Strategic Review of the
UK National Measurement System (NMS)
April – December 2005

Annex C

Synopsis of the NMS Review Discussion Papers

Introduction

From May to August 2005, five discussion papers were published on the DTI's website and responses to the questions posed were invited from the users, operators and stakeholders of the NMS. These papers covered:

- NMS strategic framework,
- Programme structure
- Programme formulation
- Advisory structures
- Knowledge transfer and impact

The papers have been condensed into the following synopsis.

Paper 1: NMS Strategic Framework

1.1 The NMS is the infrastructure of laboratories and services that underpins measurement standards and develops measurement technology essential to the UK economy and the quality of life of UK citizens. Its mission is to meet the needs of users in industry and the community by driving up measurement standards, whilst continuing to work at, and exploit, the leading edge of measurement research.

1.2 The NMS has a wide scope of diverse activities. In conjunction with fundamental research into measurement, it supports innovation in industry by:

- Stimulating the continuing development of better measurement techniques and equipment,
- Providing high-accuracy calibration and testing services,
- Maintaining primary national standards,
- Providing traceability in measurements,
- Disseminating good measurement practice,
- Underpinning measurement regulation, and
- Supporting international links.

1.3 Measurement also underpins a wide range of public goods, including consumer protection ("legal metrology"), forensic science, environmental controls, safe medical treatment and food safety regulation, as well as the technical standards that ensure barrier-free trade. The National Measurement Institutes (NMIs – NPL (National Physical Laboratory), TUV NEL Ltd (the former National Engineering Laboratory), LGC Ltd (the former Laboratory of the Government Chemist) and NWML (National Weights and Measures Laboratory)) are the principal suppliers of these standards and technical services.

Question 1
What do you consider to be the core function, or functions, of the NMS now? How do you see this changing over the next 10 years?

Question 2
What do you consider to be the UK's future need for NMS activities? Should the NMS change or adapt to meet that need and if so, how?

Question 3
Innovation can be defined as the exploitation of new ideas, turning scientific and technological discovery into new and profitable products and services. How can the NMS best stimulate and support such innovation in the UK?

1.4 The macro-economic arguments for funding the NMIs and measurement programmes based on market failure are well established. Recent DTI strategy papers, notably the Innovation Report published in December 2003, accept that there is a role for Government in helping to provide the investment for measurement programmes and services that have a wider public benefit. Firms have little incentive to develop measurement standards since they cannot exclude other firms from the benefits. Added to the efficiency gains made from the use of standard measurements, the NMS can be said to underpin not just measurement technology but also innovation performance and swathes of activity essential to a dynamic modern economy. There is a strong correlation between the breadth and depth of measurement systems within an economy and the sophistication of that economy's industrial processes and technological capability. The US National Institute of Standards and Technology (NIST) sees a clear link between having the best measurement capabilities in the world (being the international leader) and accelerated scientific discovery that leads directly to higher productivity through industrial R&D.

1.5 A review published in 1999 said that the NMS makes a significant contribution to the UK economy (£5 billion of GDP in 1999). In 1999 the UK's instrumentation sector alone was worth £8 billion (DTI Innovation Report, 2003). By comparison, funding for NMS programmes in that year was £38 million. Despite this huge contribution and the excellence of its measurement laboratories, NMS programmes seem to be little known or understood even within the S&T community.

Question 4
How can the profile of the NMS be raised so that its services and value are better known and exploited?

1.6 In recent years, Government policy has been to promote R&D, encouraging industry to innovate as a means of enhancing industry's competitive position. NMS programmes have reflected this policy by increasing the proportion of research carried out within most programmes. However, this puts pressure on the proportion of funding available to maintain the infrastructure (laboratories, facilities, equipment and staff capability) which catalyses and facilitates that research. Also the provision of traceable standards and reference materials has had to be balanced with the drive to include projects that push the boundaries of leading edge innovative research. Whilst traceability and associated services are the parts of NMS that seem to be most valued by industry and attract most industrial support through fees, there are questions about whether or not they should depend on the large-scale infrastructure investment that the UK Government provides as part of its NMS programmes.

Question 5
How integral is the maintenance of the infrastructure (laboratories, facilities, equipment and staff capability) within the UK NMIs to the development of new research areas in metrology? Could the UK have the latter without the former? Are there alternative models by which the NMS supporting infrastructure could be funded?

Question 6
How should the NMS programme portfolio be structured? For example by:

- **The present model of a mix of SI and derived units, market focussed programmes, underpinning research and crosscutting programmes?**
- **Industrial or technology sector? Or by,**
- **The Government Technology Strategy themes?**

Are there alternative groupings and why would they be preferable?

1.7 DTI's NMS budget currently allocates about £60 million per annum to NMS science and technology programmes. The spend runs on a three-year cycle although individual programmes start and finish at different times. A large proportion of programme funding goes to investment in the infrastructure to support measurement activity. This Strategic Review will be considering other models for providing this resource in later papers. Against a background of limited resources and competing priorities, there are concerns that the UK's capability to provide underpinning metrology support to the science base in certain areas may fall below optimal levels; and, that we fail to meet the metrology demands for future technological needs. In either case NMS may not maximise its contribution to the UK economy.

Question 7
Should the NMS favour a comprehensive scope of capability or one that is more specialised and focussed by excellence and why?

Question 8
Which of these options would give greater support to innovation in the UK? And which would achieve the greatest impact in terms of maximising the contribution of the NMS to the overall UK economy?

Question 10
Are there areas where the measurement expertise lies outside the UK NMIs, or in which the NMIs do not have the staff or the facilities to pursue this work? Please name these areas. What other organisations are capable of undertaking such work?

