

Strategic Review of the UK National Measurement System (NMS)

April – December 2005

Julia Johnson – Leader

Maggie Statham

The NMS Review Team

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Contents

Section	Page
Summary of Findings of the NMS Review	3
1. The NMS	5
2. The strategic review of the NMS	6
Purpose	6
Summary of key issues	8
3. Government funding	8
Why the Government should fund the NMS	8
What the Government should fund	9
4. Detailed findings and recommendations	11
4.1 Strategic positioning of the NMS	11
4.2 The NMS programme portfolio	14
4.3 The balance between infrastructure and R&D	18
4.4 Programme formulation	19
4.5 Advisory structures	23
4.6 The awareness of the NMS	27
4.7 Dissemination and Knowledge Transfer	29
4.8 NMS Impact	32
5. Acknowledgement	32
6. Summary of recommendations	33

Annex A	The Terms of Reference of the NMS Review
Annex B	The main communities that were consulted
Annex C	Synopsis of the NMS Review discussion papers
Annex D	Analysis of the responses to the discussion papers
Annex E	NMS Programme Summary – as at April 2005
Annex F	New structure of the NMS programme portfolio
Annex G	Characterisation of Metrology R&D and NMS Knowledge Base programmes
Annex H	The Impact of the NMS

Strategic Review of the UK National Measurement System (NMS)

April – December 2005

Summary of findings

The purpose of the review is to set a strategic framework for the NMS that:

- Identifies and meets stakeholders' and customers' needs now and in the future (at least ten years)
- Maximises the contribution of the NMS to the overall UK economy
- Considers the Government's science and innovation priorities and examines the contribution made to them by the NMS.

It gathered the views of stakeholders, users and customers through a web-based consultation beginning in June 2005, followed by some workshops and face-to-face interviews. On the basis of the wealth of this data and the evidence from impact studies carried out during 2005, **the review recommends:**

1. **The creation of two main streams of measurement programme by separating infrastructure and R&D programmes (with fewer and larger programmes), whilst recognising their interdependency and the need to build sufficient flexibility into the allocation of funding across the programme portfolio.** The primary standards, facilities, knowledge and skills and that make up the NMS would continue at its heart in a set of consolidated metrology programmes that make up an NMS Knowledge Base. In parallel there would be a set of Metrology R&D programmes that would promote industrial innovation by exploiting the Knowledge Base and by reflecting and serving the Government's Technology Strategy and other Science & Technology priorities.
2. **The development of an explicit medium to long-term strategy for the NMS.** Mechanisms would be in place to allow the NMS to work closely with others in industry and across Government, including with the Technology Programme and Research Councils, so as to align the NMS programmes with Government science and innovation priorities. DTI's NMS Directorate would develop high quality, strategic, relationships with

key stakeholders and potential collaborators and conduct high level horizon scanning and mapping of strategic priorities that form the basis of a five to ten-year strategic framework for the NMS.

3. **A revised programme formulation process.** Formulation would become more flexible and its planning processes more defined, within the scope of the strategic framework. There would be a longer term planning horizon based on the existing 3-year funding periods, with an extra indicative 3 years attached, so that strategic priorities could be mapped in detail and with some certainty across six years. Outline budget approval would be based on a business case setting out the detailed strategic priorities at the start of the formulation process. There would also be a rolling formulation, based on the existing annual review processes, allowing greater scope to stop failing projects and start new ones and to adjust to changing priorities, if necessary.

4. **An adaptation of the present advisory structure to reinforce the strategic role that the main advisory group would play.** The status of the main group would change; the Measurement Advisory Committee (MAC) would be subsumed into a new advisory group, with a stronger strategic remit and a membership drawn from a wider range of stakeholders (including industrial users, the research community and wider Governmental). The group would no longer have advisory NDPB status. This would bestow the advantage that organisations, rather than solely individuals, could be invited onto the group, allowing substitutions if meeting agendas merited it and achieving a better spread of representation within a fixed composition. This would make the group and its contribution to the processes of setting strategic priorities and programme formulation more dynamic and flexible. Working Groups of independent experts would continue as at present to advise DTI on the scientific and technical content and progress of programmes, and priorities within formulation, but would be fewer in number to reflect the reduction in the number of programmes.

Strategic Review of the UK National Measurement System (NMS)

April – December 2005

1. The NMS

1.1 The purpose of the NMS is to provide the UK with the infrastructure of laboratories, services and expertise that upholds the UK's measurement standards and develops the measurement technology essential to advancing 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. It makes a significant contribution to ensuring the health and safety of UK citizens and to promoting a business environment in the UK in which innovative companies have the confidence to apply new technologies and develop world-class products.

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

- Stimulating the continuing development of better measurement techniques and equipment;
- Providing high-accuracy calibration and testing services;
- Upholding and improving primary national standards;
- Providing traceability in measurements;
- Disseminating good measurement practice;
- Underpinning measurement regulation; and,
- Ensuring international harmonisation of measurement standards.

1.3 Measurement science also underpins a wider range of public goods, such as consumer protection, forensic science, environmental controls, safe medical treatment and food safety regulation, as well as the technical standards that ensure barrier-free trade. In this way, the NMS serves as a cross-Governmental resource that helps to fulfil the policy agendas of not only DTI but other Government Departments, principally the Department of Health, Ministry of Defence, DEFRA and the Health & Safety Executive.

1.4 The custodians of the primary measurement standards are the National Measurement Institutes (NMIs) – NPL (National Physical Laboratory), TUV NEL (the former National Engineering Laboratory), LGC Limited (the former Laboratory of the Government Chemist) and NWML (National Weights and Measures Laboratory). The NMIs supply primary calibration services to the commercial laboratories of the UK Accreditation Service (UKAS). These, in turn, provide secondary calibration and testing services to industry, academia and commerce. Users of the services, such as the automotive and aerospace industries, the Health Service and instrumentation manufacturers, ensure that beneficial fan-out of the application of metrology occurs throughout the economy. **At the heart of this process is the NMIs’ infrastructure of facilities, equipment, knowledge base and skilled people.**

2. The strategic review of the NMS

Purpose

2.1 In reviewing the NMS, the intent is to check and refresh its strategic priorities in order to validate and reinforce NMS’ place in the technology world. This requires a radical and systematic re-think of what the NMS does, why and how. It implies increased collaboration with industry, better alignment with the Government’s Science strategies, particularly the Technology Strategy and the Research Councils’ priorities, and more connected strategies, including those of RDAs, for delivering knowledge transfer and dissemination of outputs.

2.2 The NMS has justifiable cause for a claim that its portfolio of programmes produces what UK industry requires in terms of advancing metrological parameters and that it consequently delivers considerable economic and societal impact to the UK. However, the NMS needs the means to deliver forward looking programmes that address the future needs of the economy and industry. It needs to be flexible enough to deal with new technologies (and Government priorities attached to them) that should be the lifeblood of any scientific activity. It needs to be able to collaborate with other areas of the science base, that are also investigating these new technologies, in order to maximise the impact of public spending in each area.

