denmark | 7 | 5 | 71% |

The pattern of collaboration amongst the main countries can be seen at Annex 4.

8. An analysis of 'hot papers' (over the last 2 years) can be seen at Annex 5. 'Hot' papers are those which receive rapid and significant numbers of citations and can therefore signify the key papers in their field. These may be indicative of the hot topics within analytical science. The 'hot' topics which emerge from this analysis are:

| Field | No. of ‘hot’ papers | No. of citations |
|---|---|---|
| Tandem Mass Spectrometry | 3 | 44 |
| Affinity Chromatography | 2 | 13 |
| Electrospray Ionisation Mass | 2 | 12 |
| Electrophoresis | 1* | 25 |
| Dielectric Spectroscopy | 1* | 3 |

* Collaborative paper

The top countries which emerge from the hot papers analysis are:

| Country | No. of ‘hot’ papers | No. of citations |
|---|---|---|
| USA | 5 | 26 |
| Denmark | 2 | 18 |
| Brazil | 1 | 28 |
| Germany | 1 | 25 |
| UK | 1* | 25 |
| Canada | 1 | 3 |

* Collaborative paper

These results also support the evident emergence of Canada, Denmark and Brazil seen in the ‘highly cited papers’ analysis.

**Top Institutions**

9. Looking across the highly cited papers in all sub-disciplines, the top publishing institutions are the University of California at Berkeley, Max Planck, CNR, Cornell University, Glaxo Wellcome Research and Development (UK) and MIT. Apart from these, no institutions emerge as being prolific in publishing across analytical science subjects. A list of the institutions publishing across the full spectrum of analytical science subjects is given at Annex 6.

The following UK institutions feature, but, in line with the general publishing pattern in analytical science, not at a significant level:

| UK Institution | No of papers |
|---|---|
| Glaxo Wellcome Res & Dev | 6 |
| University of Oxford | 3 |
| ICSTM | 2 |
| University of Bristol | 2 |
| University of Manchester | 2 |
| AFRC Inst Food Research | 1 |
| Astra Charnwood | 1 |
| Kings College London | 1 |
| Loughborough Univ Technology | 1 |
| Micromass Ltd | 1 |
| National History Museum | 1 |
| QinetiQ | 1 |
| RAL | 1 |
| UCL | 1 |
| University of Aberdeen | 1 |
| University of Lancaster | 1 |
| University of Leeds | 1 |
| University of Keele | 1 |
| University of Plymouth | 1 |
| Zeneca Pharma | 1 |

**Conclusions**

10. To summarise the key conclusions:

I. The USA, Germany and the UK are the top three publishing countries across all analytical science subjects. The UK ranks in 3rd position behind USA and Germany based on an analysis of highly cited papers. This compares favourably with the UK's world position in chemistry as a whole at 4th behind USA, Japan and Germany (from an '05 EPSRC study of E&PS subjects). Japan does not feature as a strong competitor in analytical science.

II. The top analytical science fields, as measured by the number of highly cited papers, are capillary electrophoresis, capillary electrochromatography, electrophoresis, gas chromatography, tandem mass spectrometry, atomic absorption spectrometry and infrared spectroscopy.

Current analytical science 'hot topics' are tandem mass spectroscopy, affinity chromatography, electrospray ionisation mass, electrophoresis and dielectric spectroscopy.

III. The USA is the top publishing country in most analytical science disciplines, but the UK is marginally ahead in voltammetry and thermal analysis and Brazil significantly ahead in atomic absorption spectrometry. The UK also shows a strength in Tandem Mass Spectrometry and, marginally, in solid phase extraction.

IV. Countries showing emergence in analytical science fields, supported by highly cited papers and/or hot papers analyses are Canada, Denmark, Brazil, the Netherlands, Switzerland and Belgium.

V. The UK's level of collaboration in analytical science is low. Within the top 12 publishing countries, the UK ranks 11th as a collaborator, measured by the percentage of its papers which are collaborative.

VI. There appears to be low concentration of analytical science subjects within institutions, as measured by the home institution(s) of publishers of highly cited papers.

**Potential Further Work**

11. Given time, it may be worthwhile extending this study to include:

- A more detailed breakdown of analytical science subjects over 5/10 year periods to get a better idea of trends.

- An analysis of the top scientists in the field.

Lesley Tracey February 2006

## Appendix 7 LIST OF POSTERS PRESENTED AT THE THEME DAY.

| Grant Ref | Title | Name | Surname | Institution | Grant Title |
|---|---|---|---|---|---|
| GR/R93193 | Professor | Mark | Bradley | University of Edinburgh | High content, real time in situ screening and sensing |
| GR/S12722 | Professor | William | Smith | University of Strathclyde | Understanding the mechanism of resonance raman scattering |
| GR/S12739 | Dr | David | McComb | Imperial College, London | Understanding the mechanism of resonance raman scattering |
| GR/S19899 | Dr | Paul | Monks | University of Leicester | Next generation proton transfer mass spectrometry|: A hadamard transform instrument |
| GR/S26699 | Dr | Joanne | Elliott | University of Reading | Correlating nanostructure with electro catalysis activity |
| GR/S40640 | Professor | Malcolm | Levitt | University of Southampton | Development of recouping techniques in solid-state NMR |
| GR/S46048 | Dr | David | Watkins | University of Oxford | Crystallography and the chemist |
| GR/S48110 | Professor | David | Birch | Strathclyde University | Progress towards single-metabolite sensing |
| GR/S48240 | Dr | Ben | Horrocks | University of Newcastle-upon-Tyne | Silicon quantum dots as spectroscopic problems in biology |
| GR/S56993 | Dr | Paul | Hodgkinson | Durham University | Testing the limits of resolution in solid-state NMR |
| GR/S64134 | Professor | David | Russell | University of East Anglia | Nanostructured assemblies for the detection of biological agents |