Paper 2: NMS Programme Structure

2.1 The NMS portfolio is currently made up of 21 individual science and technology programmes that aim to link together to form an integrated and coherent entity. The programmes, by underpinning measurement standards and developing measurement technologies, are collectively a key driver of better innovation and industrial performance in the UK economy. They also contribute directly to the protection of the quality of life (health, safety and environment) of UK citizens, the enhancement of the UK's science base and skill-set, as well as safeguarding fair trade. Each aspect has critical measurement considerations for the future, and the NMS programme portfolio needs to reflect and prioritise these by strategic planning so as to have the right locus, and be in a suitable shape and size, to provide optimum benefits for the UK economy and UK citizens, looking up to at least 10 years ahead.

Question 1
Do you consider there to be a DTI strategy for the development of the portfolio of NMS programmes? If so, is it comprehensive and clearly articulated? What should a DTI overall NMS programme strategy include?

Question 2
Do you consider that the drivers (economic benefit, quality of life, skills, fair trade etc) are properly reflected and articulated in DTI's strategic direction of the NMS programme portfolio, taken as a whole? If not, can you suggest how key potential benefits to the UK could have improved, and appropriate, high-level strategic inclusion and influence?

2.2 Following DTI's Innovation Report published in December 2003, a business-led Technology Strategy Board was appointed to identify technologies that offer the greatest competitive advantage to the UK, and towards which DTI funding would be directed. This has created business "pull through" for the DTI's focussed investment aimed at catalysing the development of promising emerging technologies in areas selected by the Board. For the NMS, the Measurement Advisory Committee (MAC) provides a similar external strategic influence by advising DTI's NMS Directorate (NMSD) on the effectiveness with which the NMS supports innovation, the priorities assigned to NMS programmes and the broad objectives, balance and strategy for UK Government support of measurement.

Question 3
What is the best model or method for achieving optimum, effective, high-level strategic governance of DTI's NMS programme portfolio? Should the DTI's existing two high level innovation Boards (Technology Strategy Board and MAC), and the research information and other inputs that feed into the Boards, be aligned, or linked in some way? What would be the advantages and disadvantages of this? Should and could other high-level R&D Strategy Boards

link in (eg those governing the science and technology programmes of other Government Departments and Research Councils)?

2.3 An underpinning and dynamic element in the positioning of the future NMS programme portfolio should be horizon scanning and trend spotting in terms of assessing and reflecting the measurement dependencies of new and emerging technologies (an example is nanotechnology). The new Measurement for Emerging Technologies (MET) programme has begun to address this within a modest budget. There is some generic work undertaken to determine future technical measurement needs across all technologies. Also analyses of future trends, technical needs and potential impact are sometimes commissioned for individual programmes in order to inform the formulation of follow-on programmes.

Question 4
Do you consider that the present horizon scanning and trend spotting activities of the NMS programme portfolio are able to identify, prioritise and address the next-generation measurement requirements in an effective and timely way? If not, how would you improve this capability?

2.4 There are 5 main differentiators of the 20 NMS programmes considered in this review, in terms of basis on:

- SI Units - seven programmes (Length, Mass, Thermal, Time & Frequency, Optical, Electrical and Valid Analytical Measurements),
- Derived units - two programmes (Acoustics and Ionising Radiation),
- Market sectors or technologies - seven programmes (Measurement for Biotechnology, Photonics, Flow, MET and 3 Materials programmes – Characterisation, Performance and Processability),
- Fundamental underpinning research - two programmes (Quantum and Software Support), and,
- cross-cutting services and information – two programmes (Knowledge Transfer and International Metrology).

2.5 This programme portfolio has evolved over many years and today much of it still reflects a historical legacy, whilst striving to be forward looking, needs-based and innovative. By its nature the portfolio could appear to be disparate and fragmented and is certainly subject to a number of tensions that might dissipate its focus. There are a range of contributory factors that have shaped its present format and size:

- The SI unit is a well-established building block for international metrology programmes and characterisation, and it made sense to standardise and align a set of programmes on this basis.
- The start/end points of the 3 year lifecycles of each programme are different from each other, making combination, collaboration and the identification of synergy, overlaps and gaps difficult.
- The majority of individual programmes roll from one 3 year cycle into the next with the same nomenclature, and broadly the same coverage, so reinforcing fragmentation and isolation.
- New programmes have been added incrementally as need was identified and defined, tending to create silos and reinforce separation of specialist work streams, so militating against multi-disciplinary project working and cross-fertilisation of ideas.
- Relatively small discrete programmes were easier to find money for, and this had led to the appearance of inconsistency when comparing the total amounts allocated to each programme.

Question 5
Is there scope to brigade, or join up, some of the existing programmes so as to exploit synergies and economies of scale, reduce overlap and/or fill gaps? Which programmes would be candidates? Or should there be more individual programmes (bearing in mind that the total budget may not be increased)? If so, what should they cover and how should the programme portfolio be arranged?

Question 6
Name any gaps that you consider exist in the coverage of the present NMS programme portfolio. Are there any current and future crosscutting metrology needs that are not being addressed?

Question 7
Name any of the current programme areas that you consider could be wound down with a view to putting on hold or dropping from the portfolio? Give reasons for your choice.

Question 8
What is the scope to configure the existing programme portfolio into broader programmes based on the 5 constituent themes identified in 3.2 (SI Units, derived Units, market sector/technologies, underpinning research and cross-cutting services)? Would this have merit (or not) and be workable?

Question 9
Is there scope to configure the existing programme portfolio by industrial or technology sector, for example by following present (and in due course, subsequent) Government Technology Strategy priorities?

Question 10
Although it would take time to phase in, and would present potential workflow overloads, should there be a common 3-year programme lifecycle in order to aid collaboration and linkages and to exploit synergies? Is 3 years the optimum time in terms of allowing continuity of work, exploitation of investment and control of Government funds? If not, what length of time do you consider would be optimal, and should this apply to all programmes?

2.6 Each NMS programme contains a varying mix of activities, that can be classed loosely in terms of: maintenance of standards; R&D that facilitates innovation; and knowledge transfer activities. Knowledge transfer will be considered separately in a later paper. Maintenance of standards covers the upholding of standards for traceability purposes, and in turn requires associated developmental R&D, and comparative work, to refine and improve the standard. Innovative R&D addresses areas where there are potential exploitation routes to industrial markets and where advances in metrology could stimulate innovation or remove metrology barriers to innovation. Such R&D is often high-risk and has a longer-term payback that is hard to define because there may not be an evident industrial customer.