2.3 The over-arching objective of the review is to set a strategic framework for the NMS that identifies and meets stakeholders' and customers' needs now and in the future (at least ten years), and maximises the contribution of the NMS to the overall UK economy. **The Terms of Reference are at Annex A.** The Review took a wide-ranging look at the assets, operations, processes and outputs that make up the NMS that we have today. It also considered the Government's science and innovation priorities and examined the contribution made to them by the NMS.

2.4 The review gathered the views of stakeholders, users and customers through a web-based consultation between June and October 2005, together with some workshops and face-to-face interviews. **The list of organisations and individuals contacted is appended at Annex B.** Five consultative papers were posted on the website: the Strategic Framework of the NMS; Structure of the NMS Portfolio; NMS Programme Formulation; the Advisory Structure of the NMS; Impact and Knowledge Transfer. **These papers are at Annex C.**

2.5 The consultative papers generated 209 separate replies, from nearly 100 unique respondents, with about a quarter coming from individuals in the MAC structure, a further quarter describing themselves as users or customers of the NMS and the remainder coming from the NMIs, academia, calibration providers, Government and agencies, associations and institutions, the instrumentation sector and various interested individuals who have a connection with the NMS now or have had in the past. We consider that the absolute number of respondents was highly satisfactory, and that, taking into account their identities, this was an excellent response in terms of getting the right people to comment, with a good spread from most of the communities with whom we wanted to engage. A spin off from the consultation was that the profile of the NMS has been raised and there is a positive expectation of improvement, and even transformation.

2.6 The report that follows is based on a synopsis of the consultation papers, and the research done for them, and reflects a synthesis of the views from the consultation. **The consultation feedback analysis, with a representative set of extracts from the responses, is at Annex D.**

Summary of key issues

2.7 The following issues were at the heart of the strategic review's considerations:

- The alignment of the NMS with Government science, technology and R&D strategies
- The UK's economic and societal needs
- The maximisation of the impact of the NMS
- The enhancement of the UK's scientific and technological skills' base
- The benefits of international metrology collaborations
- The needs of industry for standards' traceability, and development of standards
- The role of the NMS in stimulating technological innovation in terms of both technology push and responding to market pull

3. Government funding

Why the Government should fund the NMS

3.1 In the UK, the NMS laboratories provide the underpinning measurement techniques and standards on behalf of the market, where the market (individual firms) could not afford to provide them or would not reap discrete benefit. Market failure also applies to basic research (because of its high-risk nature and the length of time needed to develop into practical applications) into measurement techniques in emerging technologies of strategic UK importance. This basic research is a public good that presents the UK with the opportunity to build critical capability and thus to influence the development of global measurement and other standards, such as in aspects of nanotechnology.

3.2 Without this market failure, there would be no justification for public funding. Recent Government strategy papers, including the Innovation Report published in December 2003, state that there is a role for Government in helping to provide the investment for measurement programmes and services that have a wider public benefit. The UK Government is not alone in this policy. All industrialised nations (notably in the US and Europe), and newly industrialising nations (particularly in Asia and the Far East), place significant emphasis on measurement science as part of the push for technological capability, and the drive for innovation.

3.3 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 in measurement science) and accelerated scientific discovery that leads directly to higher productivity through industrial R&D (*NIST 2010 Strategic Plan*). However, this relationship is notoriously difficult to map and quantify, both because of the long term nature of the development of standards and the time needed to realise their practical value, and because of the dispersed effects throughout the economy. A US study estimated the impact of the absence of NIST research and delivery of standard reference materials. It concluded that there would be significant additional cost to industry and users, and that it would take 5 to 10 years, depending on the industry, for an industry association to form and become accepted as the de facto standard-setting body.

3.4 An NMS econometrics study (June 2005) estimated the degree of dependence by UK business innovation on knowledge from measurement. It demonstrated that innovation is promoted by measurement intensity at each level: it increases investment in innovation; increases product and process innovation; and, increases novel innovation.

What the Government should fund

3.5 The NMS's first and prime task at the beginning of the last century was to provide traceable, recognised standards to enable international trade. Today, this seminal function retains its critical importance, although many standards and routine calibration services are now provided by the facilities of the UKAS laboratories and other commercial providers. However, at the heart of the measurement fan-out, the validity and accuracy of most measurement standards is ultimately traceable to, and dependent on, the primary standards that are maintained and improved as a public good by the UK NMIs (or in some cases, by overseas NMIs, at other countries' expense). In a December 2005 evaluation study of 1200 businesses, 60% considered traceability critical for their business.

3.6 Our consultation gave a resounding vote of confidence to this process, and to the excellence of the NMS and NMIs in providing leading-edge measurement traceability and world-class services and advice.

3.7 There is therefore a very clearly defined role for the NMS to undertake the basic research that leads to the development of standards and to continue until a practical standard (for example a calibrated user-friendly instrument) is developed which can be provided, in the first instance, as a non-routine NMS service by the NMI for a specialised industrial application. Once there is sufficient demand or affordability these services can be devolved for provision on a commercial basis by the NMI or others, but still underpinned by traceability to the NMI's primary standard (or by traceability provided by an overseas NMI).

3.8 A second role for the NMS is to stimulate technological innovation through R&D that promotes and supports the development of innovative applications of measurement science in new and emerging technologies, leading to new competitive products and services. The nature of this R&D is founded on a mix of technology push and market pull, and by its nature should be highly collaborative, drawing in potential users.

3.9 Our consultation endorsed this second role of stimulating technological innovation as one of increasing importance to the future impact and relevance of the NMS of the future. A critical dependency was made between the NMS infrastructure, consisting of the NMIs' primary standards and techniques, and their associated facilities and skills, and the ability to perform R&D that would lead to technological innovation.

3.10 A third feature of the NMS that justifies public funding is the preservation and growth of the UK's scientific and technological skills base, together with the associated world-class reputation of the UK's NMIs. The NMIs have excellent skills' capabilities in physics, chemistry and mathematics which were identified in the DTI's Spending Review in 2004 as key disciplines in which there are emerging problems in attracting recruits and in which the UK's international standing is relatively weak. An exception is in the area of measurement science where the majority of scientists operate within these disciplines, and many are widely regarded as world class. Through public funding, the NMS provides significant opportunities for employment and development of top class physicists, and scientists generally.

4. Detailed findings and recommendations

4.1 Strategic positioning of the NMS

4.1.1 Our own research, and the responses of those consulted, indicated that the NMS does not have a clearly articulated strategy, either for itself or as part of a wider DTI or Government strategy. The DTI's 2003 Innovation Report and the Government's Science & Innovation Investment Framework 2004-2014, published in July 2004, both stated their aim of ensuring that all elements of the UK innovation system form an active network to develop and disseminate the technologies that are critical to the successful growth of UK businesses. This would include closer alignment between Research Councils and Government Departments and greater synergy between the initiatives and programmes that they fund. The NMS does not appear to have established itself as a key player in this strategic drive, although there has been dialogue and some success at operational level (for example The Measurement for Emerging Technologies programme).

