Analytical and Measurement Sciences Platform Knowledge Transfer Plan

Harry Ziman, Sarah Galbraith, Dave Barnes, Liz Towns-Andrews
RSC Project Manager: Mario Moustras

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Prepared by PHS Consulting Limited, Pryors Hayes Farm, Willington Road, Oscroft, Tarvin, Cheshire CH3 8NL
Tel: 01829 752935 e-mail: harry.ziman@phsconsulting.co.uk

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Vision

Analytical and Measurement Sciences (A&MS) are regarded as vibrant and valued contributors to all parts of the supply chain throughout the business community. A&MS practitioners are valued team members, working across techniques and disciplines to solve problems and have rewarding careers.

A wide range of general and specialised skills training is available to equip new entrants for a rewarding career in A&MS profession. Education providers also develop team working skills and business awareness to prepare their students for the modern business environment.

World-class analytical science is used to drive innovation, and best practices are used to deliver routine measurements quickly and reliably. Universities, service providers and instrument manufacturers jointly enhance delivery and progress in A&MS to suit a wide-range of industries and deliver in a client-centred manner.

Knowledge transfer is endemic with a wide range of activities facilitating and accelerating the rate of innovation. Participation in networking is regarded as both valuable and important. The public sector, learned societies and academia are working together to support this and advance the boundaries of knowledge in anticipation of future business needs.

Analytical and Measurement Sciences Platform Knowledge Transfer Plan

Executive Summary

The goal of this plan for the Royal Society of Chemistry and the Chemistry Innovation Knowledge Transfer Network is to exploit the capability of Analytical and Measurement Sciences (A&MS) in the UK's chemistry using industries.

The approach adopted has been to focus upon the role of A&MS in business supply chains based on an understanding of the issues, perceptions and challenges of those engaged in this field or using its results for commercial purposes. Current activities were mapped and previous programs reviewed.

There is no doubt that A&MS has a vital role to play in science, technology, manufacturing and commerce but many barriers were found. There were positive findings too, particularly where analytical scientists were fully integrated into multidisciplinary teams and had an active primary role, not an arms length service function, in supply chain development.

The background research, both desk and the many discussions that were held with people, brought out a vast number of issues. One of the key issues which needs to be looked at urgently is that of skills and training. There is a widespread belief that a number of contributing factors are leading to a general erosion of the skill base in the UK relative to that needed by modern commerce.

The plan proposes courses of action to address this and other issues. These are not new but should be seen as a continuation of themes that have arisen in previous initiatives, studies and reports (these are described to in the accompanying background report). Whilst we must learn from the previous reports, there is a need to move forward and address these issues using a fresh approach.

The newly formed Chemistry Innovation Knowledge Transfer Network provides such a fresh approach, particularly when combined with the strengths of the RSC. Capitalisation upon this opportunity is advocated in preference to creating a new, expensive and high-profile initiative. Actions and activities are proposed that are highly complementary and synergistic to plans for other technology platforms and, very importantly, they focus upon the basic issues identified by business. There are substantial benefits to be had by connecting and aligning initiatives and building alliances with partners.

There are very few opportunities to secure additional funding at the present moment in time. Accordingly the plan takes maximum advantage of the processes put in place by the RSC, the Chemistry Innovation Knowledge Transfer Network and other bodies. A minimum level of initial resource totals 1.5 dedicated people to manage the platform but significant additional resources should be sought once credibility is obtained from a track record of engagement and delivery of meaningful (but initially modest) targets.

The project partners must lead a communications programme and engage with stakeholders on the strategic issues arising. We suggest the resource allocation is biased in favour of the following areas where the greatest return can be gained for resources invested.

- Skills and training (section 3.1) (Appoint a professional communications person)
- A&MS in the supply chain (section 3.2) (Bring together people from along supply chains (including those internal to large organisations) to explore the role that A&MS can play)
- Process measurement and control (section 3.3) (Demonstrate the business benefits of improved process measurement and control whilst simultaneously providing routes to connect to expertise)
- Knowledge dissemination (section 3.4) (Develop and promote new mechanisms for sharing knowledge and problems in A&MS)

The process should be governed using the normal Chemistry Innovation structures and the steering group for the current project should form a nucleus for the future advisory panel under the leadership of an industrial chairman.

The largest risk is related to human resources – assembling a team with the appropriate blend of technical knowledge, business experience and the influencing skills to persuade partners to work towards a common aim. Strong leadership is required and it is vitally important to inspire industry to participate and exploit the opportunities generated.

Acknowledgement

The authors wish to acknowledge and thank the members of the steering group who were generous with their time, constructive with their inputs and diligent with their comments. Particular thanks are due to Mario Moustras of the Royal Society of Chemistry for his overall project management and assistance in drawing various the disparate threads together.

The Steering Group consisted of:

Simon Allen	ICI	Mario Moustras	RSC
Anne Bennett	RSC	Carmine Ruggiero	EPSRC
John Conti-Ramsden	Intertek	Peter Stockwell	PS Analytical
John Green	RSC	Rodney Townsend	RSC
Dennis Lewis	Unilever	Paul Worsfold	University of Plymouth
Peter Lyne	LGC		

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1 Introduction

1.1 Introduction to this Project and Chemistry Innovation

In early 2006 the DTI funded the Chemistry Innovation Knowledge Transfer Network to stimulate innovation in the chemistry using industries. Led by industry, its aim is to coordinate product and process innovation activities to deliver significant additional GDP for the UK in line with the national strategy for the Chemistry Using Industries. Its activities can be summarised as:

- Integrate and simplify access to UK national capability
- Catalyse cooperative effort
- Define and align UK long term innovation agenda
- Review UK initiatives & guides their evolution
- Foster development of key technologies and competencies
- Advise and inform funding organisations and processes to achieve more coherent investment

The design of the Chemistry Innovation Knowledge Transfer Network's business plan called for the development of a number of technology platforms, three of which were already being advanced through former Faraday Partnerships. Others were to be added over time and one of these is for the Analytical and Measurement Sciences. The Royal Society of Chemistry (RSC) commissioned the current study to develop plans for the platform as part of its contribution to the new KTN. The purpose is to answer a basic question – what should be done to promote the Analytical and Measurement Sciences to derive benefit for the Chemistry Using Industries?

1.2 Methodology

The methodology to prepare this plan involved the following major activities.

- Assessment of business drivers for A&MS
- Establishing a common language to describe innovation activities frameworks for learning
- A comprehensive desk research exercise to map
    - Current activities and organisations
    - The learning from previous studies
    - Sources of funding
- An in-depth interview program with 63 people to uncover perceptions from a carefully selected cross-section of stakeholders which included users, suppliers and those who are influencers of A&MS and promoters of innovation

- A workshop with the steering group and selected guests to probe key issues in greater detail

An early and important decision was to take a supply chain outlook based on business drivers. This heavily influenced the design of the interview program and oriented the study towards perceptions, attitudes and opinions. This had a knock-on effect through the whole project and is one of the key differentiators from previous studies.

