Science and innovation:

working towards a ten-year

investment framework

Response from

The Royal Academy of Engineering

to the consultation document

April 2004

Science and innovation: working towards a ten-year investment framework

General observations

Fellows of The Royal Academy of Engineering recognise the great importance of this issue and welcome the attention given to it by Government. Concern has been expressed at the rapidity of the consultation process which is seen as not conducive to a mature public debate. Also, it has been pointed out that a parallel can be drawn between this activity and that which led to the Scottish Science Advisory Committee's first report from which much can be drawn.

The paper seems to take a simplistic view with regard to everything being done in the UK and all research benefits being retained in the UK by UK companies and Universities. Universities with excellent research capability should not limit their research output to UK companies. In today's global village and world-markets it is often the case that the University would be better off forming partnerships with market leaders wherever they may be in the World in order to maximise returns. Ideally, if there were companies in the UK that could bring research to the market place with new products all well and good but it should not become an obsession.

The Research/Innovation Process

There is a widely held belief that the UK must increase its level of focussed, relevant and excellent R&D from which many rewards will flow. However, the fundamental question that needs to be answered is "What or where is the demand?". In order to optimise and secure the best results from a process the primary and necessary requirement is a full understanding of that process. To this end, there is an urgent need to identify the main "seekers/users of knowledge" from our Universities and Research establishments. To be clear as to who is carrying out the near-market development that yields the commercial and hence wealth creating products or services. Having identified the demand side of the equation the Government would be in a better position to influence and improve the situation by introducing appropriate and effective policies to achieve national objectives. The Government should embark on such an activity or commission an independent expert body to carry out such a study.

An additional output would be a clarification of the differentiation between R&D and R&T. Historically, the UK has been very good at R&T, which has been well supported by the Government, but not very good at R&D as evidenced by the relative lack of investment by UK companies. Government has to move its focus and, to this end, the R&D Tax Credit is a welcome step forward.

Engineering Research

The generation of research income, but not necessarily the useful application of research, has assumed greater importance with the advent and evolution of the Research Assessment Exercise. Engineering researchers have to spend more and more of their time preparing proposals to chase after vanishing funds instead of using their abilities at what they are good at and paid to do - research and its application.

Research groups demonstrating outstanding innovation and originality experience approaches from industry rather than having to spend excessive time seeking funds. However, there is a lack of industry investment in its own R&D, as compared with parts of the EU and USA, despite much effort on the part of some academics to engage with them.

The Dearing Report on Higher Education specified the need for Institutions to undertake research that matched the best in the world and made its benefits available to the nation. It said also that there was no point in spreading research monies across every institution. Each Institution needed to decide where excellence existed in its research work and to concentrate resources there. Where they did not have excellence they should seek a lower level of funding to support research and scholarship to underpin teaching. Recommendations were made to set up a "revolving loan fund of £400m to £500m financed jointly by public and private research sponsors to support infrastructure in a LIMITED number of top quality research departments where there was a need for improvements". This was suggested to give a kick-start to facilities badly in need of improvement.

Support has been expressed for centres of excellence where it is the responsibility of the Institutions to make the difficult choices of concentrating funding on those that they know are excellent or have some solid reason for believing that they can achieve excellence. This would also encourage business to look to those centres of excellence for help and where they would expect to pay for quality. It is believed that business is not happy to give general support to research activities but requires it to be specific to their needs and to move at a pace which the business needs.

Science and innovation: working towards a ten-year investment framework

EXECUTIVE SUMMARY

Q1 ***Are these the right areas for the Government and its partners to target over the next ten years? What are the underlying components of success in these areas and what roles do Government and other funders of the science base need to play in achieving these aims?***

1.1 The areas covered in the document are believed to be the correct ones for Government to address and include many useful measures. The various points made all appear to be relevant and important, but there are a number of areas where government policy runs contrary to its stated objectives. The overall objective of the Government in seeking to put a ten-year investment framework in place is undoubtedly praiseworthy and to be encouraged. The overall thrust of the proposals is supported but there are a number of areas of concern.