4.1.2 NMS programmes can seem disconnected from the rest of the Government's science, technology, innovation and business development programmes although there are examples of specific programmes that do work closely with other parts of Government such as Health and Defence. The DTI's NMS Directorate (NMSD) also seems separated from mainstream policy. Because of the NMS's trans-departmental remit, and its scientific, facilities-based, nature, it has been suggested that NMSD would have greater affinity with the remit of DTI's Office of Science & Technology, particularly vis-à-vis the Research Councils. We believe that there is merit, and potentially greater benefit to the UK, in responsibility for NMS policy remaining within DTI's innovation policy area. **We recommend that NMS policy remains within DTI's innovation policy area and becomes one of the explicit policy mechanisms that promote technological innovation.**

4.1.3 In order to reinforce the NMS's cross-governmental remit, **we recommend that the NMS retains, at its core, a mission to enhance UK innovation and industrial enterprise, facilitate trade and improve the quality of life of UK citizens, by advancing and promoting measurement**

science, standards and technology, while supporting the UK's measurement infrastructure.

4.1.4 The Government's aim is for the DTI Technology Strategy to form the focus of influence for the range of actions across Government that aim to improve technological innovation in business. On this basis, to achieve greatest impact on innovation performance, the NMS must have a strategic direction that aligns with the strategic priorities identified by the Technology Strategy, to which others, including Research Councils and regional organisations (RDAs and Devolved Administrations), are also joining and influencing. For example, an important facet of the Technology Strategy that will have relevance to the NMS will be the proposed Innovation Platforms that will integrate a range of technologies, including metrology and standards, and provide better coordination of policy and procurement.

4.1.5 In order to effect the alignment of the NMS and wider Governmental innovation policies, we recommend that the DTI's NMS Directorate should develop a set of strategic technology priorities and roadmaps for the next ten years, taking advice from the NMIs and other experts, as appropriate. These should be informed by Governmental (economic, innovation, science and technology) priorities, DTI Technology Strategy priorities, end-users' needs and input from the NMIs, standards-setting bodies (such as the British Standards Institution (BSI)) and other experts from horizon scanning research. The strategic roadmaps should identify emerging technologies of mutual interest, areas for new measurement capability, interactions between physical and documentary standards, areas of existing excellence (including for possible European collaboration) and areas of mature measurement that could be devolved to commercial providers (including UK NMIs) or to overseas NMIs. The roadmaps should be reviewed on a rolling basis so as to incorporate changing priorities, scientific advances and any convergence of technologies that would show potential opportunities for linkages and cross-programme working.

4.1.6 We recommend the formation of an explicit External Engagement Strategy by the DTI's NMS Directorate that identifies and maps key relationships and generates action plans to make the connections. In this way NMSD would operate in partnership or collaboration with its counterparts within Innovation Group working on the Technology Strategy's Technology Programme, would strengthen relationships with other government departments

and would develop similar high quality relationships with the Research Councils, industry groupings, standards and accreditation bodies (for example BSI and UKAS) and with universities at NMI level.

4.1.7 The Strategic Roadmaps, once aligned and agreed within Government, would become the strategic driver and basis of the development of a business case for particular NMS programmes. **We recommend that the business cases for NMS programmes be put to Ministers and senior officials to obtain up-front approval for the strategic priorities, impact, scope and funding envelope for the proposed programme.** In this way, the programme can then be assembled on the premise of agreed scope and allocated funds, subject to official-level checks and controls. Benefits of this early approval are that it aligns more closely with the procurement of Technology Programme projects and that nugatory effort put into the formulation process is avoided.

4.1.8 The present three-year time frame of the NMS programmes can seem rigid and does not lend itself to the planning and establishment of strategic programmes that should be designed to meet longer term innovation priorities, as defined in the Strategic Roadmaps. In the context of potential collaborations to devolve measurement standards, it has a particular resonance since we understand that an arrangement between NEL and PTB that would have engaged PTB to provide traceability for part of the Flow Metrology Programme failed because PTB considered that a guarantee of three years' funding was not sufficient to allow PTB commitment.

4.1.9 **We recommend that the business case for NMS programmes should be based on an appropriate long term planning horizon, possibly seeking approval for 3 years ahead plus an outline approval for a further 3 years.** The Strategic Roadmaps should determine the planning horizon. Although it should not be assumed that all programmes would run for 6 years, we envisage that strategic priorities for Year 4 (the first year of any second programme period) would be refined in Year 1 in line with the strategic priorities across the whole programme portfolio. A key benefit of such a 3 + 3 years' planning cycle would be to provide a more secure basis for the investments in infrastructure, skilled human resource and collaborative ventures upon which the NMS depends. **A consistent message from our consultation was that the future benefits to the UK from the NMS would come from present investments and that the NMS needs to operate in a more secure**

strategic environment that would generate medium to long-term confidence and commitment from the NMIs and collaborators.

4.2 The NMS programme portfolio

4.2.1 The portfolio is currently made up of 20 individual programmes (excluding Legal Metrology which is subject to separate arrangements under the Hampton Review). **A pie chart showing the current NMS programmes and their funding allocation is at Annex E.**

4.2.2 There are 5 categories of programme, based 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,
- Crosscutting services – two programmes (Knowledge Transfer and International Metrology).

4.2.3 Each programme contains a mix of activities, loosely classed as:

- Maintenance of standards – the upholding of standards for traceability purposes, requiring developmental research, and continuing comparative work to refine and improve the standard, using the NMIs' knowledge base and infrastructure as a foundation;
- R&D that facilitates innovation which includes potential exploitation routes to industrial markets and advances in metrology which could stimulate innovation or remove metrology barriers to innovation;
- Knowledge transfer that covers the dissemination of information and measurement techniques that are specific to the programme (and separate from the overarching knowledge transfer for NMS generally).

4.2.4 This programme portfolio has evolved over many years and reflects, by and large, historical legacy whilst striving to be forward-looking, needs based and innovative. By its nature, the portfolio could appear disparate and fragmented and is certainly subject to a number of tensions that might dissipate its focus.

There is a range of contributory factors that have shaped the present size and format of our programme structure:

- The SI unit is a well-established building block for international metrology programmes and characterisation, forming the basis of the agreed standards for international trade. It made sense to standardise and align a set of programmes on this basis;
- The start and end points of the 3-year lifecycles of each programme are different from each other, making difficult comparison, combination, collaboration and the identification of synergy, overlaps and gaps;
- 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 defined, tending to create silos and to reinforce separation of specialist work streams;
- Relatively small discrete programmes were easier to find money for, leading to the appearance of inconsistency when comparing the funding allocated to each programme.

4.2.5 We considered the way that overseas NMIs arrange their metrology programmes. PTB have a streamlined portfolio under 9 programme areas: Mechanics and Acoustics; Electricity; Chemical Physics and Explosion Protection; Optics; Precision Engineering; Ionizing Radiation; Temperature and Synchrotron Radiation; Medical Physics and Metrological Information Technology; Scientific and Technical Cross-sectional Tasks. Similarly NIST brigade their programmes under eight accessibly titled divisions: Building and Fire Research Laboratory, Information Technology Lab, Electronics and Electrical Engineering Lab, Chemical Science and Technology Lab, Manufacturing Engineering Lab, Material Science and Engineering Lab, Physics Lab and Technology Services; and then map those to specific sectoral interests (Aerospace, Automotive, Chemical processing, communications, computers, construction, electronic/semiconductors, energy use and conservation, health care, homeland security, manufacturing). These examples, although they cannot readily be translated to the UK NMS, serve to illustrate that programme names and content can be an important strategic instrument in setting programme coverage and intended impact.