2.7 Each NMS programme depends to varying extents on investment in infrastructure, this being laboratory facilities, specialised equipment, scientific capability and an appropriate knowledge base. In many cases the provision of such infrastructure is viewed as absolutely necessary in order to conduct the elements of the programmes that are charged with maintaining and refining certain measurement standards in order to provide traceability and non-routine calibration services. Past heavy investment in infrastructure might then justifiably be used to advocate continuity of such "maintenance" projects in order to maximise the value of the up-front commitment. This could, as a consequence, reduce flexibility within programmes, and across the whole portfolio, in terms of setting an appropriate balance between "maintenance" and R&D to stimulate innovation. It could also diminish the amount of money available for such innovative R&D and work on vital new technologies.

Question 11
What measurement standards and references do you consider that the NMS programme portfolio should provide for in terms of supporting their maintenance and associated development, and providing traceability? Please state for your own area of engagement with the NMS, and for other areas if you are able.

Question 12
Within NMS programmes, is there scope to separate maintenance, development and traceability of measurement standards, and associated infrastructure requirements, from the R&D element that stimulates innovation, leading to new and improved industrial processes, products and services? Are there dependencies? What are the advantages and disadvantages of such separation? Please comment from your own area of engagement with the NMS, and for others if you are able.

Question 13
Could and should the requirement to maintain or purchase the expensive infrastructure, particularly capital facilities and equipment, that underpins some programmes be considered more strategically and prioritised across the whole programme portfolio? Should the planning timescales be longer than the present 3-year programme lives? Is there scope for gaining contributions from third parties who would benefit from the infrastructure? Please comment from your own area of engagement with the NMS, and for others if you are able.

Paper 3: NMS Programme Formulation

3.1 Formulation is the term used for the process of defining the scope of a future NMS programme, taking into account trends, new technologies, potential impact and user needs, and selecting the projects that will support its objectives and form its content. The process is well established, its structure is tried and tested, and it is applied almost consistently across the portfolio of 21 individual NMS programmes.

3.2 The formulation process has the following stages:

- Strategic Programme Overview – DTI process to set the scene by considering future trends, markets and linkages to wider strategic objectives of Government and other stakeholders
- Orientation – Determination of programme scope and objectives
- Consultation – Establishment of needs of stakeholders and the user community. Design and costing of potential projects. Consultation on draft programme content.
- Prioritisation – Expert assessment and ranking of proposed constituent projects
- Programme Development – Drawing up and approval of final programme, including contractual arrangements.

3.3 The timescale of the formulation process is about 18 months and tends to start mid-way through an existing programme. The process is led by a Programme Formulator, invariably appointed from the most appropriate National Measurement Institute.

Question 1
Do you consider that DTI presents the right evidence and information to give a clear steer to the formulation process on the need for the proposed NMS programme, and its fit within, and contribution to, wider NMS and Government objectives? Please comment from your own area of engagement with NMS programmes, and for others if you are able.

3.4 In practice, in the present formulation system, it seems to be the presumption that existing programmes will move seamlessly into another 3 year phase in broadly the same format and size, albeit maybe with re-considered technical emphases, a refreshed set of projects and financial adjustments. There appears to be little re-checking of the rationale or evaluation of the impact of the previous programme. Also there appears to be no strategic "grand plan" for individual programmes that looks forward beyond 3-year time horizons.

Question 2
Are the observations above a true representation of the way in which NMS programmes evolve? Please tell us what it looks like from your perspective and suggest alternatives or improvements.

3.5 The formulation process, by having a set timescale and presenting a defined window of opportunity for identifying needs and relevant projects, could have a constraining influence on the make-up of the future programme in areas where technologies and user needs are rapidly changing. Strategic needs in a programme may shift but the programme is to some extent fixed after completion of formulation with little scope to rebalance or accommodate new directions or potential collaborations with other NMS programmes that are being formulated at different times. There is a formal Annual Review built into each programme but the remit is operational rather than strategic.

Question 3
Could you suggest ways in which NMS programmes could become more responsive to changing needs during the lifetime of the programme? How could the programmes become more dynamic and flexible in terms of accommodating new projects?

3.6 The Programme Formulator is appointed by DTI following nomination by the appropriate NMI. The Formulator is invariably an expert in the field and will probably be involved with (and maybe manage) the new programme.

Question 4
Should the Formulator be an "insider", as at present, or independent of the proposed programme? What are the pros and cons? Give reasons for your view.

3.7 The objective of the **Orientation phase** is to guide and shape the formulation process by defining the scope and direction for the new programme and enlisting buy-in by key stakeholders, all of whom hopefully share a common vision. It features an Orientation meeting at which representative experts and stakeholders, covering the range of the proposed programme, agree the focus and recommend the

work areas to be considered. At this meeting, NMSD provide DTI's strategic direction, as gained from the earlier Strategic Programme Overview stage of formulation. Reports from the meeting are posted on various websites to allow continuing comments.

Question 5
In your experience, does the Orientation phase as presently operated meet the objective stated above? Is the evidence presented at the Orientation meeting comprehensive and sufficient? Are the right representatives present at the meeting? Could you suggest ways in which this phase could be improved?

3.8 The **Consultation phase** is a means of seeking, recording and reflecting the technical needs of the user community. It draws upon a wide range of inputs, for example from industry, business, Research Councils, academia, regulators, trade associations and overseas NMIs, by such means as literature reviews, websites, discussion fora, market research, interviews, focus groups, studies and questionnaires. Input from these sources is used to compile a Public Comment Document that sets out a proposed draft programme. The document is publicised on DTI's NMS website as part of further consultation on the programme's content. The consultative process enables the Formulator to draw up a Programme Document containing descriptions of proposed projects, together with supporting data and costs, that reflect the steer from the Orientation phase and feedback from the Consultation phase.