1.2 Particular attention needs to be paid to ensuring the availability of skills and greater investment by Industry and Government in Industrial Research and Technology linked to the investment in Academia. This area of the innovation process is currently the weakest.

1.3 It is not clear that the most critical issues are given adequate emphasis and that corrective measures to address these will be proportionate and adequate in either diversity or magnitude. The choke-point that must be addressed is the gap between research output and innovation performance to achieve the translation of science, engineering and technology into wealth. In summary, there are three key elements in bridging the science-exploitation gap that appear to be being under-utilised: encouraging venture capital; using the commercial technology intermediaries; and sustained visionary government procurement linked to the Science base.

1.4 Stability of funding is seen as the key to securing successful research in all sectors. The objective of supporting world-class research is clearly also very important. However, the case made in the paper is rather superficial and based on unsupported statements about the present standing of the UKs research at an international level.

1.5 A key area not mentioned is “Building sustainable and strategic international collaborations”. Given that we operate in a network of globally-extended enterprises, unless we learn how to engage in a manner that enables “open-innovation” we may miss important opportunities. For example, competitive “knowledge economics” are also growing strongly in China, Korea, Australia and Japan – the need therefore is to be linked in with key partners in strategic areas. Instruments are needed to enable this.

1.6 The assumption is that the generation of innovative science in the UK is secure and the objective of the policy is how best to open avenues for this to benefit the economy through a closer collaboration between generation and the corporate sector. Corporate involvement can channel innovation, but it does not improve its basic quality. There is far too little in the report on how this can be maintained and improved beyond current levels.

1.7 The implication that world-class research only happens at the strongest "centres of excellence" is mistaken. A great deal of world-leading research goes on outside these recognised centres. The concentration of funding in "centres of excellence" and, by implication, reduction of funding for excellent activities elsewhere in the UK, will have the effect of reducing their competitiveness. They will no longer be continually looking over their shoulders at the groups that are competing with them elsewhere in the UK. If funding is to be concentrated in "centres", then there needs to be due account taken of the excellence outside the centres and a mechanism put in place to recognise and support this excellence.

1.8 There is a need for a clear view as to what is meant by "excellent research". As the Lambert review has pointed-out, there is not a particularly strong correlation between the universities that have scored highly in the RAE and those that have a strong record of working closely with industry. Some universities that had scores of 4 or below in the RAE were rated very highly in terms of their industrial contribution and vice versa. If the proposed investment framework really is to make a "step-change in the responsiveness of the research base to the needs of the economy and public services", then the system of measuring excellence through the RAE score would have to change significantly.

1.9 Interest in application by researchers is important for the development of innovation. Some measure of this is an important criterion for awarding research funds. Income from Industry and Commerce for Applied Research is one such useful criterion. The underlying components are:

- clever, well educated, well motivated and well funded researchers with time to think,
- Freedom of enquiry and freedom of the inventor to exploit the research. The limitation on the freedom of academics to create their own Companies can be damaging and inhibit innovation. The tendency for Universities to wish to own all the IPR developed by their academics stifles some innovation.
- More examples of researchers who become wealthy as a result of innovation.
- A bigger supply of risk funds for investment in innovation

The Government funders should ensure that IPR is held by the originator not the employing Institution.

UK SCIENCE: PERFORMANCE AND IMPACT ON INNOVATION

Q2 Which strengths of the UK science base could be further developed; what are the weaker areas that need to be addressed; and what are the risks to the UK's continued production of internationally competitive levels of research? What criteria should the Government use to help determine its overall commitment to science?

2.1 Core historical strengths in chemistry, biological sciences and engineering (process) need to be more effectively integrated to deliver on innovation.

2.2 The weakness that might be addressed, or a question that should be asked is whether the UK is, de facto, producing science of unsurpassed quality. There should be a greater emphasis in the report on how one improves the quality of innovation in science not only to compete with but to surpass that of the USA.