The results of all these activities were aggregated, analysed and reported both at meetings and in writing. It was reported in <u>two parts</u> which should be read together.

A substantial amount of information was generated so two reports were generated.

- This plan describing the bare issues and focussing on the activities needed to address them

- A larger Background Information report containing the evidence base and more details of the findings from the aforementioned activities. This <u>develops and enriches the description of the issues summarised herein.</u>

1.3 Structure of this Plan

The next section is the foundation of the plan. It outlines the issues that need to be addressed and the approach taken to do this. The detailed actions are developed in section 3 where for each of the priority themes we provide:

- A problem statement capturing the essence of the issue

- High level objectives for activities to be undertaken

- A list of proposed activities and lead organisation to undertake them. These will change over time

- The desired outcomes that indicate progress has been made

Appendix 1 extends this to other strategic issues that emerged.

The next step is to consider how the management of the plan can be overseen before considering risks and mitigating factors in section 5. Evaluation is then considered before finally listing the steps that need to be taken to initiate implementation of the plan.

2 The Business Case – Overview

This plan is concerned with increasing the economic contribution that A&MS makes to the economy in the UK. In part this is due to the commercial business of making analytical and other measurements, a sizeable activity in its own right, but more importantly is due to the positioning and role of A&MS in business supply chains.

This project has been commissioned by the Royal Society of Chemistry in connection with its contribution to the Chemistry Innovation Knowledge Transfer Network which aims to improve the competitiveness of the chemistry using industries through innovation. However, A&MS has a direct impact on a broad range of supply chains in sectors that are, at first sight, a long way from chemistry - for example food and drink, forensics, security, agriculture and healthcare to name just few. The scale of these industries is large.

There is no doubt that A&MS has a vital role to play in science, technology, manufacturing and commerce. Although this is widely recognised and appreciated the research demonstrates that it is undervalued and analysts often feel unappreciated. Advances in technology are exacerbating the situation as a "black box" syndrome reduces understanding of technology by users and customers alike. There were many positive findings too, particularly when analytical scientists were fully integrated into multidisciplinary teams and had an active primary role, not an arms length service function, in supply chain development.

The nature of A&MS provision has changed. It is no longer the preserve of an internal function within manufacturing businesses and one increasingly finds contract facilities or even completely outsourced provision as the norm. Increasing numbers of people are demanding information as regulatory matters increase and businesses require greater product assurance, particularly for consumer end applications. The nature of the business has changed and will continue to change.

The nature of UK business is changing with increasing emphases on information, technology, knowledge and innovation. A&MS, with its high skill requirements, not only fits this mould in its own right, but is an essential enabling field that is essential to enable other knowledge and technology driven sectors. The increasing role of sustainability in society will also generate new A&MS requirements.

These changes are making new demands upon those employed in the A&MS sector requiring greater commercial acumen and new relationship skills. A&MS professionals and managers in general business at all points in the supply chain need to jointly address cost versus value challenges and opportunities.

The background research, both desktop and the many discussions held with people brought out a vast number of issues. They can be condensed to the following eight problem statements.

- **Skills and training** – The current study indicates that business expectations of the technical, personal and problem-solving skills of practitioners in A&MS are not being satisfied. Providers of A&MS services are hindered in their delivery of excellent services. The concerns are technical, cultural and commercial in nature. Low morale was found in places.

- **A&MS in the supply chain** – Many analytical scientists have found themselves unwilling or unable to become part of a wider team, leading to frustration on the part of the analysts and their customers. In addition, many organisations, particularly SMEs, are not benefiting from the availability of less expensive and wider ranging analytical techniques. This results in the power of A&MS not being exploited up and down supply chains.

- **Innovation drivers** – Several areas, in particular nano-technology and high-throughput technologies, are driving A&MS innovation to new levels. Legislation is also placing new demands on A&MS. It is not clear that the A&MS community is rising quickly enough to meet these challenges

- **Innovation, research and universities** – Unlike a number of European countries, such as The Netherlands and Switzerland, analytical sciences are under-funded compared to the higher profile disciplines of physical, inorganic and organic chemistry in the UK,. The balance between fundamental research, novel applications and collaborative research is not appropriate for current needs.

- **Process measurement and control** – Historically, it has been difficult to introduce new process measurements into a manufacturing environment. There are both practical and cultural issues, and both aspects need to be addressed. Changes to pharmaceutical regulations in the US will be a driver in this area.

- **Instruments and standards** – Whilst most instruments are becoming more sophisticated, faster and cheaper, there are still issues in availability of relevant standards and validation methods.

- **Information and software** – Despite considerable debate on this topic over many years, there still appears to be no general software standard to allow analytical instruments to communicate on a common platform. In addition, the increased automation and use of high-throughput techniques generates vast amounts of data, with consequent handling difficulties.

- **Knowledge dissemination** – Traditional means of disseminating knowledge – journals, conferences and exhibitions - are now perceived to be too expensive and time-consuming, but acceptable replacements are not emerging quickly enough. Use of web-based technologies, network formation and enhancement of collaborations will all play a part in more effective spreading of knowledge.

Why address these issues? Are they important? The answers to these questions arise from the vital position of A&MS as an essential enabling technology directly linked to business drivers in the diverse range of industries referred to above. For example it directly links to key business drivers of speed to market, design and quality and cost. It is instrumental to regulation and compliance, environmental performance, QA and manufacturing, consumer demand and quality of life factors. It is clear from the problem statements above that businesses will materially benefit from addressing the points raised and these benefits are strategic in nature. For example, A&MS advances are an integral part of the developments of new technology such as nanotechnology. Process measurements underpin the new PAT requirements in pharmaceutical manufacturing to give another example. Addressing the challenges identified above will contribute in a meaningful and widespread way to the UK economy through its impact throughout the supply chain. The interview data can be used to demonstrate this.

An analysis was undertaken of high level strategic business drivers and innovation stimulators of interviewees who were drawn from a wide range of organisations from innovation providers through manufacturing to near-consumer suppliers. Under the guidance of the steering group three “Tier 1” business drivers were identified as follows:

- Cost and competitiveness
- Implementing innovation
- Quality

A strong and innovative A&MS community is a vital enabler for these general strategic drivers. These are fundamental to business strategies in general; they are not statements specific to A&MS provider businesses. The results shown in Figure 1 demonstrate that A&MS is core to these three major business drivers in equal proportion.