Question 6
In your experience, does the Consultation phase provide optimum capture of stakeholders' and users' technical requirements? Could you suggest ways in which this phase could be improved?

3.9 The Prioritisation phase aims to recommend an optimised programme in terms of a prioritised list of constituent projects that could be carried out within the indicative budget. The phase is underpinned by a Decision Conference attended by the nominated members of the Measurement Advisory Committee Working Group for the programme.

3.10 The Decision Conference uses a form of multi-criteria decision analysis in order to produce a prioritised list of projects in terms of value for money. The scoring is against 5 pre-defined criteria, namely:

- Contribution to economic impact,
- Quality of life impact,
- Science impact on innovation,
- Improvement of quality, originality and prestige of NMS (NMI) science, and
- Support for standards and technical regulation.

3.11 Working Group members are provided with the Project Descriptions document that is the outcome of the Consultation phase. It lists projects, within pre-defined themes, that can be delivered within about 120% of the maximum budget. WG members must knock the list down to a prioritised set in terms of value for money that can be delivered within budget. The proposed projects cover a disparate mix of activities in the programme, and can be classed loosely in terms of: maintenance of standards; R&D that facilitates innovation; and knowledge transfer activities. Maintenance of standards covers the upholding of standards for traceability purposes, and in turn requires associated developmental R&D, and comparative work, to refine and improve the standard. Innovative R&D addresses areas where there are potential exploitation routes to industrial markets and where advances in metrology could stimulate innovation or remove metrology barriers to innovation. Knowledge transfer disseminates the outcomes of the programme and seeks to maximise its impact.

3.12 The projects also vary considerably in terms of their cost with some requiring funding from DTI in the order of up to £50k competing against others costing up to, for example, £500k. In addition there are inter-dependencies between projects, and with other NMS programmes, plus "infrastructure" considerations in terms of making use of and providing for facilities, equipment and scientific capability. Each programme varies in terms of the number of proposed projects but typically the range is between 10 and 40. Adoption of this number of projects sometimes leads to accusations that the available budget is being "salami-sliced" and spread thinly over too broad a remit that consequently dilutes the impact of the programme and addresses usually the low-risk options.

3.13 MAC Working Group members are the judge and jury at the Decision Conference but they take advice from the Programme Formulator and the proposed Programme Manager (may be the same person). They are invited to score projects against the selected criteria (as above), but NMSD and the NMI also input scores for economic impact, NMS science and support for standards. The weightings

given to the criteria are set by Working Group members at the Decision Conference. They can be very influential because many of the prospective projects may impact against only one or two of the criteria.

Question 7
In your experience, does the Prioritisation phase, particularly the Decision Conference, give you confidence that the right projects have been selected to meet stakeholders' and users' needs, as articulated at Orientation and Consultation? Do the selected projects offer optimum value for taxpayers' money? If not (to either or both questions), explain why. Could you suggest improvements or alternatives?

Question 8
Could and should there be separate (and maybe different) formulation mechanisms for different types and size of project within a programme? Are there any types of activity that should be taken out of the formulation process and selected and approved by other means?

Question 9
Should there be a smaller number of (larger) projects? If you agree explain why.

Question 10
Who should have a vote at the Decision Conference? Should it be restricted to MAC Working Group members?

The model described and discussed above (Overview, Orientation, Consultation, Prioritisation) takes about 18 months to work through. It largely focuses on the programme in question and has as its starting point an indicative budget. Projects that do not get through the Decision Conference are dropped, even though they may be more "worthy" than some in another programme that do get through their own Conference.

Question 11
Could you suggest alternative (better) models for the formulation process?

Question 12
Is there scope to streamline the current process and/or make it more efficient? If so, could you suggest how?

Question 13
Is it possible, through the formulation process, to introduce competition between programmes, and constituent projects, for limited financial resources?

Paper 4: NMS Advisory Structures

4.1 DTI's National Measurement System Directorate (NMSD) takes advice from a variety of sources in order to define, direct, commission and supervise the DTI's portfolio of 21 NMS programmes. Advice may be:

- Strategic - sought from stakeholders and beneficiaries of the NMS, from a formal advisory committee and from scientific, technical and economic experts, in order to shape and position the portfolio of programmes to achieve optimum impact and benefit for the UK economy and citizen;
- Operational - supplied by formal working groups, external experts, business groups and interested users, particularly in the context of the development (formulation) and operation of each of the NMS programmes;
- Informative – specially commissioned advisory reports, analyses, studies, roadmaps, workshops, seminars etc to inform NMSD's policy-making, and to underpin strategic and operational considerations;
- Contractual – external review and verification embedded in NMSD's contract with a programme supplier. This applies particularly to the overarching Science contract that DTI has with NPL (National Physical Laboratory), the UK's leading NMI (National Measurement Institute).

4.2 In addition there is an ongoing exchange of advice and information between NMSD and other parts of DTI, wider Government and the NMIs that operate the majority of the NMS programmes.

Question 1

At a strategic level, comment on whether or not you believe DTI's NMSD to be well informed by its various advice sources so that it is able to understand the present and future measurement needs of industry and the wider UK community, and/or to make sound, balanced, decisions on the scope and content of the NMS programme portfolio.

Question 2
At an NMS programme operational level, comment on whether or not you believe DTI's NMSD to be well informed by its various advice sources so that it is able to:

- **Preside over the formulation of programmes in order to assure that they meet fully and effectively the objectives of stakeholders and users, and/or**
- **Supervise the operation of the individual programmes in order that they stay on track and achieve optimum impact and value for money.**

Question 3
Are there any gaps or deficiencies in the range of NMSD's knowledge of the NMS, and the future needs of its stakeholders and users, that could be remedied by seeking and taking advice from different sources than used at present, or by asking more from existing sources?