4.2.6 A call from our review's consultation was for the development of an explicit long-term strategy to identify present and future need and to improve the impact of the UK's NMS programmes. We have recommended (paragraph 4.1.5)

that a set of strategic roadmaps be produced to inform the formulation of future NMS programmes. The present NMS programme portfolio's mix of many NMS programmes, of differing types, coupled with a disparate mix of constituent projects, does not lend itself to a new, impact based, strategic direction set by the Roadmap process. We believe that the composition and nomenclature of the portfolio of programmes must reflect the strategic priorities so as to enable effective steerage and to gain optimum impact. Also, importantly, the structure and naming of the NMS portfolio should maximise its perceived relevance to potential allies and users, and entice them to engage with the NMS.

4.2.7 We recommend that two main types of metrology programme be created, Knowledge Base and Metrology R&D, characterised by their intended impact. This would enable appropriate comparison of the merits and impacts of projects and programmes in each programme type. The balance between the two types of programme is discussed further in Section 4.3.

4.2.8 Within the Knowledge Base suite of programmes there would reside projects that are predominantly geared towards the essential economic and quality of life requirements for definitive measurement standards and techniques. These projects would tend to protect and develop the NMS infrastructure that is at the heart of the NMS. However, it should not be assumed that the Knowledge Base programmes do not promote industrial innovation. On the contrary, a major finding from economic modelling is that the NMS infrastructure supports innovation at all levels, including leading edge (novel product and process innovation).

4.2.9 Within the Knowledge Base, specific measurement disciplines would be preserved, such as thermal, optical, flow etc. **We recommend the formation of five programmes within the Metrology Knowledge Base, provisionally called Chemical & Biological Metrology, Engineering & Flow Metrology, Ionising Radiation Metrology, Materials & Thermal Metrology and Physical Metrology.** We consider that five such programmes are about the right number to allow effective portfolio management and comparative priority setting. **We recommend that DTI's NMS Directorate, together with the NMIs and expert advisers, review the nomenclature and project assignment of the Knowledge Base programmes so as to devise the optimum arrangement.**

4.2.10 Within the Metrology R&D suite of programmes, there would reside the NMS projects that are predominantly aimed at developing new measurement

capabilities in areas of strategic national priority, and particularly in areas of prioritised new and emerging technologies. They would allow a much more responsive approach to changing technologies and user needs. **We recommend the formation of three programmes within the Metrology R&D suite, provisionally called Metrology for Advanced Manufacturing & ICT, Metrology for Healthcare & Security and Metrology for Transport, Energy & Environment, and based on the current Technology Strategy priorities.** This suite of programmes would incorporate the present projects beginning under the Measurement for Emerging Technologies programme. **We recommend that DTI's NMS Directorate, in conjunction with wider DTI, the NMIs and expert advisers, review the nomenclature and project assignment of the Metrology R&D programmes so as to devise the optimum arrangement.**

4.2.11 In addition to the two main programme areas **we recommend the creation of two crosscutting strategic NMS programmes comprising an International programme and an NMS Portfolio Knowledge Transfer programme** (discussed further in paragraph 4.7.6). DTI's NMS Directorate should direct both programmes. The International Programme would coordinate the development of the UK NMS on the European and global stage. It would be characterised by contributions to European initiatives that bring benefits to the UK through cross-NMI coordination and collaboration. The International Programme would be responsible for devolution policy and top-level negotiations with overseas NMIs and partners, including drawing up criteria and guidance for potential devolutions. We envisage that individual NMS programmes would continue to handle operational international work such as inter-comparisons and representation at appropriate international standards committees. However, the crosscutting programme should form an overview of the worth of such committees and ensure that the right people are attending.

4.2.12 As an adjunct to the five Knowledge Base programmes, **we recommend two underpinning programmes, comprising Software Support for Metrology and Quantum Metrology that pick up and satisfy the requirements of the Knowledge Base programmes in these fields.** The Quantum Metrology programme would contribute to advances in world metrology at a fundamental level, addressing the realisation of base and derived units of the SI and the determination of fundamental constants. The programme's work streams would be characterised by the UK NMIs' world-leading scientific excellence in the field, and their contribution to the advancement of science by collaborations with other world-class NMIs. The programme would tend to deliver

results in a timescale of about 10 years. It would be largely based on the present Quantum programme, augmented by projects that fit its remit from other existing programmes (for example the Watt Balance project).

4.2.13 **Annex F depicts a structure for the suggested NMS programme portfolio** that proposes 12 programmes (five Knowledge Base, three Metrology R&D and four Cross Cutting/Underpinning).

4.3 The balance between infrastructure and R&D

4.3.1 Feedback from the review's consultation emphasised the immense value of the NMS's infrastructure, knowledge and skills capabilities and considered these to be the indispensable foundation of the far-reaching impact of the NMS in underpinning the UK's industrial, commercial and social systems. An explicit link was made between the NMS infrastructure and the ability of the NMIs to promote industrial innovation through collaborative R&D. **We recognise this interdependency, and advise that it must be preserved by maintaining beneficial linkages between the proposed Knowledge Base and Metrology R&D programmes.** For example, the Knowledge Base infrastructure of standards, facilities and expertise is key to seeding and enabling innovative, collaborative, metrology R&D that is speculative, with a projected industrial impact in 5 to 10 years. In turn, the innovative R&D could be working towards developing infrastructure and capability in emerging technologies that may in due course become mainstream and be taken up by the Knowledge Base in the form of new standards and techniques. To break this virtuous circle (for example by cutting back on the underpinning NMS infrastructure) would put at risk the considerable investment that the Government is making in the NMS and jeopardise the present and future contribution of the NMS to industrial innovation and indeed the national well-being.

4.3.2 We acknowledge that the differentiation of the projects that form the current NMS programmes into the proposed Knowledge Base and Metrology R&D programmes cannot (and should not) be done with exactitude or by formula. Many projects benefit from being a hybrid of both infrastructure and innovation deliverables. However, in successive formulations, we envisage that respective projects will be assembled that match the strategic criteria that would characterise the Knowledge Base and Metrology R&D programmes, so making the

programmes powerful drivers of their particular priorities (paragraph 4.4.9 gives more detail in the context of the formulation process).

4.3.3 Our preliminary allocation of current projects suggests an opening balance by value of approximately 60% infrastructure projects in the Knowledge Base and 25% innovative R&D projects in the Metrology R&D programme suite. The remaining 15% is made up of projects in the strategic crosscutting and underpinning metrology programmes. The future balance of programme resources should be a strategic decision taken by DTI's NMS Directorate based on a coordinated process that considers advice on programme inter-dependencies, impact and user benefits, and takes into account the priorities identified from the Strategic Roadmaps and other high level national policy drivers.