Tier 2 drivers which influence these tier 1 drivers are indicated below:

- Speed of innovation
- QA and manufacturing
- Customer demand
- Regulation and compliance
- Quality of life
- Environment

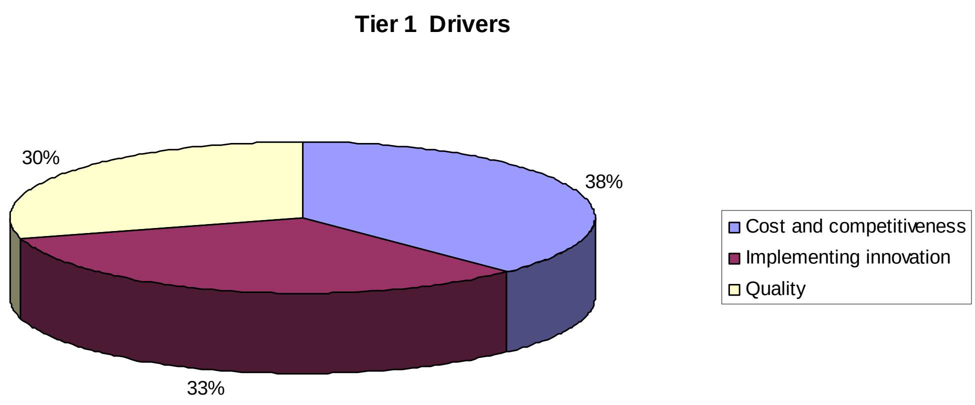

Figure 1: Tier 1 business drivers

In the same vein an analysis of "Tier 2" factors that stimulate innovation was undertaken based on the interview records. The results are displayed in Figure 2 which shows that three quarters of the findings arose in the factors of speed of innovation, QA and manufacturing and customer demand.[1]

[1] The other three categories should not be dismissed – for example many manufacturing measurements also relate to regulation and the environment and quality of life would feature more prominently if the health sector was included.

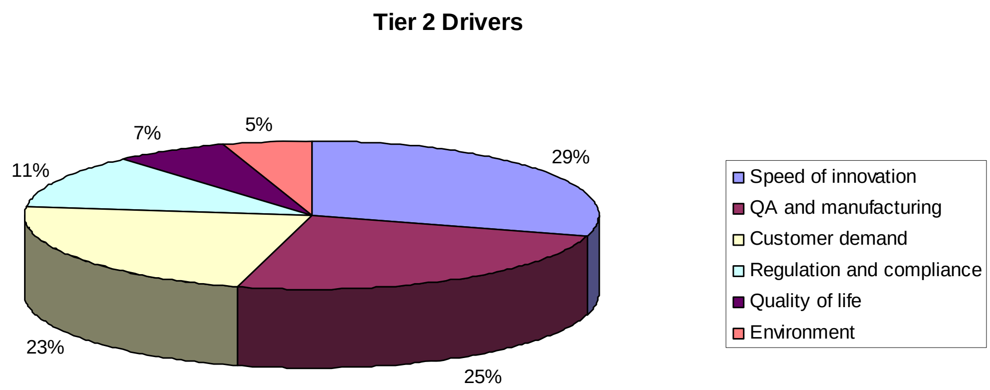

Figure 2: Tier 2 innovation factors

Once again we stress that these findings were not drawn specifically from the A&MS industry itself but from a wide range of companies in many sectors that use A&MS. It shows that A&MS is integral to innovation, manufacturing and end-customer requirements.

Having identified the drivers and challenges the question to be answered by this plan is how to address them and where can resources be found to do this. These questions are answered in more detail in the next section where many of the activities advocated are in areas such as communications, influencing a wide range of stakeholders, organising events, building alliances and working in partnership. There is no need, at present, for large projects requiring their own infrastructure. Most interventions are not self-standing roles but lie within newly created Chemistry Innovation KTN or existing roles in the RSC and NPL. However, they need more resources, direction and energy – plus targets and deliverables.

Some areas are clearly being managed by market forces and there is little case for intervention. For example outsourcing, instrument development and routine technique development. A key area of market failure is in the use of on-line and/or at-line analysis in manufacturing. This will become increasingly important as the PAT agenda is advanced by regulators and the new opportunities from continuous manufacture.

Even a cursory glance at the Background Information report accompanying this plan shows that there is a vast amount of activity and infrastructure in the A&MS community. Around 90 such examples have been identified not including the regional activities of the Royal Society of Chemistry. Figure 3 shows a consolidated set of these. This is a large and complex picture and one can argue that there may be omissions and in some areas gaps that this plan could propose to fill. One striking example is that although the RSC Analytical Division is the natural professional body for many A&MS scientists there is no trade association to promote the interests of A&MS businesses and laboratories.

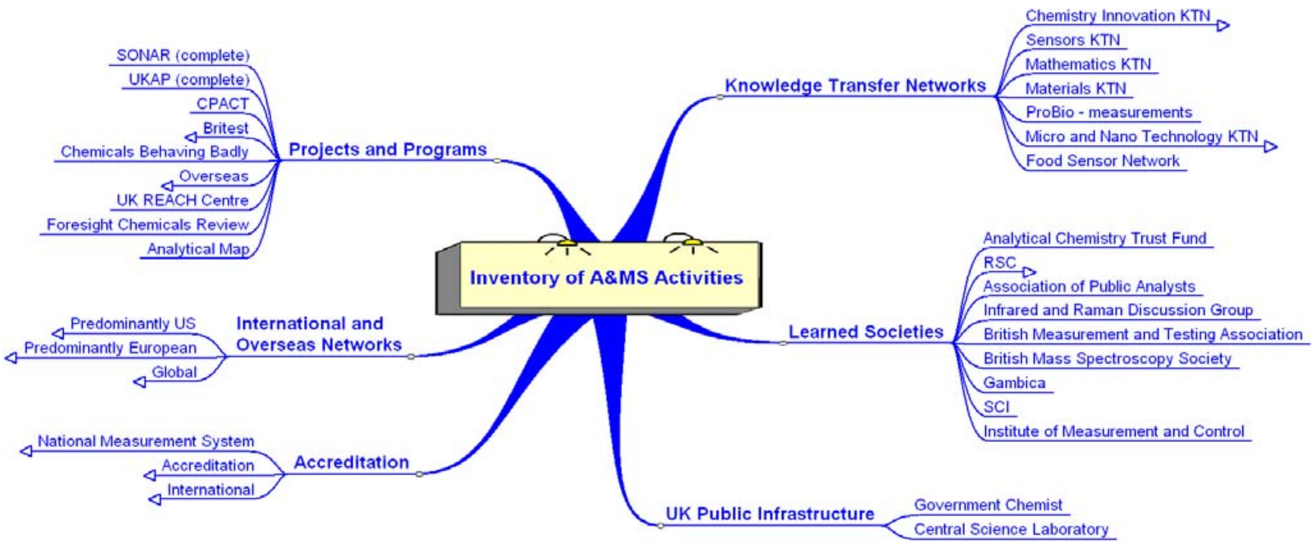

Figure 3: Simplified inventory of A&MS activities

It is our considered view that this plan should not be adding to this picture by creating a new “big-bang” type initiative. There are many reasons for this.

- The track record of large initiatives is not conducive to the creation of another
- It will be hard to attract resources
- The picture is complicated enough already!
- The whole philosophy of the Chemistry Innovation Knowledge Transfer Network is to rationalise, simplify and connect activities
- The nature of the tasks to be undertaken does not require a large centralised organisation
- The time taken to organise and fund a large initiative is too long

Accordingly this plan builds upon the work of the current project, its steering committee, Chemistry Innovation Knowledge Transfer Network and the RSC itself.