Question 4
Specifically, comment on whether or not you believe DTI's NMSD to be well informed by its various advice sources in the area of horizon scanning and trend spotting for the new and emerging technologies that could be exploited by innovative measurement R&D.
Are there any gaps or deficiencies in NMSD's knowledge and information in this area that could be remedied by seeking and taking advice from different sources than used at present, or by asking more from existing sources?

4.3 At a strategic level, NMSD's prime source of formal external advice on its portfolio of NMS programmes is the Measurement Advisory Committee (MAC) and its supporting Working Groups. A further source of advice is the various stakeholders and users of the NMS programmes and the services, such as calibration, that are underpinned by them. This advice is usually sought in the context of the formulation of the individual NMS programmes. The objective of the Orientation phase of formulation is to guide and shape the formulation process by defining the scope and direction for the new programme and enlisting buy-in from key stakeholders. It features an Orientation meeting at which experts and stakeholders, covering the range of the proposed programme, advise on the focus and the work areas to be considered. The Consultation phase that follows is a means of seeking, recording and reflecting the technical needs of the user community. It draws upon a wide range of advisory inputs, for example from industry, business, Research Councils, academia, regulators, trade associations, NMS user-clubs and overseas NMIs, by such means as literature reviews, websites, studies, discussion fora, questionnaires, market research, interviews, focus groups, workshops and seminars.

Question 5

- **Do you feel that the right stakeholders and users are consulted during programme formulation, and that the most appropriate means are used?**
- **Do you think that the advice of stakeholders and users is given sufficient weight by NMSD and the programme formulator (usually from the relevant NMI) in defining the constituent projects of the programme?**

Give reasons for your views.

4.4 The NMS Materials programmes, for historic reasons, each have a number of formal Industrial Advisory Groups comprising the programmes' industrial stakeholders, which are in many cases those that co-fund projects within the programmes. These groups have a role in steering the projects at an operational level and ensuring that they stay on track to meet their target output. The Groups also have a role in disseminating the outputs of the projects.

Question 6
Is there a role for Industrial Advisory Groups, or similar groupings, in other NMS programmes? If so, what is that role? How would it fit with MAC's role?

4.5 NMSD also takes advice from expert advisers through a budget set aside for commissioning reports and analyses of measurement issues. Some of the reports are for internal use; others are made available to MAC and/or published on the DTI's NMS website. There is not a forward programme of such reports because they tend to be commissioned on an ad hoc basis, when need arises.

Question 7
Does the Expert Advice budget appear to be used effectively?
Could you suggest better ways in which it could be deployed and/or areas of research or investigation that it should cover, but doesn't appear to?

4.6 DTI also takes advice from the Royal Society / Royal Academy of Engineering Advisory Group for NPL. This is a group set up for the purpose of DTI's monitoring of the overarching Science contract with NPL to deliver around 14 of the NMS programmes in the portfolio. The Group advises DTI on:

- NPL's performance in maintaining and improving the quality of science at NPL,
- Broad strategic issues, notably NPL's longer-term research capability and how its reputation for excellence is being maintained, and
- Whether NPL is maintaining its ability to fulfil the needs of DTI and its other customers.

4.7 The quality of science in the NMS programmes supplied under contract by TUV NEL Ltd and LGC Ltd is not subject to similar independent scrutiny. Nor is there a systematic, consistent, form of scrutiny by independent scientific peer-review of the quality of science and standard of research contained within each DTI NMS programme.

Question 8
How should DTI assure itself of the excellence of the quality of science and standard of research within the NMS programmes?
Are the present checks sufficient?
Could you suggest better models?

4.8 The objective of MAC is to offer the DTI strategic advice on the:

- Effectiveness with which the NMS supports innovation and competitiveness within UK business and industry;
- Priorities that DTI should assign to programmes of work undertaken to meet the needs of the NMS; and
- Broad objectives, balance and strategy for the UK Government support of measurement.

4.9 This objective is achieved by advising on:

- The needs of users in business, industry and the community;
- Priorities for funding;
- The effectiveness of steps to ensure that good value is achieved from investment in NMS programmes and that the right balance is struck between measurement research and the needs of all users;
- The effectiveness of steps to secure greater engagement with business and industry and improve dissemination of the results of investment in NMS;
- Input to DTI's longer-term forward looks;
- Key priorities for the UK measurement system within a European and global context.

Question 9
Is MAC's above-stated remit sufficient to supply the high-level strategic advice that DTI NMSD requires in order to gauge the UK's present and future need for the advancement of measurement science and technology, and to steer and shape its NMS programmes to meet that need most effectively? If not, suggest an alternative remit.

4.10 MAC is an advisory Non-Departmental Public Body (NDPB) recruited under the principles and code of practice of the Office of the Commissioner for Public Appointments. As such, it must be accountable to Parliament and the public more generally for its activities and for the standard of advice it provides. DTI Ministers are also answerable to Parliament for MAC's policies and performance, including the policy framework within which it operates. An advantage of being an advisory NDPB is that appointees are subject to defined terms and conditions covering tenure of appointment and attendance. They are controlled in terms of their quality and commitment, and are required to uphold certain responsibilities, as befits a public appointment. A disadvantage of being an NDPB is that membership is made up of individuals rather than organisations so that substitutions cannot be made, nor can there be a fluid membership that might be more responsive to any changing or new requirements for advice. As a result MAC forms a closed, exclusive advisory mechanism. That could of course be an advantage as well as a disadvantage.

4.11 MAC's independent members hold appointments that are personal voluntary and unpaid (except for expenses). To be eligible for MAC membership the individuals must hold, or have held, a key position in an organisation (whether it be industrial, academic or governmental) in which metrology is of significant importance. Moreover, they must fully recognise the role of measurement in underpinning UK trade, quality of life, innovation and competitiveness, and be able to understand and represent the interests and needs of industrial, scientific and technical users of measurement standards, services and applied R&D.