2.3 Weaker areas include much of Engineering e.g. over the last 40 years there has been a continuous decline in the quantity and, in some cases, the quality of UK papers in Electrical Engineering. For state-of-the-art research papers one generally looks first elsewhere, notably the USA. Our weakness stems primarily from the lack of financial support for research but there are several interrelated secondary factors such as:
i) the lack of researchers with sufficient skill (which also has its origins in primary education); and
ii) the fact that industry tends to see universities as a cheap labour base for development rather than mainly in-depth research.
From the industrial side, expenditure on research is of course only justified if it subsequently directly channels into product development. The latter aspect is determined to a large extent by the industrial market strategy and competitiveness.
The way forward is quality not quantity, thus:
a) improve teaching standards in primary and secondary schools to produce mathematically and scientifically literate school leavers;
b) increase the skill/knowledge level of specialist researchers;
c) increase research funding for projects that directly relate to industrial products with industry as a main contributor;
d) bring academia and industry in closer contact through c).

2.4 This risk materialises when the top universities are required to apply quotas to applicants for places rather than basing selection on demonstrated merit alone. The target of 50% of young people acquiring a university degree, with the implicit assumption that any degree is as good as another, will inevitably have the effect of leveling down the standard of the best. The stated aim of the 10-year plan to achieve and maintain the highest standards of science and engineering on a worldwide basis is irreconcilable with the present education policies. It requires an openly elitist approach, which has nothing to do with class distinction but which recognises that not everyone is born with equal intelligence and which encourages from the earliest age the development of that ability.

2.5 The most cost-effective actions the government should take involve a reallocation of the money spent on education, from nursery school on up, concentrating resources where it says its priorities lie. Many of the newly created universities have unacceptably high dropout rates from courses of questionable value, while the top-rated universities are starved of funds needed to attract the able staff they need for research. Meanwhile there are shortages of skilled technicians with the levels of language, mathematics and science now required to take advantage of the products of higher research. If the Government is to succeed in its professed aim, it has two choices. It must either permit the universities freedom to select for entry whom they like, charge what the market will bear, and subsidise successful applicants who otherwise could not afford the fees; or they must direct resources to the same end in a command economy style. The first of these options has been shown time and again to be the most effective.

2.6 There seems to be poor auditing of previous sciences studies/research except through the citation index. Metrics are required that benchmark our international performance in terms of research outcomes and societal impact, normalised by research income. The Royal Academy of Engineering has published a paper on Measuring Excellence in Engineering Research which indicates additional parameters to be considered when assessing the quality of engineering research.

Q3 In which key technology-based sectors does the UK have the potential to maintain and grow internationally competitive value added over the coming decade? What are the barriers to capitalising on our strengths and addressing areas of relative weakness in business innovation and R&D? How can investments in the UK science base and Government support for business R&D best contribute to that growth?

3.1 The UK should plan to remain strong in Pharmaceuticals and Aerospace as these are still growth sectors and will add to the balance of payments. There are a number of opportunities in the Energy sector related to both Energy efficiency and electricity generation, medical and biomedical sectors. Government investment in R&T in industry for the more speculative technologies linked appropriately to investment in Universities would be a valuable stimulant. Funds in this area need to be increased significantly. The UK has a strong activity in functional materials and the way that they can be exploited in such areas as nanotechnology. It is quite clear from the House of Commons Science and Technology Committee report on the subject "Too little too late …" HC 56-1 that the amount of funding proposed in this area is inadequate and poorly focussed and that a 10-year strategy for the area is badly needed. Successive governments seem to have fought-shy of making major investments in single areas of science and technology, while our international competitors have not. Fifteen years ago Korea had virtually no reputation in the field of microelectronics manufacture, whereas they are now up with the world-leaders, thanks to a concerted programme of government and industry investment.

3.2 Industry in the UK tends to specialise within sectors whereas rapid growth can often emerge by the innovative translation of technology between sectors. An example is the application of defence derived technologies in mobile telephony by Racal to create Vodafone in the UK and the rise of Nokia in Finland who were greatly assisted by VTT, Finland's technology intermediary. Large innovation intermediaries like QinetiQ and Venture Capitalists operate across industry sectors and are able to translate technology to new applications. The key issue is that technology intermediary organisations that are capable of spanning sectors are at least as effective at innovation as sector specific industry and are arguably more capable of generating new sectors of innovation.