Time is a critical factor. Experience has shown that it takes many months to assemble a proposal, submit it in response to a call, await approval, negotiate contracts, recruit and then initiate the work. Even if suitable calls were open now, which they are not, active platform activity would not take place until opinions for the mid-term term Chemistry Innovation Knowledge Transfer Network review were formed. This would be far too late and be regarded negatively. The current momentum must be maintained.

In terms of overall activity coordination, alignment and coherence the study has shown that this is not at a high level; in this respect A&MS is starting from a fairly low base. Once these things are addressed and there is greater connectivity then this can be built upon as a foundation to consider large but industrially relevant and specific initiatives.

This is a study driven by “customer input” so it brings out barriers and issues driven by perceptions. These need to be tested again in, say, three years, and the strategy adjusted accordingly. However one needs to be aware that success is perceived to be the difference between expectations and outcomes; it is vitally important to manage expectations.

The level of activity or, alternatively expressed, the rate of execution of the plan, will be determined by the amount of resources devoted to it. We have reviewed funding sources in the Background Report and there are no relevant calls open at present although some programmes such as FP7 are likely to become relevant over the next year or so. These need to be monitored, influenced via Chemistry Innovation and the RSC and acted upon at the appropriate time. They are unlikely to support a broad front of activity but can be used to advance specific areas such as A&MS in manufacturing.

3 Addressing the Strategic Priorities

This chapter describes each of the key areas in detail, summarising the main issues and proposing interventions to address them. Partners, costings and funding sources are proposed, but will need to be approved by the Steering Group and Chemistry Innovation.

We have used this high level structure to organise the development of the plan. We have prioritised four themes to focus delivery of this plan. They were chosen by the number of references to each theme cited by the interviewees together with the prospects of being able to influence the situation. These themes, which the Chemistry Innovation Knowledge Transfer Network must deliver on, are:

- Skills and Training
- A&MS in the Supply Chain
- Process Measurement and Control
- Knowledge Dissemination

Each of these four sections is discussed in turn, integrating simultaneously integrating learning from all sources. A set of high level objectives is shown followed by a list of suggested actions and deliverables. These should be prioritised and reviewed by the team leading this platform with approval of the Chemistry Innovation Knowledge Transfer Network Executive Team.

The last four themes of Innovation drivers; innovation, research and universities; instruments and standards; and information and standards are mentioned in Appendix 1. These are themes that are of lesser priority and should be reviewed by the Chemistry Innovation Knowledge Transfer Network in future reviews of this platform.

Figure 4 shows these themes and the frequency with which they were raised during the interviews and workshops.

Figure 4: High level themes from the interviews and workshops

3.1 Skills and Training

Skills and training is a major issue for A&MS, its customers and practitioners. There are widespread concerns about all aspects of human resources, from the attractiveness of careers, the training given to professionals and the availability of personnel with relevant skills. There was also wide spread concern amongst the interviewees that postgraduate and undergraduate training is not adequate in universities for the production of good analytical scientists. This is an underlying issue that mist addressed in the UK if the other strategic priorities mentioned in this report are to lasting meaningful impact. It should be recognised that the Chemistry Innovation Knowledge Transfer Network (Chemistry Innovation KTN and also referred to as Chemistry Innovation) (the key recipient of this report) cannot act on this alone but can be a key influencer when it talks to Research Councils, Government, professional bodies and other key stakeholders.

Technical and problem solving skills were also cited by many but also the ability of analytical scientists to translate the fact that A&MS should be seen as a value to the business and not just a cost. This is a personal development training issue as well as a cultural issue. This should be tackled on two fronts; commercial training for practising analytical scientists in industry and a communications programme to cultivate thinking of business as well as analytical managers of the value of A&MS to their businesses.

High level objectives

- Seek to influence curriculae for university undergraduate teaching of chemistry
- Upgrade technical, commercial and problem-solving skills for A&MS professionals
- Propose means for multi-skilling and cross-disciplinary working

- Develop intensive programme of communications re careers and to improve perceptions rewards arising from A&MS

Overarching Action

- Appoint a professional communications person for A&MS. This person is best placed at the RSC.

Suggested actions

Actions	Activities	Potential Partners
Seek to influence undergraduate teaching	Series of meetings exploring how undergraduate teaching in A&MS is taught and get industry participation in terms of what is needed	Chemistry Innovation / RSC / universities / industry
Offer pathways for higher level professional skills	Design and offer intensive technical courses to Masters level in A&MS; incorporate into CPD programmes of RSC	RSC (Analytical Trust Fund) Instrument Manufacturers Universities
	Design courses based on problem-solving rather than purely techniques	RSC, Universities
	Offer courses on commercial implications of A&MS work e.g. customer focus skills, commercial understanding	RSC
	Expand the Centre for Assessment of Technical Competence Humber (CATCH) (simulation of chemical plant) to include measurement science activities	Humber Chemical Focus
	Exploit current interest in Forensic Science to secure future entrants into A&MS profession. Build links with Universities offering such courses, and with SEMTA	Chemistry Innovation with RSC
	Align with Analytical Science Network	RSC
Put in place programme of interventions to promote multi-skilling	Encourage ‘technique-rich’ larger companies to ‘god-parent’ SMEs and promote use of a wider range of techniques	Chemistry Innovation to act as broker
Use professional communications services to promote A&MS careers and status	Appoint communications intern or project manager, with professional training and background	RSC/ Chemistry Innovation
	Seek out ‘good news’ stories and publicise vigorously – celebrate academia and industry	RSC/ Chemistry Innovation
	Communicate to scientists the importance of presentation, communication, PR, media, self-promotion	RSC/ Chemistry Innovation
	Ensure that messages are carried through to school level	RSC / Regional Chemicals Initiatives (RCIs)/ CIA
	Put in place an awards programme, with appropriate publicity e.g. Young Person in A&MS; redirection of existing awards from techniques to problem solving	RSC/ Chemistry Innovation
	Collect examples of good practice from overseas	RSC/ Chemistry Innovation

Suggested Deliverables

These deliverables are offered as starting points for the eventual management team of this initiative. Numbers should be agreed and refined after discussion with the lead players.

For example

- Three new 2-3 day annual taster courses designed, piloted and offered by RSC for professional analytical scientists in industry by end 2007; 100 participants involved by end 2007

- Dialogue opened with HCF re CATCH by Q3 2006; feasibility tested by Q1 2007

- A&MS Communications Manager in post by end 2006

- Programme of communications activities agreed with RSC and/or Chemistry Innovation KTN management by end Q2 2007

3.2 A&MS in the Supply Chain

A number of issues were raised here about how A&MS services are organised and provided. These included how decisions were made on the use of measurements, analysts as team members and outsourcing. Again a number of these issues relate to management culture of companies within the UK. Those making business decisions need to be better informed of the value of measurements.

Issues of cost, benefit, value and decision making were explored. We found that cost benefit analyses were almost never performed for both instrument investment and analytical measurements. However some analytical scientists felt the economics intruded excessively. A strong message came through on the need to ensure that decision making managers were properly informed about the value and business opportunities arising from measurements and to a lesser extent that decisions were taken on rational scientific grounds.