4.12 MAC is made up of 14 appointed individuals and an appointed chairperson, all drawn from industry, business and academia. In addition there are four members that are ex-officio representatives of Government interests (from MoD, HSE, DoH and DEFRA). MAC meets formally in plenary on two occasions each year. In addition, each MAC member devotes about five days per year to the role of chairperson for one or more of the 18 programme Working Groups that MAC presides over. In practice some MAC members devote considerably more than seven days per year to MAC duties.

Question 11
Does MAC have the right membership to achieve its remit? Are the interests of all significant stakeholders and users covered effectively?

Question 12
Should MAC be an advisory Non-Departmental Public Body? Give reasons for your view.

Question 13
Should MAC membership be a paid or unpaid appointment? Give reasons for your view.

4.13 MAC is supported in its operation by NMSD, who provide administrative support and strategic input. The agenda for its twice-yearly meetings is agreed between the MAC Chairperson and NMSD. It covers the strategic advice that NMSD seeks on the direction of its programme portfolio and on specific high-level issues that have arisen in particular programmes or areas of measurement standards and technologies. An output of MAC's advisory process is the publication of an Annual Report describing the specific advice that it has delivered and the dissemination and impact of this advice.

4.14 Outside the formal meetings, communication between MAC members, individually and as a group, and NMSD tends to be ad hoc and informal. NMSD has plans to introduce an extranet for MAC and MAC Working Group representatives. The extranet would enable the sharing of information and outputs from individual programmes and from NMSD's other sources of measurement advice, leading to better-informed MAC members in terms of the bigger picture. It could stimulate online discussion and dissemination of best practice. It could also be a means by which NMSD could seek advice and opinion as issues arise, thus reserving the twice-yearly MAC meeting for debate of high-level strategic issues.

Question 14
Does MAC fulfil its current remit in an effective and timely way? If not, give reasons.

Question 15
- **Is MAC's remit clear to MAC members (and others)?**
- **Is MAC's required output sufficiently well defined?**
- **Is its advice disseminated effectively?**

Give reasons for your views.

Question 16
At a strategic, influential, level, does DTI make optimum use of MAC? If not, give reasons and suggest how MAC could be better used.

Question 17
Is MAC supported effectively by NMSD, both strategically and administratively?
Does MAC receive sufficient, relevant, information from NMSD upon which to base its advice?
Give reasons for your views.

Question 18
Operationally, does MAC work well and is it effective?
Could you suggest any improvements, both to the twice-yearly meetings and to the communications and advisory process in-between meetings?

4.15 MAC presides over 18 Working Groups, one for each of NMSD's main NMS programmes. There are approximately 150 members, spread across these Groups, all being individuals who are experts in a relevant field of measurement science and technology. They are appointed on the same basis as main MAC members (unpaid, voluntary and personal), although the Working Groups do not have NDPB status. Members are expected to devote about 5 days per year to their duty of providing specific advice on the technical content, management and progress of their individual programmes, and some contribute more.

4.16 Each MAC Working Group is chaired by an appointed member of the main MAC. In this way advice on issues related to the work of the NMS programme can be fed back to main MAC via the Chair. In addition the Chairperson can inject strategic direction and context from MAC into the Working Group's consideration of the progress of its programme. MAC Working Groups have specific duties in the formulation and operation of their programmes. They play a key role in the prioritisation of a programme under development. This phase aims to recommend an optimised programme in terms of a prioritised list of constituent projects that could be carried out within an indicative budget. The phase culminates in a Decision Conference attended by the members of the MAC Working Group, who are invited to score projects against selected criteria. The weightings given to the criteria are set by Working Group members and can be very influential because many of the prospective projects may impact against only one or two of the criteria. The advice from the MAC Working group is the main input in determining the projects that go forward to form the proposed new programme.

4.17 MAC Working Groups also have a formal role in conducting timely annual reviews of their programmes in order to assess quality, value for money, progress towards milestones, take-up of outputs and, when appropriate, to agree programme changes.

4.18 NMSD provides administrative support to the MAC Working Groups. It also recruits the members to the Groups but often has problems finding sufficient willing people who are experts in the particular narrow fields of the 18 programmes. In practice the members of a Working Group have very little contact with members of other Groups. This mirrors, and reinforces, the fragmented nature of the NMS programme portfolio. The proposed MAC extranet would facilitate some inter-Working Group communication by allowing cross-fertilisation of ideas and sharing of best practice between Working Groups.

Question 19

- **Is the remit of the MAC Working Groups correct?**
- **Is it clear to its members (and others)?**
- **Is the Working Groups' required output sufficiently well defined?**
- **Give reasons for your views.**

Question 20

- **Does the MAC / Working Group relationship operate effectively?**
- **Is the Working Groups' advice disseminated effectively to the main MAC via the Chairs of the Groups?**
- **Do the Working Groups receive sufficient and effective strategic direction from MAC, via the Chair?**
- **Do the Groups receive sufficient and relevant information from NMSD, and from the NMI that operates the programme?**
- **Give reasons for your views.**

Question 21
Does each NMS programme require a dedicated Working Group?
Could there be fewer Working Groups, covering broader programme areas?

Question 22
How could the problems of recruiting sufficient willing experts for the Working Groups be eased? Give reasons for your views.

Question 23
In the prioritisation phase, should the advice on selection of projects to go forward to form a new programme be solely in the hands of the MAC Working Group?

Question 24

Operationally, do the MAC Working Groups work well?
Could you suggest any improvements, both to the meetings and to the communications and advisory process in-between meetings?

4.19 The model described and discussed supplies NMSD with advice from many and various sources in order to shape and operate its portfolio of programmes. The MAC structure is a formal advisory mechanism that operates in a defined way, with a defined remit. Advisory input to NMSD from other sources is less well defined, and can be ad hoc. Such other sources include the NMIs, Other Government Departments, Research Councils, Universities, Industrial Advisory Groups, business organisations and user-groups. There appears to be little interaction or debate between advisory sources.

Question 25
Could you suggest alternative (better) models for the advisory process that would ensure that NMSD receives the right balance and weight of advice, both strategic and technical, from all appropriate stakeholder groups?