4.3.4 The Knowledge Base programmes are in part characterised by their exploitation of, and dependency on, the capital facilities of the NMIs. These facilities may have an operational lifetime of more than ten years, and require sizeable significant capital investment by the NMIs. The purchase or abandonment of capital facilities by the NMIs needs to be referenced to a facilities plan based on the strategic priorities set across the programmes and the requirements of future work identified in the formulation process. **We recommend that NMSD, in conjunction with the NMIs, carry out a rolling annual review for strategic planning purposes of the requirements for existing and new capital investments in facilities, taking into account whether another member of EUROMET could provide the capability.**

4.3.5 EUROMET is actively looking at the opportunities to increase co-ordination of metrological R&D across Europe whereby European NMIs would offer facilities/services as a European wide capability. It may soon be possible also to attract EU Funding under the European Metrology Research Programme. For example PTB has offered its synchrotron radiation facilities as a European facility. iMERA is also developing technology roadmaps to identify possible routes for collaboration. The NMS should be poised to contribute to these activities. **We recommend that DTI's NMSD, in conjunction with the NMIs, identifies a small number of major (world class) facilities in the UK for development as European capability which would involve strategic choices that favour areas that would enable the UK to gain leadership in world markets.**

4.4 Programme Formulation

4.4.1 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 individual NMS programmes.

4.4.2 The current 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, through Decision Conference, of proposed constituent projects,
- Programme Development – Drawing up and approval of final programme, including contractual arrangements.

4.4.3 The timescale of the formulation process is about 18 months and tends to start mid-way through an existing programme. A Programme Formulator, invariably appointed from the most appropriate NMI, leads the process, which largely focuses on the programme in question and has as its starting point an indicative (but unapproved) budget. Projects that get a low ranking at their Decision Conference in the prioritisation phase are likely to be dropped, even though they could be more “worthy” than some in another programme that get higher rankings in their own Conference.

4.4.4 Feedback from the review’s consultation showed that the majority of stakeholders in the NMS programmes were satisfied that the present formulation process could produce a coherent and effective NMS programme. However, there was significant comment about the following facets of the process:

- There are too many programmes to be formulated and reviewed effectively,
- A stronger strategic steer is needed from DTI’s NMSD to inform the formulation process,

- At Decision Conferences it is difficult to make valid comparisons between the relative values for money of infrastructure, research and KT projects within programmes,
- A planning horizon greater than 3 years is needed for effective formulation,
- New programmes can tend to be “more of the same” following re-formulation of existing programmes,
- The rigid timeframe of formulation could have a constraining influence on the make-up of the future programme in areas where technologies and user needs are rapidly changing,
- The new programme is 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.

4.4.5 We have already recommended (in paragraph 4.1.5) the drawing up of Strategic Roadmaps, aligned with cross-departmental priorities (including Technology Strategy and Research Councils), NMI input (from horizon scanning, scientific excellence, opportunities for collaboration and devolution), expert advice and other input from the relationship building that would have taken place in preparation. **We recommend that the Strategic Roadmaps be used to give greater strategic direction to the formulation of the proposed new set of NMS programmes.**

4.4.6 We have also recommended (in paragraph 4.1.7) that a business case for work within each programme be prepared at the beginning of the formulation process. It would indicate the broad scope of the programme and include high-level assessments of impact and benefits, and the specific means of evaluating impact. This should follow through to the definition of projects that would set out timescale, expected benefits, specific deliverables and possible evolution of the work. We have also recommended a funding cycle 3 years (+ 3 indicative). Programmes would still be formulated at different times (though only 10 now) but strategic priorities would be defined at Year 1 for Year 4 by NMSD and its advisers for each Programme in line with existing strategic priorities and technology roadmaps, then developed and refined, on a continuous basis, through formulation up to the end of Year 3. In this way strategic priorities and the balance of funding across the portfolio are decided on a continuous basis each year, or at least at each decision point prompted by a programme formulation.

4.4.7 We have suggested a structure for the NMS portfolio of 10 programmes (five Knowledge Base, three Metrology R&D and two underpinning) that would require formulation. **We recommend that DTI's NMS Directorate, in conjunction with the NMIs, put in place an action plan for the transition of existing programmes, and ongoing formulations, to the new structure.** The plan would involve shortening or lengthening current programmes so as to synchronise programmes that would be brigaded under a broader suite. We envisage that a new programme structure could be in place by March 2007, with high-level alignment of existing projects within the new programmes. However, it would take longer to conclude the transition of active projects.

4.4.8 We have already recommended that infrastructure and innovative R&D projects should form separate suites of programmes within the Knowledge Base and Metrology R&D programmes, supported by two Underpinning programmes. The different programme types should have different criteria for prioritisation within the decision conferencing process. The **diagram at Annex G** shows a suggested range of the characteristics of the Knowledge Base and Metrology R&D programmes, as regards the service they provide, their nature, their means of knowledge transfer and the timescale and nature of their impact. These characteristics are to some extent based on extremes and care should be taken that they do not impose a rigidity and inflexibility on the formulation processes that could jeopardise the inter-dependency of the two programmes. **We recommend that DTI's NMS Directorate, in conjunction with its external advisers, draw up a set of criteria that will characterise the Knowledge Base, Metrology R&D and Underpinning programmes for future formulation.**

4.4.9 **We recommend that DTI's NMS Directorate, in conjunction with the NMIs, instate a rolling (annual) formulation process that is incorporated with the annual review of each programme.** This would allow NMSD, formulators and Working Groups greater scope to stop projects and start new ones, in order to respond effectively to changing needs within programmes during the programme lifecycle. Formulation would be more flexible. At present it is designed so that too many proposals for projects are worked up, with subsequent rejections. In a regime as outlined above, we would expect to see fewer and better quality projects coming forward, more of which could be taken up during the course of the programme, even if not approved for funding at the outset.

4.4.10 As we have recommended that the NMS Metrology R&D suite of programmes aligns with the Technology Strategy priorities, **we recommend that DTI's NMS Directorate should consider putting in place, as a pilot, a joint call for proposals for collaborative metrology R&D with an appropriate area of the Technology Programme.** This would test an aspect of working collaboratively within the Technology Programme, and especially potentially with Research Councils, as well as opening up part of the NMS Metrology R&D budget to competition.

4.5 Advisory Structures

4.5.1 At a strategic level, DTI's prime source of formal external advice on its portfolio of NMS programmes is the Measurement Advisory Committee (MAC), 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 is 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. Appointments to MAC are unpaid, voluntary and personal.

4.5.2 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.

4.5.3 MAC's stated remit is to offer the DTI strategic advice on the effectiveness with which the NMS supports innovation, the priorities assigned to programmes of work and the objectives, balance and strategy for the UK Government's support of measurement. This remit would be achieved by advising on the needs of NMS users, priorities for funding, the effectiveness of knowledge transfer and priorities for the NMS within a European and global context.