There was some strong support for the integration of analytical and measurement scientists into multi-disciplinary teams although there were hints that outsourcing changed the relationship from “colleague” to “customer” which was not universally helpful. In this climate there is perhaps a need to assist those planning projects to understand and appreciate the value added by appropriate early A&MS involvement.

There were a number of differing views on how the trend to outsource measurement in companies was affecting A&MS. It was clear however that outsourcing is an important structure in the provision of A&MS although not suitable for all users. Intelligent purchasing of services and building relationships is key, which is not a new finding. There was also a perception that companies, including SMEs, were not aware of the relative accessibility of large or expensive instruments. More could be done to make these available to companies.

High Level Objectives

- Prepare and publicise case studies to show business benefits of enhanced A&MS

- Demonstrate and support selected projects to show how A&MS people working in teams can enhance project delivery

- Make as full a range as possible of analytical techniques and equipment available to all organisations, including SMEs;

Overarching Action

- Bring together people from along supply chains (including those internal to large organisations) to explore the role that A&MS can play

Actions	Activities	Potential Partners
Develop means for SMEs to access a wider range of analytical equipment and techniques	Put in place a series of activities (examples listed below) designed and offered to RCIs, to make A&MS techniques available to SMEs	RCIs, supported by Chemistry Innovation and/or RSC
	Ensure that the activities include all parts of the supply chain	
	Consider special promotions, show-cases, trial sites, local training courses	RCIs, supported by Chemistry Innovation and/or RSC
	Investigate operation and effectiveness of Dutch voucher scheme for SME to trial new techniques	RCIs, Chemistry Innovation
	Build links with lean manufacturing initiatives e.g. PICME, Manufacturing Institute to explore how A&MS can help progress them	Chemistry Innovation
	Provide a directory of A&MS service providers; ensure that it includes particular strengths of the various organisations	Chemistry Innovation
	Write and publicise case studies showing benefits of A&MS	RCIs, supported by Chemistry Innovation and/or RSC
Find and promote examples of enhanced team working	Provide examples of excellence in incorporation of A&MS into wider teams	Link with Communications activity in section 3.1 above
	Consider use of courses in 3.1 above to promote broader team working	RSC
	Provide guidance on early integration of A&MS into teams	Chemistry Innovation

Suggested Deliverables

- Directory of A&MS providers by end 2007 (probably on-line rather than paper)

- A program of activities bringing organisations together

- Case studies and exemplars prepared and disseminated as described above by end 2007

3.3 Process Measurement and Control

Process analytical technology (PAT) was frequently mentioned in this section of the interviews. For the avoidance of doubt, PAT is ‘a system for designing, analyzing, and controlling manufacturing through timely measurements (i.e., during processing) of critical quality and performance attributes of raw and in-process materials and processes with the goal of ensuring final product quality. It is important to note that the term *analytical* in PAT is viewed broadly to include chemical, physical, microbiological, mathematical, and risk analysis conducted in an integrated manner' (as defined in the FDA Guidelines). It is clear that PAT will have a significant impact on manufacturing in the future and that it will place new demands on A&MS through the provision of timely process measurements.

Quite separately from the requirements of PAT, which can be very demanding technically, previous projects such as SONAR have clearly shown that there are significant opportunities for cost reductions, quality improvement and even capacity increase from less sophisticated in-line or at-line measurement for control purposes.

Cultural barriers were identified between A&MS and manufacturing managers in terms of getting process measurements and particularly new equipment used more widely. The value of both process measurements and PAT needs to be publicised to the business manager and realistic expectations established for both the benefits and the resources (human and financial) needed to embed it within manufacturing.

High Level Objectives

- Address cultural issues to improve incorporation of A&MS equipment into production facilities
- Incentivise practical incorporation of advanced A&MS equipment into a production environment
- Assess the implications of PAT and whole process understanding for the provision of A&MS for both design and operation of future manufacturing processes

Overarching Action

- Demonstrate the business benefits of improved process measurement and control whilst simultaneously providing routes to connect to expertise

Actions	Activities	Potential Partners
Address cultural issues	Set up GlobalWatch Mission or monitoring in China and/or India on A&MS integration with process measurement and control	DTI, Performance Engineering
	Use communications programme (3.1 above) to find and publicise success stories	
	Where possible, communicate learning from particularly advanced organisations e.g. GSK or Pfizer	Britest
	Set up project in technology-minded business school to investigate cultural barriers, probably using MBA students as researchers	
	Explore whether or not similar issues exist in other KTNs, and if appropriate, set up collaborative teams	Other KTNs
Promote and incentivise novel applications of A&MS in process control	Set up conferences and/or events on in-line and on-line analysis	RSC / IChemE
	Offer prize together with beta-test site, for a well-specified A&MS need in process control which is not currently being met	RSC / IChemE
	Use CATCH facility on Humberside to address measurement issues	HCF

Actions	Activities	Potential Partners
	Define collaborations which could be funded and supported by the DTI Advanced Manufacturing Scheme or FP7	DTI
	Offer prize for best use of A&MS in manufacturing environment	RSC / Chemistry Innovation
	Set up horizon-scanning project to monitor new A&MS requirements emerging from novel manufacturing technologies	Chemistry Innovation
	Work with PICME and the Sustainable Manufacturing Toolbox to ensure that A&MS is taken into account in the early stages of process definitions.	PICME
Link PAT and whole process understanding with A&MS	Set up links between relevant groups to ensure that A&MS is being fully exploited in this field	RSC
	Explore work of other industry / academic groups e.g. Particle CIC in Yorkshire, BRITEST to determine their A&MS needs	

Suggested Deliverables

- Cultural issues addressed by research project (s) commissioned by end 2007
- Prize offered for ambitious development, specified by RSC / Chemistry Innovation, to take forward integration of A&MS into process measurement and control
- At least one DTI collaborative R&D grant project on PAT by end 2007

3.4 Knowledge Dissemination

Knowledge dissemination and transfer was one of the topics explored in depth. Several interviewees mentioned that it was hard to find out what was going on and that is was hard to find sources of expertise. There was a marked difference in how analysts in large and small companies contributed to the dissemination of knowledge. The larger companies not only presented at conferences, but also were visiting professors and funded academic projects. The smaller companies obtained most of their information from the internet, suppliers and the trade press.

A topic of particular interest was external networks and conferences and trade fairs which were deemed to be important in terms of finding out what was going on in a particular area. There was also expectation that DTI Knowledge Transfer Networks (KTNs) will deliver in terms of knowledge dissemination and building networks amongst those with an interest and those who need to know more about the value of A&MS.

High Level Objectives

- Build novel and productive networks in the UK and overseas using all appropriate mechanisms including events
- Ensure that web-based technologies are used extensively in order to expedite information transfer and to enthuse younger members of the profession
- Develop cross-fertilisation with other KTNs

Overarching Action

- Develop and promote new mechanisms for sharing knowledge and problems in A&MS especially in terms of networking mechanisms.