3.3 The lack of a long term national level strategy is a continuing barrier, as is the absence of adequate timely investment in infrastructure co-ordinated at the national level. Research projects that require massive funding such as space exploration, nuclear physics etc. present problems for the UK while small scale projects demanding a high intellectual/skills input are very cost effective, given an adequate supply of high quality specialists. The synergy between academia and industry is generated by increasing the research funding for projects that relate directly to industrial products with industry as main contributor.

Q4 In order to inform decisions on the future investment framework, and building on the Research councils' extensive consultations with stakeholders, in what areas are there opportunities for the UK research base to excel and contribute to the economy and society, which might form the basis of future strategic research programmes over the next ten years?

4.1 To answer this in a logical manner there is a need to start with industry to establish those areas of the economy and society that can benefit from new product lines. Industry can then assess the global competition and identify the research necessary to give it an advantageous and significant edge.

4.2 Areas of opportunity for the UK research base to excel and contribute to future economic success include:

a) "Nano-manufacturing" i.e. converting our extensive science base in nano-science into real products that can be manufactured sensibly
b) Personal and pharmaceutical product engineering
c) Energy technology (incl. nuclear)
d) Aerospace, including Gas turbine technology
e) Materials science
f) Biomedical engineering

MANAGEMENT OF THE SCIENCE BASE

Q5 In the light of the changes to be made to the next RAE, how can funding mechanisms build on existing resources and research assessment reforms to reward excellence and underpin sustainability?

5.1 The difficulty of assessing, within the RAE, the excellence of research activities carried out in partnership with industry is well known and will always be difficult. That the focus on academic papers and kudos is at odds with the need to commercialise the results of research for wealth creation and added value is well recognised also. The move towards the greater recognition of the importance of Applied/Practice based research in the next RAE is welcomed but, there is likely to be a need to train Panel members who may be unfamiliar with or have little experience in gathering or evaluating evidence from commercially oriented research.

5.2 The subsequent allocation of funds should endeavour to maintain the current levels of selectivity. Prior allocation of QR funds has contributed to the closure of a number of Engineering departments and some loss of capacity. QR monies should recognise the true cost of performing research in the different subjects. Research Councils should recognise that they have a role to play in maintaining core skills as well as funding project-based research.

Q6 What are the main barriers or challenges to the achievement of a sustainable public research base in the medium term? What further action could the Government take, in partnership with universities and other funders of research, to create robust incentives on all parties to work together to deliver greater financial sustainability of the UK's research base?

6.1 It is important that both Research and Teaching are sustainable and that there is continuity of funding. Governance/Accounting standards for Universities should be defined which would require clear evidence to be provided that the University is not overtrading. The terms of employment of academics could be compared with those in other countries in an attempt to derive a more appropriate solution.

6.2 The policy in the document somehow assumes the institutional structures in the UK are optimal for the generation of science at the highest levels. This may not be true. For example, there is much competition among the top UK Universities. Is it not time that they were encouraged to co-operate not as research consortia but as a way of creating the world's best institutes of advanced studies that draw on talent from various competing institutions, without removing the stars from such institutions? These could also work collaboratively with other countries. Perhaps a high-level working party is required to look at the scope for novel styles of institutional science structure in the UK?

Q7 How could funding for universities provided by Government and other funders create stronger incentives for the effective creation management and usage of the research base infrastructure over the next decade?

7.1 Universities could be required to make more strategic long-term plans for a proportion of their research activities. However, this would require also a change in capability and performance from RDAs and the DTI.

7.2 There are a number of difficulties in initiating "spin-out" businesses from Universities. Firstly, it is (still) a relatively unusual occurrence at most Universities and they are not well-equipped to deal with it. The tendency is for the commercialisation officers to adopt procedures similar to licensing an invention to a multi-national where the emphasis is on securing the future value for the University. In practice however, very few "spin-outs" reach substantial value and, when they do they have almost certainly had so much additional funding and self-generated innovation that the original invention responsible for the spin-out is a miniscule part of the final value realisation. It would be more practical for Universities to cut "quick and dirty" deals for, say 10% or so of the equity, and let such "spin-outs" happen as often as possible – the emphasis should be on "letting many flowers bloom".