4.5.4 Feedback from the review's consultation consistently presented the view that MAC is not fulfilling optimally its stated strategic remit. One reason suggested for this was that DTI's NMSD were failing to consult MAC at an appropriate strategic level. Another reason was that MAC, as an NDPB, forms a restricted, exclusive advisory mechanism that is disconnected from Governmental priorities, users' needs and the NMIs' strategic considerations, as key stakeholders. Yet another reason cited was that MAC members' involvement in the NMS was too focussed at individual programme level, through their chairing of programme Working Groups, so pulling down MAC's advice to an operational, rather than strategic level.

4.5.5 **We recommend that DTI's high-level measurement advisory group (currently MAC) should become more strategically focussed.** We believe that its membership will have to change to achieve this. **We recommend that a new Measurement Advisory Group be set up to replace MAC, with named members from business, wider Government, Research Councils, representative organisations such as the CBI and regional representation from the RDAs, together with an explicit link with the DTI's Technology Strategy Board through a shared member.** Because of the more eclectic representation on the Advisory Group, **we recommend that the Chair of the Measurement Advisory Group be a senior DTI official.** We believe that the Director of Technological Innovation, the parent DTI Directorate of NMSD, would be a suitable choice, having appropriate strategic high-level connections within Government and externally. We consider that it is not appropriate for the NMIs to have full membership status on the advisory group, but that as key stakeholders in the NMS, they should attend the meetings of the group, as appropriate to the agenda, and when invited to do so. We make suggestions in paragraphs 4.5.14 and 4.5.15 about the future role of Working Group Chairs in the Measurement Advisory Group.

4.5.6 In order to be in best shape to fulfil a more strategic role, **we recommend that the new Measurement Advisory Group should not be an advisory NDPB.** NMSD should take advice from Cabinet Office as to the most suitable type of official group that would allow for the provision of advice to Ministers and/or officials, as well as giving greater flexibility of membership to enable representation by stakeholder organisations and expert individuals in order that the most appropriate people could attend a given meeting, depending on the agenda.

4.5.7 The remit of the Measurement Advisory Group would be to give advice, particularly on:

- The long term strategy and vision for the NMS, based on Technology Roadmaps and other strategic submissions,
- The business cases for individual programmes,
- The alignment of the NMS programme portfolio with Governmental objectives,
- The balance of priorities and funding between, and within, the Knowledge Base and Metrology R&D programmes,
- The formulation process, including the criteria by which programme types are assessed,
- The infrastructure requirements of the NMIs,
- The impact of the NMS.

4.5.8 Existing members of MAC could be appointed as members of the new Measurement Advisory Group or remain solely as Working Group Chairs or be free to stand down. We hope that all members will feel that they have a continuing role to play in the development and operation of the NMS. Individual MAC members have made an outstanding contribution over the years, and this was universally recognised in the responses to our consultation.

4.5.9 The DTI's Technology Strategy Board (TSB) is a business-led expert group. Its remit is to influence directly the priorities of the Government's Technology Strategy that sets out a vision for technological innovation across Government. The TSB's remit includes consideration of the role of the NMS in contributing to the early uptake of new technology. Taking into account the evolution of the Technology Strategy and the TSB's strategic role, as well as the performance of the new Measurement Advisory Group, **we recommend that the continuing role of the new Measurement Advisory Group be reviewed after about two years' operation.**

4.5.10 MAC is currently supported in its operation by DTI's NMSD, who provide administrative support and strategic input. **We recommend the establishment and staffing of a dedicated Secretariat in NMSD that will support the Measurement Advisory Group, and in particular will gather and present the relevant strategic roadmaps and business cases to the Measurement Advisory Group.** Advisory Group papers should be tightly defined, in order to present members with a set of strategic options and a precise framework with decision points on which to advise. The Secretariat should ensure that the

Advisory Group is connected to other sources of strategic input, for example the NMIs, Research Councils and the Government's Technology Strategy. **We recommend that the Advisory Group Secretariat produce an Induction Pack for members of the Advisory Group and Advisory Working Groups.** The Secretariat should administer and promote the use of the existing (MAC) Community Extranet, which should become the authoritative means of communication and information sharing for the Advisory Group community.

4.5.11 MAC at present presides over expert advisory Working Groups, one for each of DTI's main NMS programmes. There are approximately 150 working group members, spread across 18 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 task of providing specific advice to DTI on the technical content, management and progress of their individual programmes, and some contribute more.

4.5.12 Feedback from the review's consultation strongly supported the independence of the Working Groups from the NMIs' operation of the programmes. There was a widespread view that the Working Groups are staffed with exceptional people in terms of the extent and depth of their metrology expertise and their whole-hearted commitment to the NMS. There was real confidence that through their impartial advice and independent expertise, the best projects, in line with users' needs, were formulated and constituted as NMS programmes. However, there were comments that the Working Groups received insufficient strategic steer from DTI and that as a consequence there was concern that projects that are recommended to form the NMS programmes may not reflect DTI priorities.

4.5.13 **We recommend that independent expert DTI Advisory Working Groups, attached to individual programmes, continue at the heart of the formulation and review of the new portfolio of NMS programmes.** A smaller number of working groups would be needed because there would be fewer programmes. However, to gain a representative spread of experts, it may be necessary to carry a larger membership, although this may best be deployed by convening topic sub-groups. We consider that it would not be necessary to staff the Working Groups with experts on the depth of detail of every project. Instead, experts should be appointed for their breadth of knowledge of

programme areas and their ability to assess the attributes and impacts of the range of projects within the programme's scope.

4.5.14 In line with feedback from the consultation, we believe that there should be an effective means of reflecting DTI's strategic priorities for the NMS in the operational direction and decisions taken by the Advisory Working Groups. The new senior Measurement Advisory Group should be proactive in enabling DTI to set the strategic direction, and in particular the criteria, by which programmes would be formulated. There certainly need to be linkages between the senior Advisory Group and the programme Working Groups but we do not consider that dual membership of each group for the Working Group Chairs is an effective way of achieving this. Feedback has told us that such dual membership results in conflicts of interest and that the wealth of experience on the present MAC is not being deployed optimally, taking into account the specific strengths of members. **We recommend that members of the Measurement Advisory Group be not automatically appointed as Chairs of the programme Advisory Working Groups.**

4.5.15 The Chairs of the Advisory Working Groups should be appointed on account of their expertise in the relevant programme area as well as, importantly, for their skill in running meetings and ability to work within, and contribute to, a strategic envelope set by DTI and the new Measurement Advisory Group. DTI's NMSD should put in place mechanisms to ensure strategic linkages. Such measures should include provision for the Working Group Chairs' attendance (not membership), if appropriate, at meetings of the main Advisory Group, consultation on and sight of papers for the main Group and consistent feedback of strategic information and decisions via the extranet and plenary sessions for Working Group Chairs. The DTI Advisory Group Secretariat would have a key role to play in ensuring the transfer of information and direction between the main and subsidiary groups.

4.6 The awareness of the NMS

4.6.1 Significant numbers of respondents, not least the NMIs themselves, expressed concern about the lack of awareness within industry of the contribution that measurement technology could make in facilitating product or process improvements or innovations. A good deal of comment was generated about the best ways to redress this, and to whom that effort should be targeted in order to

engage those that would benefit the most from taking-up measurement advice and services. Stop-start initiatives or one-off mail shots of brochures or leaflets, without regular follow-up, were perceived as expensive ventures with low-value returns.