Actions	Activities	Potential Partners
Make full use of web-based technologies	Use web-based technologies to create a portal for better communication and sharing of expertise; consider use of wiki and blog technology	NPL
	Offer, perhaps via RSC web site, an enhanced Analytical Abstracts service	RSC
	Revitalise bulletin boards and message groups, using trained and experience moderators	Chemistry Innovation
	Develop targets and objectives for use of each of these web-based tools	NPL / Chemistry Innovation
Promote network formation	Organise a series of events on leading-edge A&MS; offer at locations around the UK	Chemistry Innovation / RSC
	Structure events so that networking is facilitated, and organise post-meeting activities to reinforce connections	Chemistry Innovation / RSC
	Seek means to develop and maintain networks with countries whose A&MS culture is aspirational for the UK	DTI Globalwatch
	Make full use of export support schemes to ensure that users and suppliers of A&MS attend relative trade shows	Chemistry Innovation
Enhance collaborative working	As well as the techniques above, and the communications programme described in 3.1, Chemistry World should also to provide examples of excellent collaborations	RSC
	Seek ways in which those companies with excellent internal networks might, if commercial confidentiality allows, permit limited access to non-competing SMEs, perhaps their own customers and suppliers	Chemistry Innovation
	Explore collaborative possibilities with other KTNs ensuring that participation broadens beyond the "usual suspects"	Chemistry Innovation

Suggested Deliverables

- A portal, bulletin board or message board with enhanced levels of participation – both posting and reading

- Well-attended events, promoting enhance A&MS services to a wide range of chemistry-using and related industries

- At least one collaborative project involving two or more KTNs, with the partners working on novel applications of A&MS

3.5 Summary

In summary, the nature of the activities envisaged by this plan can be captured as encompassing typical KTN activities.

- Influencing
    - Training, universities, funding etc.
- Collaborations
    - Process measurement and control
- Alignment
    - Other KTNs, NPL, RSC, LGC
- Knowledge Transfer
    - Companies, event, newsletters, case studies
- Culture
    - A&MS specialists, manufacturers, users etc

Many of the issues and objectives will have strong parallels with those in other platforms.

4 Management and Resources

4.1 Overall Management of these Activities

It can be seen from the previous section that the majority of the suggested activities fall on the RSC and Chemistry Innovation to advance although other partners such as NPL and LGC are involved too. It is vital that they are coordinated in a systematic way and that strategic oversight and industry connectedness remain in place. This is directly analogous to the other existing platforms within Chemistry Innovation and similar governance mechanisms can be put in place.

One key part of platform governance is an advisory panel drawn from industry and other vital organisations to guide the development of the platform. It could be developed from the steering group for the current project thereby maintaining the knowledge and very importantly the momentum that has been generated. This advisory panel should have a chairman from industry, ideally a user of A&MS.

A key advantage of this approach is that the platform can benefit from the leverage and influence of Chemistry Innovation KTN.

Chemistry Innovation contains infrastructure and capability for many of the actions in this plan. Its Technical function would own the technological and strategic aspects of the plan, the Commercial function would lead engagement with industry and the Projects Function provides a mechanism to execute larger tasks. The events and communications functions of Chemistry Innovation are very important too. More information about all these can be found in Appendix 2.

The three distinctive features of this plan that differ from those in other Chemistry Innovation platforms are skills, culture and image, particularly for new entrants and for general graduate education. Skills can be advanced through Chemistry Innovation's strategic links into academia, but it may be prudent to delay this until Chemistry Innovation has a more general opportunity to determine how it wishes to address these topics in general. Consideration should be given to working with the Regional Chemical Initiatives on skills too, along with image where they often have established programs.

One of the key activities for the platform is to monitor and take advantage of project calls such as Framework 7 as detailed in the Background Information. This is a key activity for Chemistry Innovation's Commercial function.

Consideration should also be given to establishing strong links to the Analytical chairs funded by the EPSRC and RSC.

4.2 Resources

Given the recommendation to advance the platform by means of Chemistry Innovation and the RSC itself, it is important to consider the level of resource required. As stated earlier the rate of progress with the action plan will be determined by the amount of resources available but equally one must be realistic about the other demands upon the time of these organisations. The levels shown in the table are the BARE MINIMUM that should be contemplated and, in an ideal world, it is recommended that they should be at least twice as much. The suggested actions and deliverables should be prioritised and reviewed critically by Chemistry Innovation KTN Executive Team and a proper project plan, with timescales and milestones and is integrated with the work of the other platforms, should be produced and implemented. Chemistry Innovation may want to stagger projects as well as consider any extra resource that may be needed.

It is strongly recommended that this is regarded as a "seed" level of resource. Once a track record in industry engagement, influence and above all outcomes is achieved then a case should be made in, say, twelve months for additional resources. The activity will then have the credibility to claim that these will increase the rate of proven delivery (and hence benefits). If a compelling case is to be advanced at a later date to the DTI for funding another project in A&MS there will be a need for current quantitative information on the size of the sector – the current data is old. At the appropriate time consideration could be given to investing in the region of £10,000-£20,000 to generate some quantified data on the size of the sector.

In addition full opportunity should be taken using the project capacity in Chemistry Innovation to propose and participate in specific projects arising from regional, national and European programs with openings for A&MS activities.

	Chemistry Innovation	RSC
Dedicated resource	0.5 Platform Portfolio Manager 0.5 Other (projects, commercial)	0.5 Internee
Contribution from existing Departments	University, academic and other stakeholder processes Government influencing processes Company engagement Communications Events Website	Analytical Division Communications Website Industry and Technology Forum
Additional incidental expenses[2]	£10,000 per year	£10,000

The dedicated resource represents roles that are committed solely to advancing this platform. The work in Chemistry Innovation will require a range of skills, so we consider it unlikely that this will be a single unique person and some dedicated time will be required from all the major departments described in appendix 2. In addition to this the A&MS platform will be advanced alongside other platforms as part of the normal processes in Chemistry Innovation. This will include linking in with universities, the Technology Strategy Board and similar organisations. There are minimal extra resource implications for this and it represents some of the synergies realised through the formation of the KTN.

It should be noted that additional resources will be deployed through partner organisations such as other KTNs and so on – influencing and taking advantage of this should be a key deliverable from the Platform Portfolio Manager. Overtures should be made to equipment manufacturers, commercial providers and other organisations to address specific topic areas.

The RSC should also consider how it should resource any training courses and how it should help the A&MS Platform in terms of a dedicated and sustained communication programme to promote the benefits of A&MS.

5 Risks

It is appropriate to consider the risks that could disrupt the plan from its intended effect.

Resources: This plan has identified a lot of issues that need to be advanced and resources will be strained. It is essential that Chemistry Innovation establishes A&MS as a platform alongside the established ones. Its management and the advisory panel need to monitor and prioritise activity. On the other hand the platform will benefit from the existing infrastructure: for example communications, marketing and company engagement activities will not incur additional costs.