7.3 Another difficulty lies with management skills. It is relatively unusual to find good commercial skills within the research team of a University's technology department. This was largely ignored during the late 1990s because the boom conditions led to all sorts of teams being funded. In the more sober times that exist today, a substantial number of good innovation ideas languish for the want of good entrepreneurial management skills in the founding team. It may be possible to develop some support scheme which would encourage a 'dating agency' between inventors and entrepreneurs. This might be a suitable project for Regional Development Agencies. In many cases, experienced entrepreneurs might not be locally obtainable and it might be worthwhile trying to develop a scheme to attract them back from, for example, careers in Silicon Valley.

Q8 What is the optimal means of developing access to large research facilities at national and international level? How should funding of large facilities be prioritised?

8.1 The management of these facilities should be closely integrated with stakeholders and be required to demonstrate their impact to the community. A further suggestion is that the management should be by well run and effective National Laboratories whose staff are there mainly on secondment from their Universities.

8.2 Large facilities incur a large up front investment and high fixed cost. By comparison the marginal cost of using the facility is relatively small. Charging the full cost can lead to under-utilisation and therefore marginal costing is the most appropriate means of charging the researcher with the balance provided centrally. This has the advantage of maximising throughput.

8.3 There is a clear need for the UK to invest in large central facilities that can be widely accessed by industry and academia. This was proposed for Nanotechnology by the Taylor report, but the DTI has clearly missed this opportunity, instead going for an attempt to network existing facilities, with a relatively small amount of investment to assist this. The Micro-nanotechnology (MNT) initiative has suffered considerable criticism. The attempt to underpin government investment by trying to pull-in RDA investment has several unfortunate consequences. It will tend to skew the investment towards the areas where there is most RDA money, rather than to the areas where it is needed from a technical point-of-view. It also fragments the facilities. The technical and organisational difficulties of “networking” such facilities across several sites should not be under-estimated. It would appear that the decision to drive the MNT programme in the way it is being driven has been made on the basis of economic expediency rather than sound technical advice.

KNOWLEDGE TRANSFER AND THE LAMBERT REVIEW

Q9 The Lambert Review was based on extensive consultation during 2003. Reactions to the analysis and proposals set out by the Lambert review, and in particular to the Government's proposed response, are very welcome.

9.1 It is essential that the contributions of universities to the wealth creating forces in the UK be recognised as an aspect of research quality that determines the HEFCE research allocation to any given university. It is essential that this aspect of research quality be rewarded through a contribution from Government towards the costs of the research activity that is directly benefiting industry. This should be in addition to money that is hypothecated for knowledge transfer activities.

9.2 There is wide variation in practices across Universities. More funds to assist innovation should be focused on those that demonstrate good practice. There is scope for Universities in a region to operate staff development courses together. For example, staff need access to expert training in: research exploitation, starting and running a research led company and may benefit from an entrepreneurs club. Evolutionary work is also of importance as innovative products arise not only from cutting edge Research.

9.3 The consultation addresses the interaction of (principally) manufacturing industry and academia but does not significantly address how already existing large bodies of capability can be unleashed to greater innovative effect. The other principal resources are Venture Capitalists and integrated science and technology intermediary organisations. Nor does it address whether knowledge transfer is likely to be to UK industry or offshore. High-growth companies rarely grow just from a science seed. Except in some life science areas, most science-based exploitation requires an extended period of complex innovation, closely related to significant market opportunities. The Science Strategy must address new market opportunities and how to link these to science in a sustained way through market responsive mechanisms. It needs to bridge this gap in sectors that offer high growth for the future.