| | | | | | |
|---|---|---|---|---|---|
| GR/S75727 | Dr | Ewan | Blanch | University of Manchester | Surface enhanced raman optical activity (SEROA): A new spectroscopy |
| GR/S84347 | Professor | Phillip | Wright | University of Sheffield | Gel-free proteomics: High-throughput micro fluidic shotgun analysis for organisms |
| GR/S85443 | Dr | Michael | Hughes | University of Surrey | Dielectrophoretc well plates fro high through-put screening |
| GR/S90751 | Professor | Gareth | Morris | University of Manchester | Advances in diffusion-ordered NMR spectroscopy |
| GR/S98771 | Dr | Simon | Aldridge | Cardiff University | Detection of chemical warfare agents for anti-terrorist and forensic applications |
| GR/S98788 | Dr | Mikhail | Soloviev | Royal Holloway | Fast protein profiling techniques |
| GR/T10190 | Professor | S | Tsang | Reading University | Magnetic nano-composites with novel miniaturised separations for a high throughput screeening of physicochemical properties of drug candidates |
| RRAH10724 | Dr | Chris | Mayhew | Birmingham University | Ion-molecule reactions and uses in trace gas analysis |

## Appendix 8 Evaluation Questionnaire.

### 1. EVALUATION QUESTIONNAIRE OVERALL RESULTS

There were 17 respondents to the questionnaire (not all questions were answered by all respondents). The overall responses are given below together with a summary of comments.

In giving you the opportunity to provide evidence of the quality and achievements of your work, how useful was:

| | | Very useful | Useful | Not useful |
|---|---|---|---|---|
| 1. | The Synopsis | 5 | 7 | 1 |
| 2. | Your poster | 4 | 8 | 1 |
| 3. | The panel visit to your poster | 2 | 5 | 3 |

Comments:

Comments about the preparation of the Synopsis and Poster were almost universally that it had been a valuable exercise to look at the work that they were carrying out from a different perspective. Several respondents complained that there was insufficient time and space to view the posters. A number of industrial respondents would also have liked to have seen the academic posters.

The panel visit was found less useful by a greater number of respondents. The main complaint being (as it always seems to be ) that 15 minutes was not enough time to fully appreciate the research presented and that the discussion was limited with not much feedback from the panel. For the future, better communication of the purpose of the day and the fact that panel members will have spent much more than 15 minutes reading synopses and the poster visit is just to clarify remaining issues, is required.

4. How informative did you find the presentations / discussions?

| Very informative | Informative | Not informative |
|---|---|---|
| 4 | 5 | 3 |

Comments:

The majority of the respondents found at least some of the presentations informative and there was particular enthusiasm for that given by Prof. Denton.

5. How useful did you personally find the Theme Day?

| | | |
|---|---|---|
| 4 | 8 | 1 |
| Very useful | Useful | Not useful |

Comments:

The most commonly mentioned benefit was the networking opportunity offered by the theme day and the stimulation of new ideas and collaboration that this offered. The breakout sessions were also cited as being very useful but too short. Some attendees who had attended previous, similar exercises felt that new ways of doing the breakouts should now be sought. Several respondents appreciated the opportunity to take part in and learn how EPSRC obtains feedback from the community to inform policy. There was varied comments regarding the breakout activities with a number of respondents commenting that the grand challenge and facilitation used may not have been appropriate. The feedback from industrial respondents tended to be more positive regarding the breakout activity.

6. Please provide comments on the structure or timings of the day to help us improve future events.

Comments:

The great majority of comments on the organisation of the day and the venue were positive and broadly speaking start (10am) and finish (4.30pm) times were suitable for the respondents. There were some travel difficulties for those living ‘intermediate’ distances from London (i.e. Northwest and Northeast). There were a number of comments that Heathrow was not the most appropriate location and if it was not possible to have a venue in central London then a midlands location would be more appropriate. Most comments on timing were on the need for more time for posters and breakouts and reporting back.

7. Any comments on other aspects of the day?

Comments:

The only additional common comment was that industrial representation should have been included on the academically focussed day. Another comment was that the poster presenters be given the panel score and comments on their posters.

## 2. LEARNING POINTS

### 2.1 Synopses and Posters

Many of the synopses and posters did not give the requested information despite The emphasis placed on the different approach required.

### 2.2 Breakouts

More time was needed to present the outputs from the breakouts. The current breakout techniques also need refreshing (a constant process) – perhaps we should review them and produce guidance for the future.

### 2.3 Communication.

This as always could have been better – the message as to what the theme day is all about needs making clear to the participants. Hopefully the report will help to clear up some of the need for feedback.