Medium risk

[2] This assumes that costs for publications etc are covered by pre-existing budgets

Human: People are key to the success of the A&MS platform. A range of skills will be required to inspire others successfully into action. Technical knowledge and credibility will also be required. Those giving their time freely on the advisory panel or releasing staff to work on this project need to be satisfied that worthwhile progress is being made to retain motivation.

High risk

Activity: An increased level of activity, if not carefully considered, will add to the background "noise" experienced by people in industry in general thereby exacerbating rather than ameliorating the issues. Care must be taken to improve existing interfaces, networks and events or to replace them with more relevant alternatives rather than creating new demands and additional choices in an area that is already saturated.

High risk

Momentum: Maintaining and increasing momentum as the work transfers from this study phase into action is vital, not least of all due to the need for substantial progress by the mid-term review. The plan takes advantage of the existing resources and steering group but this is a vulnerable time. It must also be recognised that the issues identified herein will require persistence and the initial market response may be slow.

Medium risk

Leadership: This is essential. The platform needs strong leadership and guidance, both within the KTN and RSC but also coordination from outside through the advisory panel. The work changes from the relatively stimulating analysis and planning phase to the sustained perspiration of execution. It will require sustained energy and commitment. The platform will not have a full time dedicated project manager. Steering Group commitment and leadership, particularly from industry, is critical.

High risk

Partners: Partners are essential to this delivery plan. Alliances need to be built and joint working established. Many will be willing to participate but this may not be universally the case. Partners also introduce additional needs which need to be satisfied thereby adding to the overall burden.

Medium/low risk

Industry: The ultimate success of the project will hinge on the response from industry to the activities. Companies need to be clear how value can be added and to respond accordingly – this is true for all platforms. Industry commitment to the steering group is promising but the outcomes from the SONAR project are not encouraging.

High risk

6 Evaluation

The project must contain an evaluation component and this may not be easy to put in place. Meaningful performance measures may be difficult to ascertain but Chemistry Innovation will need to establish across all its activities. This platform should use these to avoid unnecessary profusion so none are proposed here.

If it is desired to track changes in the A&MS and associated communities arising from this project and other factors over the next few years then it would be necessary to establish a quantitative baseline that can be used as a reference point for future comparisons. This could be done by formal attitude surveys the first of these would need to be undertaken at the current moment and then repeated at, say, two yearly intervals. It would be difficult to distinguish changes arsing from this action plan from other general background changes. At the current time we do not consider that scarce human or financial resources should be allocated to this.

7 Next Steps

The steps required to initiate this plan are as follows.

1. The plan needs to be approved by the Steering Group and commended to Chemistry Innovation

2. Chemistry Innovation to adopt the plan (28th July)

3. RSC to adopt plan (end July, Mario Moustras)

4. Steering group to become Advisory Panel, appoint chair, review membership (Mario Moustras, 15th August)

5. Chemistry Innovation staff to be briefed in detail on plan (Harry Ziman (acting for Chemistry Innovation), to complete by 15th August)

6. Chemistry Innovation and RSC to jointly agree prioritised actions

Appendix 1: Further Strategic Themes

Drivers for Innovation in A&MS

Although this study has not set out to systematically develop innovation priorities a substantial amount of important information was generated from users of A&MS. The largest single area was nanotechnology. This need has already been recognised, for example by the CEMMNT project.

An interesting area is the wide range of measurements of products in their end uses and in many cases the challenge is to find objective reproducible measurements for consumer perceptions. There will always be a wide range of unique assessment methods for products, applications and manufacturing.

There were also instances reported where universities, pharmaceutical and personal care organisations were driving analytical techniques to the limit. These examples, which very probably will have a wider relevance, are rarely reported in the analytical literature, and may not be picked up for wider dissemination.

There is a strong view that automation and high throughput technologies (HTT) will have an increasing role to play although a cautionary note was expressed that this could exacerbate the dumbing down of the subject. The experience of current users is that it increases productivity but present major problems in assessing outcomes of experimental work, places demands on good experimental planning and data handling is challenging.

High Level Objectives

- Work with partners to ensure that A&MS capabilities and timescales fit the needs of new technologies such as nanotechnology and HTT
- Find means by which outstanding uses of A&MS can be collected from various journals and publications, and then publicised
- Explore means of capturing and communicating A&MS developments in end-use applications e.g. consumer perceptions
- Monitor needs of legislation, especially REACH, for A&MS input

Overarching Action

- Integrate A&MS into innovation strategies for all technology platforms

Actions	Activities	Potential Partners
Explore requirements for A&MS resulting from new technologies or legislation. Put in place plans to meet them	Build links with Nano-technology research community to explore how to develop techniques and standards in an appropriate time-scale	CEMMNT/ MNT KTN/RSC Chemistry Innovation
	Continue to support HTT technologies; participate in appropriate groups within Chemistry Innovation	Chemistry Innovation
	Organise and run an event to explore and define A&MS requirements from REACH	CIA / RSC
	Set up monitoring service to watch for other A&MS requirements in emerging legislation	RSC / CIA
Develop means for scanning literature for novel applications	Ensure that demanding and novel applications for A&MS are drawn from *non* A&MS sources, and communicated widely	Chemistry innovation / RSC
	Explore use of RSC web-site or other electronic publishing to highlight such developments	RSC
	Continue to monitor developments in end-use or customer 'experiences', as allowed by commercial confidentiality	Chemistry Innovation
Support creation of A&MS entrepreneurs	Encourage and support potential entrepreneurs with novel A&MS ideas to consider establishing businesses	RSC (via small business web portal and planned small business studies)

Suggested Deliverables

- Event on REACH implications for A&MS
- Joint meetings and forward plans to ensure that A&MS can support nano and HTT
- Monitoring service in place to watch for new legislative requirements
- Web-site pages or other means for communicating particularly innovative uses of A&MS

Innovation, Research and Universities

There is general dissatisfaction research and innovation is insufficient in the UK and is often only in reactive rather than proactive. Academe has a role to play but A&MS is not given a high profile. Increased collaboration is sought, particularly at the boundaries between disciplines and by application of existing techniques in new areas. This latter aspect is hampered in universities as such extensions of existing techniques appear not to be readily supported by research councils.

Industry does not speak particularly highly of academe and particularly of the experience of collaboration where there is a clear tension between the research and IP agendas of universities and the needs of industry. Equally universities are faced with a shortage of collaborators in industry and they too share the view that analytical science is the poor relation of other branches of chemistry.