4.6.2 The routes to market (i.e. to the potential user) for the various elements of NMS knowledge transfer tend to be primarily direct (e.g. through calibration services, NMS websites, collaborations etc) rather than indirect (e.g. through intermediaries such as business support organisations, consultants, trade associations and the media). There have been some knowledge transfer activities directed at a regional level, and attempts made to engage the English Regional Development Agencies (RDA) and the Scottish equivalent 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 e.g. the DTI's Manufacturing Advisory Service.

4.6.3 We believe that developing measurement (and NMS) awareness is primarily a responsibility of DTI's NMS policy Directorate, taking advice from the NMIs and communications and marketing experts on the message, the means and the optimal target audience. It needs long term strategic commitment and should be integrated with the marketing efforts done under other governmental and regional business programmes, including the DTI's Technology Strategy and its associated Technology Programmes, particularly the Knowledge Transfer Networks and Collaborative R&D. **We recommend that DTI's NMSD draws up, and implements, a costed, impact driven, strategy for raising awareness of the benefits to potential users of the application of measurement technologies.** The strategy should include the balance between general awareness and technical advice, the extent of the regional, sectoral and technological focuses, the best methods and means of transferring knowledge and how user needs and potential impact should be identified, measured and evaluated.

4.6.4 This work should be informed by the results of a survey of 1200 users and non-users of NMIs' services in November 2005. Analysis shows that many of the non-users were active in measurement improvements and that there could be considerable scope for the NMIs to add value to these activities. Users see measurement as being of increasing importance but they tend to be users of specific services. There is potentially some scope for cross-fertilisation and raising

the strategic value of measurement to these businesses. The survey also pointed to the opportunity that greater use could be made of the database of users in order to advise them of other support available from NMIs.

4.6.5 Another concern expressed in the consultation was the representation of the NMS on the Internet, and particularly on the DTI's website and those of the various NMIs that display NMS programmes under various brands. We believe that the NMS needs consistent branding and better coherence and cross referencing on the Internet. There were also criticisms about the accessibility and intelligibility of NMS advice to non-NMS-aware users trying to problem solve via either the DTI or NMIs' websites. 80% of the businesses surveyed in the survey of November 2005 said that they used the Internet as a first source of advice.

We recommend that the DTI's NMS website be overhauled to explain better what is available for potential users of measurement services, as well as installing appropriate links to the NMIs and to other parts of the innovation and Science & Technology base, such as the Technology Programme and Research Councils.

4.6.6 A consistent view from the responses to our consultation was that the beneficial uptake of measurement technologies is best promoted by direct intervention by experts, with an emphasis on targeted practical action that would deliver a selective business advantage. Several regional outreach programmes that ran out of funds before complete evaluations could be done were held up as good examples. They used a model of taking referrals from a variety of regional intermediaries and brokering solutions for these firms. Similarly the West Midlands RDA have set up a metrology advice centre involving the DTI's Manufacturing Advisory Service at the Coventry Technopole. **We recommend that NMSD, in the context of drawing up the measurement awareness strategy, should review the effectiveness of regional brokerage initiatives and consider possible models for replication elsewhere.**

4.7 Dissemination and Knowledge Transfer

4.7.1 To be most effective in its economic and societal impact, the outputs of the NMS programmes 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.

4.7.2 NMS knowledge transfer (KT) is in place at three levels in DTI’s NMS programmes: project, programme and portfolio levels. Each is considered in the following paragraphs.

4.7.3 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. Our consultation endorsed such deliverables as being highly effective in transferring the specialised output or message of the projects to the audience that would most benefit.

4.7.4 A bibliometric study of the trade press as a knowledge transfer route (DTI September 2005) suggested that peer reviewed scientific publications could be complemented by a corresponding article in the trade press. Overall the readership of trade journals that ran articles from the NMIs was around 183,000, proving to be a substantial route to dissemination. **We recommend that NMS project specifications should include, where appropriate, dissemination targets to new audiences, including goals for circulation of articles in the trade press as well as in the more traditional scientific publications.**

4.7.5 At **individual programme level** there is 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. **We recommend that programme level KT continues, with a remit of maximising any unique benefits of the programme to existing and potential users.**

4.7.6 **At programme portfolio level**, an overarching NMS KT programme ran until early in 2005, but is currently largely in abeyance. The programme centred

on awareness raising and the provision of information and advice in order to educate and stimulate user take-up of NMS outputs. We have made a recommendation in paragraph 4.2.11 that this function should continue and be directed strategically by DTI's NMS Directorate. We believe that a portfolio level KT programme should encompass this function, as well as performing a light-touch (ie not command and control) coordinating function for KT for synergistic programmes where a more holistic approach to KT may have good impact. This should include the facilitation of KT between NMIs and between individual NMS programmes. **We recommend that there should be a new strategic NMS Portfolio KT programme, directed by DTI's NMSD, which would implement the DTI's NMS KT strategy and have a coordinating role for programme level KT.** This would supersede the current overarching NMS portfolio level KT programme.

4.7.7 The currently operating Measurement for Innovators (MfI) programme arose from the DTI's 2003 Innovation Report. It 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 main NMIs. The MfI's limited funding is due to end in 2006. At present funds are allocated for three MfI offers:

- 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.

4.7.8 Our consultation provided much positive feedback on the effectiveness of the MfI programme as a continuous offer and targeted resource that provides direct, quick and easy access to the NMI's experts and produces collaborative solutions to measurement problems. **We recommend the establishment of a permanent NMS Measurement for Innovators programme as a continuous tactical offer to those in need of measurement expertise and solutions.**

We envisage that this programme would come under the auspices of the strategic NMS Portfolio KT Programme discussed in paragraph 4.7.6. Any MfI-like projects currently carried out in other NMS programmes (for example the Studio Projects

in the Materials programmes) should be assigned to the MfI programme in order to present a coherent offer.

4.8 NMS Impact

4.8.1 Annex H outlines the most recent evidence of NMS impact from a series of different assessments of impact. Different methods of evaluation give different estimates of value of the NMS to the economy but overall, widespread and substantial economic value from the public investment in the system is well established. **We recommend that the impact studies undertaken in November 2005 be refreshed on a regular basis.**

5. Acknowledgement

5.1 The NMS Review team wish to express their thanks to the many people who have helped us to complete this review of the NMS. We are especially grateful to those that responded to our testing consultative papers and provided such valuable and discerning input to our evidence base. Thanks also go to those that advised us as we deliberated our findings. We were impressed by the sincerity and depth of commitment to the NMS that came through strongly in our consultation, and by the extent to which people were prepared to put time and effort into shaping the future of the NMS.