9.4 Venture capitalists are one group of organisations that bridge this gap. Although UK universities generate spin-outs prolifically, these have little value unless they are turned into high growth companies. Therefore the Strategy must also embrace the technology intermediaries - the Independent Research and Technology Organisations, (the AIRTO companies). However, one factor stands in the way, namely that as they are not manufacturing companies they have great difficulty in participating in any programmes involving 50% company contribution. Equivalent organisations in other European countries receive Government funding for research that they can use for their 50% contribution, an important consequence is that they are incentivised to direct their efforts towards their domestic industries. One way to overcome this problem might be if they were able to participate in Research Council funded programmes, partnering with universities and companies and providing bridges to application.

EDUCATION, SKILLS AND PUBLIC ENGAGEMENT WITH SCIENCE

Q10 ***Following the 2002 review by Sir Gareth Roberts of the supply of scientists and engineers and the Government's response, what is the emerging evidence on the prospects for the supply and demand of science, technology, engineering and mathematics skills? What further steps could the Government take to ensure that the supply of these skills is responsive to the demands of the economy over the coming decade? How could women and other low participatory groups be more encouraged to pursue higher education in science, technology, engineering and mathematics and to pursue careers in these areas?***

10.1 At the graduate level, this can be viewed as simply a demand and supply problem. If a high level of skill in research is seen as a profitable career then more graduates will come forward and there will be a greater demand for relevant courses. In the present scenario the emphasis is on quantity, not quality of graduates, as evidenced by the rapid decline in 'hard' as opposed to 'soft' university courses. What we need is something nearer to elitism rather than the levelling-down, concealed by league tables and research exercises.

10.2 Better teaching of Science and Engineering in Schools is of paramount importance. Not all of the Sir Gareth Roberts review recommendations have been implemented particularly those relating to schools. The first step would be to implement them. The decline in mathematical skills and training at secondary school level in the UK is proving to be a serious problem for recruitment into UK engineering departments and the subsequent education of those who are admitted. The recent report by Professor Adrian Smith into post-14 mathematics education provides a very thorough, evidence-based analysis of the problem. It is recommended very strongly that the Smith report be acted upon without delay and that adequate funding be provided to that end. Without this, any future investment into science and innovation would be seriously flawed.

10.3 The number of students undertaking undergraduate courses in science or engineering is falling and many university departments in these subjects are shrinking or closing. Some universities also report a fall in the quality of students. Without an adequate supply of graduates none of the ideas expressed elsewhere in the report can be realised. Two important reasons for the increased reluctance of students to study science and engineering are:
i)The poor quality of many science and mathematics teachers. Better people will not be attracted into teaching until teachers of science and engineering are better paid. The Government ought to grasp the nettle and accept that, unfair as it might seem, science, engineering and mathematics graduates have a higher "market value" than graduates in many other subjects and will not be attracted into teaching unless they are paid more.
ii)Schoolchildren and those who advise them have little idea what a life in science or engineering is like, especially if there are few scientists or engineers amongst their family's friends and relatives. Many think that its is a dull soulless grind in search of sordid profit. Few teachers of science have actually worked in industry. It is necessary to show schoolchildren and those who advise them that life in industry is useful, satisfying and enjoyable. It is useful because it contributes to the wealth of the nation and the world. It is satisfying because it is concerned with the solving of stimulating problems in an environment where the necessary resources are usually available - making the best of those that are

available is sometimes part of the challenge. It is enjoyable because you work in co-operation with colleagues who are usually helpful and pleasant to work with. It is hard to get a message across to people who don't want to hear it but unless we can do so Government's efforts will be wasted.

10.4 The need for initiatives in this area is recognised but rather than a triad of small initiatives, what is needed is a "Big Vision" with the development of major themes (topical) that run sequentially (or perhaps some in parallel). The role of major academies, such as The Royal Academy of Engineering, affords a key opportunity to enhance integration and assist with delivery. Examples of good practice seen elsewhere to encourage the younger generation include:
i) High impact mobile exhibitions to schools e.g. the German “NanoTruck”
ii) Inspiring examples of innovation and creativity on TV (Great Inventors etc.) and on the Web e.g. www.storiesofinnovation.org

10.5 Another activity could be the assessment of the RDAs based on their performance in capturing the science base and its implications in their region. Universities likewise, by enhancing their press office/technology transfer interface.