High Level Objectives

- Improve links between universities and industry
- Raise the standards of innovation in the UK to approach those found in Europe
- Re-market A&MS in the same way that interest has increased in forensics and security applications of A&MS to improve recruitment of high-quality undergraduates

Overarching Action

- Engage the academic community to more closely align research and innovation to the needs of industry

Actions	Activities	Potential Partners
Carry out benchmarking study across Europe and identify means to close gaps	Seek out quantitative date to assess nature of gap	Chemistry Innovation / RSC
	Identify centres of excellent practice and capture learning	Chemistry Innovation
	Prepare action plan for closing the gap	
	Revisit use of Analytical Chairs; set clear objectives, including mix of fundamental research and applications	RSC
	Identify potential UK centres of excellence; provide tailored support re funding and international collaboration	Chemistry Innovation
	Similarly, identify individuals who are potential science leaders in A&MS; seek ways to enhance their contribution	Chemistry Innovation / RSC
Develop suite of activities to promote collaboration between industry and academia	Consider provision of a clearing house / brokerage service for potential partners	Chemistry Innovation / RSC
	Organise road shows, demonstrating academic A&MS capabilities to industry (such as Car Boot Sales).	Chemistry Innovation
	In promotional activities in 3.1 above, ensure that there are sufficient examples of industry / academic collaboration	Chemistry Innovation
	Ensure that FP7 is exploited to promote wider collaborations i.e. bringing European good practice in A&MS to UK industry and academia	RSC
Participate in recruitment activities to make A&MS more attractive to academic high-flyers	Support universities in provision of attractive, exciting recruitment / promotional material	RSC
	Identify schools and educational charities (e.g. Gabbitas Tring) which support academic high-flyers, and provide supporting material for careers service, summer schools etc	RSC
	Consider provision of a dedicated web-site, with teaching material, show-casing careers achieved by A&MS specialists	Chemistry Innovation
Influence evolution of National Measurement Systems	Participate in discussions on the future structure of the National Measurement System in the light of anticipated future reorganisation.	Chemistry Innovation, RSC, NPL, LGC (Government Chemist)

Suggested Deliverables

- Benchmarking study complete and communicated
- Revisit, clarify and communicate role of Analytical Chairs
- Prepare detailed action plan for preparation of a set of communication tools to encourage high-performing students into A&MS-linked undergraduate courses.

Instruments and Standards

The trend to cheaper, faster and more sensitive instruments was welcomed. There was a warning that instrument manufacturers are overselling their equipment but they also fulfil an increasing role in knowledge transfer. There are issues around standards and validated procedures despite the extensive activity that was found in this area (see background report).

There was a remarkable, though not unexpected, difference in the approach to capital expenditure on laboratory equipment. The environmental and chemical industries were cautious and parsimonious. The pharmaceutical and personal care industries had annual spends that the smaller companies could only dream of. However, the instrument manufacturers may be feeling some price pressures. The growth of outsourcing has led to fewer purchases of major pieces of equipment, and some of the purchasers are finding it easier to negotiate keen prices.

High Level Objectives

- Improve processes to exchange knowledge concerning standards, methods and reference materials and collate information on knowledge gaps that need to be closed
- Assist instrument manufacturers with technologies for the next generation of instruments
- Strategically influence work of standards bodies

Overarching Action

- Improve communications between providers and consumers of reference materials, standards and validated methods

Actions	Activities	Potential Partners
Standards, methods, reference materials	Establish a free-to-use portal methods and reference materials	LGC (via Anamap), RSC
Next generation instruments	Engage organisations supporting the development of instruments	Gambica, CEMMNT, Sensors KTN
	Establish instrumentation and standards needs of next generation manufacturing processes	Britest, CPI
	Explore collaborative projects for development of hybrid techniques for industrial problems	Instrument manufacturers
Strategically influence work of standards bodies	Build links with UK representatives on standards bodies thereby leveraging their programs and activities	LGC, NPL, RSC
	Promote knowledge dissemination to facilitate adoption by UK industry	NPL

Suggested Deliverables

- A web portal linking to methods and sources of reference materials
- KT activities linked to standards organisations

Information and Software

There is clearly a problem with compatibility of software between different instruments, systems and manufacturers. One company even reported retaining old legacy instruments purely as a means of accessing its essential data archives. Although improvements have been made people are clearly dissatisfied with the current situation which also needs to take into account information stored in older systems.

Users also reported the generation of large amounts of information, a trend that is likely to continue as technologies such a process analytics and high throughput techniques gain an increasing hold as well as the normal growth in analysis and measurement. The handling of data and links to informatics and chemometrics were seen as challenges.

High Level Objective/Action

- Advocate the creation of common software platforms

Actions	Activities	Potential Partners
Common software platforms	Communicate the findings to the instrument and laboratory information community	Gambica amongst others
	Establish software communications as one of the areas in the web portal (see next section)	NPL

Suggested Deliverables

- Deployment of emerging software standards in UK industry
- Problem solving forum based on knowledge of user community

Appendix 2: Chemistry Innovation Functions

These PowerPoint slides are taken from a general presentation on the organisation and structure of Chemistry Innovation and summarise the primary responsibilities of the major functions within it. Each is led by a member of the Executive Team.

Chemistry Innovation
Knowledge Transfer Network

Technical Team responsibilities

Knowledge Transfer Networks
A DTI business support solution
Delivered through the Technology Programme

- Research Councils
  - advise on areas they are investing in
  - advise on the technical issues they are considering
  - advise on knowledge transfer process
  - Understand how we can help them
- To influence Government policy on technology and skills
  - Advising on science policy development
  - Interface with the DTI Technology Strategy Board
- Engagement with academic community
  - Academic stakeholder forum
  - Faraday Associates
- Technology strategy development
  - Interface with ISB
  - Technology horizon scanning
  - Roadmapping
  - International interface
  - Platform identification and development including interactions with other KTNs
- Strategic deployment of Case Awards
- Maintenance and delivery of technical competency of Chemistry Innovation through internal capability and access to external providers

Chemistry Innovation
Knowledge Transfer Network

Commercial Function Responsibilities

Knowledge Transfer Networks
A DTI business support solution
Delivered through the Technology Programme

- Delivery of commercial offering such as the Sustainable Manufacturing project
- Business development including Key Account Management
  - Individual companies
  - Trade associations
  - Regional stakeholder forum such as the RDAs with their Science and Industry Councils
  - Interaction with other KTNs
  - Identifying opportunities to exploit
- Maintenance and delivery of innovation competency of Chemistry Innovation through internal capability and access to external providers
- Marketing and communications
  - Brand and trademark management
- Supplier accreditation and agreeing sales and purchase contracts
- Monitoring performance of UK plc in chemistry innovation

Projects Function Responsibilities

Chemistry Innovation
Knowledge Transfer Network

Knowledge Transfer Networks
A DTI business support solution
Delivered through the Technology Programme

- Assessment of new opportunities identified from technical and commercial teams
- Project planning
- Assembling consortia and putting in proposals for funding
- Helping to define the SusChem programme on behalf of the UK
- Project implementation and delivery
- Project evaluation and closure of projects
- Responsible of projects of a 1-3 year timescale
- Implementing of Case Awards

Operations Responsibilities

Chemistry Innovation
Knowledge Transfer Network

Knowledge Transfer Networks
A DTI business support solution
Delivered through the Technology Programme

- Implement the event programme
- Implementing and maintaining the website
- Maintaining the Customer Relations Management system and contacts database
- Data Protection compliance
- Provision of infrastructure services including IT, office support, procurement of company office supplies