Julia Johnson – Leader

Maggie Statham

The NMS Review Team

February 2006

6. Summary of Recommendations

Strategic positioning of the NMS

1. We recommend that NMS policy remains within DTI's innovation policy area and becomes one of the explicit policy mechanisms that promote technological innovation. (Paragraph 4.1.2)
2. We recommend that the NMS retains, at its core, a mission to enhance UK innovation and industrial enterprise, facilitate trade and improve the quality of life of UK citizens, by advancing and promoting measurement science, standards and technology, while supporting the UK's measurement infrastructure. (Paragraph 4.1.3)
3. In order to effect the alignment of the NMS and wider Governmental innovation policies, we recommend that the DTI's NMS Directorate should develop a set of strategic technology priorities and roadmaps for the next ten years, taking advice from the NMIs and other experts, as appropriate. (Paragraph 4.1.5)
4. We recommend the formation of an explicit External Engagement Strategy by the DTI's NMS Directorate that identifies and maps key relationships and generates action plans to make the connections. (Paragraph 4.1.6)
5. We recommend that the business cases for NMS programmes be put to Ministers and senior officials to obtain up-front approval for the strategic priorities, impact, scope and funding envelope for the proposed programme. (Paragraph 4.1.7)
6. We recommend that the business case for NMS programmes should be based on an appropriate long term planning horizon, possibly seeking approval for 3 years ahead plus an outline approval for a further 3 years. (Paragraph 4.1.9)

The NMS programme portfolio

7. We recommend that two main types of metrology programme be created, Knowledge Base and Metrology R&D, characterised by their intended impact. (Paragraph 4.2.7)
8. We recommend the formation of five programmes within the Metrology Knowledge Base, provisionally called Chemical & Biological Metrology,

Engineering & Flow Metrology, Ionising Radiation Metrology, Materials & Thermal Metrology and Physical Metrology. (Paragraph 4.2.9)

9. We recommend that DTI's NMS Directorate, together with the NMIs and expert advisers, review the nomenclature and project assignment of the Knowledge Base programmes so as to devise the optimum arrangement. (Paragraph 4.2.9)
10. We recommend the formation of three programmes within the Metrology R&D suite, provisionally called Metrology for Advanced Manufacturing & ICT, Metrology for Healthcare & Security and Metrology for Transport, Energy & Environment, and based on the current Technology Strategy priorities. (Paragraph 4.2.10)
11. We recommend that DTI's NMS Directorate, in conjunction with wider DTI, the NMIs and expert advisers, review the nomenclature and project assignment of the Metrology R&D programmes so as to devise the optimum arrangement. (Paragraph 4.2.10)
12. We recommend the creation of two crosscutting strategic NMS programmes comprising an International programme and an NMS Portfolio Knowledge Transfer programme. (Paragraph 4.2.11)
13. We recommend two underpinning programmes, comprising Software Support for Metrology and Quantum Metrology that pick up and satisfy the requirements of the Knowledge Base programmes in these fields. (Paragraph 4.2.12)

The balance between infrastructure and R&D

14. We recommend that NMSD, in conjunction with the NMIs, carry out a rolling annual review for strategic planning purposes of the requirements for existing and new capital investments in facilities, taking into account whether another member of EUROMET could provide the capability. Paragraph 4.3.4
15. We recommend that DTI's NMSD, in conjunction with the NMIs, identifies a small number of major (world class) facilities in the UK for development as European capability which would involve strategic choices that favour areas that would enable the UK to gain leadership in world markets. Paragraph 4.3.5

Programme Formulation

16. We recommend that Strategic Roadmaps be used to give greater strategic direction to the formulation of the proposed new set of NMS programmes. (Paragraph 4.4.5)
17. We recommend that DTI's NMS Directorate, in conjunction with the NMIs, put in place an action plan for the transition of existing programmes, and ongoing formulations, to the new structure. (Paragraph 4.4.7)
18. We recommend that DTI's NMS Directorate, in conjunction with its external advisers, draw up a set of criteria that will characterise the Knowledge Base, Metrology R&D and Underpinning programmes for future formulation. (Paragraph 4.4.8)
19. We recommend that DTI's NMS Directorate, in conjunction with the NMIs, instate a rolling (annual) formulation process that is incorporated with the annual review of each programme. (Paragraph 4.4.9)
20. We recommend that DTI's NMS Directorate should consider putting in place, as a pilot, a joint call for proposals for collaborative metrology R&D with an appropriate area of the Technology Programme. (Paragraph 4.4.10)

Advisory Structures

21. We recommend that DTI's high-level measurement advisory group (currently MAC) should become more strategically focussed. (Paragraph 4.5.5)
22. We recommend that a new Measurement Advisory Group be set up to replace MAC, with named members from business, wider Government, Research Councils, representative organisations such as the CBI and regional representation from the RDAs, together with an explicit link with the DTI's Technology Strategy Board through a shared member. (Paragraph 4.5.5)
23. We recommend that the Chair of the Measurement Advisory Group be a senior DTI official. (Paragraph 4.5.5)
24. We recommend that the new Measurement Advisory Group should not be an advisory NDPB. (Paragraph 4.5.6)
25. We recommend that the continuing role of the new Measurement Advisory Group be reviewed after about two years' operation. (Paragraph 4.5.9)
26. We recommend the establishment and staffing of a dedicated Secretariat in NMSD that will support the Measurement Advisory Group, and in

- particular will gather and present the relevant strategic roadmaps and business cases to the Measurement Advisory Group. (Paragraph 4.5.10)
27. We recommend that the Advisory Group Secretariat produce an Induction Pack for members of the Advisory Group and Advisory Working Groups. (Paragraph 4.5.10)
28. We recommend that independent expert DTI Advisory Working Groups, attached to individual programmes, continue at the heart of the formulation and review of the new portfolio of NMS programmes. (Paragraph 4.5.13)
29. We recommend that members of the Measurement Advisory Group be not automatically appointed as Chairs of the programme Advisory Working Groups. (Paragraph 4.5.14)

The awareness of the NMS

30. We recommend that DTI's NMSD draws up, and implements, a costed, impact driven, strategy for raising awareness of the benefits to potential users of the application of measurement technologies. (Paragraph 4.6.3)
31. We recommend that the DTI's NMS website be overhauled to explain better what is available for potential users of measurement services, as well as installing appropriate links to the NMIs and to other parts of the innovation and Science & Technology base, such as the Technology Programme and Research Councils. (Paragraph 4.6.5)
32. We recommend that NMSD, in the context of drawing up the measurement awareness strategy, should review the effectiveness of regional brokerage initiatives and consider possible models for replication elsewhere. (Paragraph 4.6.6)

Dissemination and Knowledge Transfer

33. We recommend that NMS project specifications should include, where appropriate, dissemination targets to new audiences, including goals for circulation of articles in the trade press as well as in the more traditional scientific publications. (Paragraph 4.7.4)
34. We recommend that programme level KT continues, with a remit of maximising any unique benefits of the programme to existing and potential users. (Paragraph 4.7.5)

35. We recommend that there should be a new strategic NMS Portfolio KT programme, directed by DTI's NMSD, which would implement the DTI's NMS KT strategy and have a coordinating role for programme level KT. (Paragraph 4.7.6)
36. We recommend the establishment of a permanent NMS Measurement for Innovators programme as a continuous tactical offer to those in need of measurement expertise and solutions. (Paragraph 4.7.8)

NMS Impact

37. We recommend that the impact studies undertaken in November 2005 be refreshed on a regular basis. (Paragraph 4.8.1)

NMS Review Team

February 2006