Question 26
Is there scope to streamline the current advisory process and/or make it more efficient or effective? If so, could you suggest how?

Paper 5: Knowledge Transfer and Impact of NMS

5.1 The NMS, by underpinning measurement standards and developing measurement technologies, is a key driver of better innovation and industrial performance in the UK economy. It also contributes directly to the protection of the quality of life (health, safety, security and environment) of UK citizens, the enhancement of the UK's science base and skill-set, as well as safeguarding fair trade.

5.2 To be most effective in its economic and societal impact, the outputs of the NMS must be converted successfully into tangible benefits to the UK. The means and processes by which this is driven, and made to happen, are crucial to the successful exploitation of the outputs of DTI's NMS programmes. In addition, it is vital that the output of the NMS programmes is directly geared to the needs of UK businesses and citizens now and in the future. The NMS generally, and at individual programme level, must be tuned into, and reflect, feedback from its potential beneficiaries about their emerging requirements. It must also have the means to evaluate the impact of its output so as to "prove" its benefit and shape further activities.

5.3 The aim of NMS knowledge transfer (KT) is to improve uptake and use of measurement technologies and best practices by UK businesses and academic organisations by awareness raising and advice. KT is in place at three levels in DTI's NMS programmes. Each is considered in the following paragraphs.

5.4 Almost all of the **projects** that make up individual NMS programmes are expected to include an element of KT to disseminate their results to potential users, who tend to have highly specialised requirements, that they themselves recognise. Examples of project KT are reports, good practice guides and specialised calibration services.

5.5 At individual **programme level** there is expected to be a further means of disseminating information and results, and spreading best practice, emanating from the programme as a whole. An example would be the metrology clubs, training courses, seminars, conferences and programme-specific websites and help-lines. Programme-level KT tends to be targeted at those with a specialised interest in the programme's field, who generally know what their needs are.

5.6 At **overarching NMS portfolio level**, there has been an NMS Knowledge Transfer programme that ran until earlier this year (2005). It is currently largely in abeyance pending formative input from this review and other strategic considerations. The KT programme aimed to reach those that might gain much benefit from NMS outputs but were not aware of, or had not acted upon, their measurement need. It largely centred on awareness raising and the provision of information and advice in order to educate and stimulate user take-up of NMS outputs.

5.7 A recent adjunct of the KT programme is the Measurement for Innovators programme. It arose from the DTI's 2003 Innovation Report and is designed to offer practical help to technology-based companies that are looking to innovate, by providing access to the measurement knowledge, skills and

facilities of three NMIs. The MfI's limited funding is due to end in 2006. At present funds are available for three MfI products:

- Joint Industry Projects – multi-partner collaborations that aim to solve measurement problems in the development of specific new products or methods,
- Consultancies - up to 4 days' free advice to SMEs from NMS experts on a specific measurement problem,
- Secondments – the transfer of people in or out of the NMIs, to and from industry, universities, trade associations and other NMIs, including overseas organisations.

5.8 DTI's Technology Programme includes the Knowledge Transfer Networks (KTN) programme. It aims to promote and accelerate the transfer of knowledge between industry and the science, engineering and technology base. Virtual communities of interest are formed and facilitated in an internet-enabled environment, which allows free exchange of ideas, solutions and best practice. DTI is in the process of launching a Measurement, Characterisation and Standards KTN that will form part of its NMS KT programme.

5.9 Taking into account the strands of KT that run through the DTI's NMS activities at various levels, the following is a simple summary of the measurement KT mechanisms that are (or have been) employed to varying degrees:

- General promotional/ awareness raising material on NMS activities and services and associated benefits (hard copy and on websites)
- Measurement advisory services/ help-lines / consultancies (telephone and web-based, and MfI)
- Information issued from specific projects and programmes (reports, brochures, websites)
- Training courses, seminars, conferences, events
- Case studies, demonstrators, company visits
- Awards
- Calibration services (direct from the NMIs and through traceable standards)
- Industrial collaborations (within NMS projects and MfI)
- Secondments and exchanges (within NMS projects and MfI)
- Networks (metrology clubs, virtual networks such as KTN)
- NMS input to standards committees

5.10 The routes to market (ie to the potential user) for the various elements of NMS KT tend to be primarily direct (eg through calibration services, NMS websites, collaborations etc) rather than indirect (eg through intermediaries such as business support organisations, consultants, trade associations and the media). There have been some KT activities directed at a regional level, and several attempts made to engage the English Regional Development Agencies (RDA) as intermediaries and sponsors. Also, there have been some activities with sectoral bodies, such as trade associations, and attempts to tie-in with support organisations for particular technologies and processes eg the DTI's Manufacturing Advisory Service.

5.11 The landscape above presents a wide-ranging spread of past and present NMS KT activities and methods. Some are undoubtedly working well, whilst others have maybe worked less well, although there has not been a systematic evaluation and comparison of the impact of the various activities. The strategy for KT activities for DTI's NMS programmes, collectively and individually, is currently under consideration in DTI. Issues to be decided include the balance between general awareness and technical advice, the extent of the regional, sectoral and technological focuses, the best methods and means of doing KT and how user needs and potential impact should be identified and reflected.

Question 1
What is your general view of the effectiveness of the KT landscape of activities described above?

Question 2
Could you suggest, in broad terms, what an effective NMS KT strategy should focus on and include?

Question 3
a) What is your view on the relative priority that should be placed on KT activities at project, programme and overarching levels?
b) Should there be an overarching KT programme? If yes, what should be its remit?

Question 4
What is your view on the effectiveness in terms of value for money and impact of the various strands of KT listed above, individually and/or as a whole?

Question 5
Do you have first-hand, or particular, experience of any of the strands above eg the Metrology Clubs, MfI products, training courses, help-line, calibration services etc? If so, please tell us about their effectiveness, whether your experience was positive or negative and make any suggestions for improvement.