Q11 Do UK business leaders and managers have the necessary skills and knowledge to exploit new technology and research to maximum effect? Where are the areas of greatest weakness and opportunity in terms of sector size of enterprise and level of management? What can and should be done to bridge the gap?

11.1 Too few UK businesses see technology as an essential part of their business strategy and consequently do not look forward enough. The lack of Scientists/Engineers on their Main Boards also has a detrimental effect on the scientific/engineering workforce who have lower career prospects unless they move into General Management.

11.2 Venture Capitalists appear to have a wide variety of backgrounds created by experience rather than structured training. Developing the embedded skills of innovation in scientists and engineers supported by appropriate specialists is a lengthy process of hard won experience. The skills of commercial technology intermediaries are capable of further development and present considerable opportunity for more effective engagement if the UK applied comparable government funding to Finland (VTT) and Germany (Fraunhofer Gesellschaft). Whilst these organisations receive substantial grants a variety of mechanisms to achieve the same outcome could be proposed.

11.3 The skills necessary to bridge the gap between invention and its application or even to understand increasingly sophisticated technology and the innovation opportunity it presents and formulate compelling business propositions are rare and complex yet, these are only preparation for the greater hurdles of realisation in the commercial market. Evolutionary innovation within existing sectors is simpler. There is a significant risk to the growth of innovative companies once they have proven their innovation in the market and are beginning to reap commercial rewards. At this stage, it is fairly common to need to grow the skills of the senior management, or to replace them with more experienced management with the founder taking on the role of "technology strategist" or similar. This, coupled with the "Venture Capital Clock", which leads VCs to seek a return on their investment between 5 and 10 years after investing, leads to a prevalence towards a trade sale. It is often much easier to obtain an exit for founding management and VCs by selling the business, frequently outside the UK, rather than by refinancing and building a new management team. There are a number of factors here, ranging from the relative lack of larger amounts of follow-on investment capital, capable of giving VCs an exit, to the relative liquidity and power of the USAs technology stock markets. These are issues which are extremely difficult to address.

11.4 An example of good practice is the creation of “Centres of Industrial Collaboration” by Yorkshire Forward – these provide regional outward facing capabilities across research groups and departments in Yorkshire and Humber Universities. These seek to disseminate information and actively promote technology transfer to small and large companies in appropriate sectors.

Q12 What should the role of Government be in improving the interaction between science and society? Are there areas where Government could improve the promotion of science in society? How can we improve public confidence in the Government's use of science? What should we be aiming to achieve in this area in the next ten years?

12.1 Society has lost confidence in its Scientists and Engineers as a result of a number of past failings. In the first instance the lessons must be learnt from these failings and implemented in order to restore confidence. Secondly, there is a need to promote the successes and to increase the level of awareness of engineering and technology in daily life for every individual - at home, work or play, to help people recognise the role fulfilled by engineers, technologists and scientists. Government also needs to recognise modern Engineering otherwise we may continue to invent ideas which are exported free and buy back the products based on them as imports. Science does not generate wealth, but engineering, innovation and manufacturing do.

12.2 However, we must be careful of not falling foul of the "deficit model" of the public perception of science ("if only the public understood more about science, they would embrace it whole-heartedly"). People, on the whole, are quite capable of getting to grips with scientific issues if they have a sufficiently pressing need (as is seen with parents who have a child with a genetic problem and very quickly get up to speed on the science behind the problem). The issue here is one of good science education at the primary and low secondary levels (up to Key Stage 3). If people receive a really good basic science education at that level, it stays with them for the rest of their lives and empowers them to be able to absorb scientific information and understand scientific issues later in life, even if they become "non-scientists".

12.3 With the difficulty of obtaining teachers with science and technology skills, particularly in Primary Schools, it is even more important to find opportunities to expose children to scientific concepts. The 'Generation Science' project, which has grown out of the Edinburgh International Science Festival, tours highly entertaining scientific demonstrations around Scotland's schools (last year presenting shows to over 70,000 children). This project is overwhelmingly private-sector led, and should be encouraged to grow throughout the UK.