Question 6
Could you suggest other effective means of KT that could be deployed within the NMS that are not listed above?

Question 7
Could you suggest ways of identifying and implementing effective sectoral focus for NMS KT activities?

Question 8
Could you suggest ways of identifying and implementing effective regional penetration for NMS KT activities?

Question 9
Should the NMS KT activities favour targeting users direct, even though these users tend to know already what they require?
And/or should KT activities focus on working through regional and/or sectoral intermediaries such as business support organisations and trade associations to reach potential users that are not aware of the NMS?

5.12 At the orientation, consultation and prioritisation phases of formulation, KT activities are captured within projects and at programme level. However, there seems to be no consistency of approach to KT or sharing of best practice between programmes. At the Decision Conference in the prioritisation phase, there is no separate budget available for KT projects. They are assessed by the same criteria as the scientific projects, and have to compete against these projects for limited funds.

Question 10
How should KT activities be treated in programme formulation?

5.13 It is recognised that there should be a more strategic, cohesive, approach to KT in the NMS, and that it would benefit from being aligned with the KT activities of others.

Question 11
a) Who should put the NMS KT strategy together and implement it?
b) What should be the role of the NMS Measurement Advisory Committee in that process?
c) What should be the role of the NMS Measurement Advisory Committee KT Working Group in that process?

The economic impact of the NMS

5.14 Evaluation of impact is broadly the process by which the levels of benefit gained by users or others in the economy is assessed. The assessment of impact for measurement services has always been notoriously difficult in common with other technology provision because of the complexity of tracing over time the diffusion of the benefits throughout the economy. Where and what do we measure? The most quoted impact statistic for NMS is that provided by the 1999 review of NMS by PA Consulting of £5 billion or 0.8% of GDP of value to the economy against NMS costs of £38 million. Set against the £8 billion worth for the instrumentation sector alone, cited in DTI's 2003 Innovation Report, this figure looks particularly low as a value of the total effects within the economy. Nonetheless this calculation of £5 billion has not enjoyed credibility with those who make decisions about budgets because it relies in simple terms on too many assumptions and extrapolations from one set of figures to a possible impact on various sectors of the economy.

5.15 In common with other countries providing measurement services at high levels and high value (in terms of excellence), the UK relies on a basket of metrics to evaluate the various aspects of measurement provision. These are broadly the formal studies of economic impact and more informal and anecdotal assessments of the benefits to direct users of measurement services.

5.16 The US uses a cost benefit ratio based on the cost to industry and the economy caused by the absence of a recognised measurement standard or as rates of return to the nation for social benefits. For instance, in an assessment of the development of radioactivity standards, a study concluded that without the central government research, and their development of standard reference materials, it would have taken between 5 and 10 years for an industry group to form and become accepted as a de facto standards setting body at a total cost (including of opportunity and uncertainty) of at least $1.3 million per year. At that point NIST (National Institute of Standards and Technology) research costs were around $210 thousand per year, a factor of 6 times the projected absence cost, increasing exponentially as benefits accrued to the economy from the diffusion of the new and more accurate standard.

5.17 Canada has used the market's willingness to pay for ISO 9000 and 14000 standards as a proxy for the willingness to pay for measurement services since these standards tend to rely on measurement of environmental performance, air emissions, waste water etc. Benefits of their NMS activities exceeded costs by a factor of 13. Canada also use, as do all major NMIs, including, bibliometric analysis (counting the number of articles published and the number of times each is cited elsewhere); benchmarking against other NMIs (mainly from the assessment of capability and range of services in BIPM's (Bureau des Poids et Mesures) Key Comparisons Database); the degree of industrial participation in research work; patent applications; the number of calibrations (and in most cases, but not always relevant, the bottom line value to the user in terms of reduced time or costs). From the latter, the UK undertakes an evaluation every few years to develop case studies of the type and value of benefit to direct users. In 2003 for instance, the last time this study was made, users of NMS increased profits by an average of £50 thousand against increases of about £16 thousand for non-NMS users. For NMS users these increases were typically based on sustainable time savings or cost reductions rather than a one-off increase in sales.

Question 12
Do you know of any other measures of impact that might represent the true value of measurement?

5.18 There is a perception that measurement is not regarded as a true science by the academic community, but at the same time potential industrial users view the work done under the NMS programmes as too academic and remote from their requirements. This may be because there is fundamental dichotomy in views about the sense of purpose of the NMS amongst those most involved in its activities. Recent feedback has identified one strong perception of the mission of NMS as being to provide better measurement and to continue to focus on some areas of pure science that enhance the reputation of the UK's NMIs. Others have, by contrast, indicated that the primary obligation of the NMS is to satisfy users' demand for the provision, and improvement, of primary standards and measurement techniques. They have also suggested that the latter leads much more firmly towards better innovation, being predominantly industry driven, and as a consequence to higher economic impact.

Question 13
a) Is there room for the NMS programmes to pursue both types of activity?
b) Are new technological needs pushing us in one direction or the other?

5.19 The evaluation of economic impact outlined above can only measure impacts retrospectively. However, the formulation of NMS programmes requires (for the prioritisation phase) an assessment of likely future impact of projects within a programme, which is difficult to predict. This may present difficulties when immediate priorities might mean relinquishing, for a time, a capability that could, in due course, become valuable, in terms of impact, for the research and application of future technologies.

5.20 There is some evidence that providing measurement services across a broad base of areas ensures that excellence is maintained in as many areas as possible. However, it may also be the case that spreading activities too thinly across a broad base could cause programmes to fall below critical mass because of resource constraints, leading to quality being compromised in all areas.

Question 14
In your view, is there a set of criteria that we could apply to the prioritisation process within programme formulation that would ensure that we retain potentially high value capabilities in the long term?

Question 15
a) What should happen to the programme or project areas that are prioritised out, assuming that we might lose the ability to provide any measurement services in those areas in the long term?
b) Would there be scope to devolve these areas elsewhere eg to overseas NMIs?

NMS Review Team: November 2005