12.4 A number of new Science Centres have been created in recent years, largely funded by Millennium Lottery awards. Now that these centres are completed, they are finding it very difficult to operate commercially as was envisaged. This has resulted in the lack of investment in replenishing the displays (which is essential) and a tendency to cut costs by reducing staff – often including education officers. Education Departments must not be 'agnostic' as to whether school trips went absailing or went to a science centre – it is much better for the future of the UK that they go to a science centre and such centres deserve ongoing public support. There are no substantial science centres in the world which exist without subsidy.

PARTNERSHIP FUNDING

Q13 What is the outlook for business investment in R&D over the next decade? How can business investment contribute to the success of a ten-year framework for science and innovation?

13.1 To ensure sustained growth it is vital that there should be an increase in Business investment in R&D over the next ten years. This area needs to be kept in sharp focus by Government.

13.2 Examples of good practice that can be emulated are the Rolls-Royce University Technology Centres and BNFL University Alliances. The BNFL Alliance has built significantly into the underlying science and engineering base at Sheffield, Leeds, Manchester and UMIST and delivered long term value back to the company.

Q14 What are the research aspirations and funding plans of the medical charities over the coming decade? How best can Government and charity funders work together to enhance the impact of their complementary research efforts on national and global health outcomes and contribute to the development and maintenance of a sustainable UK science base?

No response from Fellows of The Royal Academy of Engineering.

Q15 Are there ways in which Government support for medical research – in terms of both institutions and the distribution of funding – could be better structured in order to maximise the benefits of investment from partners in industry and the medical charities? What should Government and the NHS be doing over the ten years of the science and innovation framework to ensure successful partnership working in medical science in the long term?

15.1 In order to create an effective research system that delivers both economic activity and quality of life by increased quality of care, effective bridges need to be created between healthcare delivery (the NHS), industry and academia (including those partly within the health service).

15.2 One of the key steps required is that the market pull of the NHS should be integrated to identify the underlying research needs. These needs must then be communicated to industry and other members of the supply community. The NHS is potentially one of the largest markets of its type in the world but, because of its highly fragmented nature, it fails to exert market pull and influence innovators.

15.3 The DTI Innovation Report identifies that NHS estates should have a co-ordinated procurement approach to drive innovation. This should be extended into other areas including for example medical devices. The NHS innovation hubs should also be sustained as gateways for a longer period than is currently envisaged because of the level of culture change required in the NHS.

Q16 In the light of the second Wanless report, where are the weaknesses in public health research capacity? How can we improve the links between academics and deliverers of public health, to ensure a strong evidence base both on causality and on effective, well targeted interventions? How should the roles of the various research bodies be better co-ordinated in relation to public health, to ensure the public health research requirements are met in a structured and coherent way?

16.1 Two issues underlie this. The first is that the nation needs to transition to "early health" models of healthcare ("healthy health") rather than "late or disease oriented" models. The second is that we need to focus also on more effective delivery within the healthcare system without impacting on care or creating sub-optimal sub-systems. Healthcare delivery faces the continuing requirement for cultural change i.e. inserting effective management into a system that is driven by care without damaging research agenda that is not over politicised. A mechanism should be put in place to generate and communicate this.

SCIENCE AND RESEARCH ACROSS GOVERNMENT

Q17 What are the public service objectives and priorities for science and research over the next decade to contribute to policy development service delivery and the wider economy? How can the wealth creation potential of investments in R&D across different Government programmes be increased?

17.1 The creation of better investments and returns across government programmes demands a 'Big Vision' or strategic road map – inherent excellence must be recognised and built upon. Big visions often need to be built upon networks of people with visions and correct attitude to foster collaborations. Consideration should be given to how this could be achieved.

17.2 The Science Strategy must address not only the bridge, but also both sides of the gap. The importance of government using its procurement thoughtfully to pull new applications and new business in a visionary way, as has been recommended in the DTI Innovation Review, cannot be emphasised enough.

17.3 Innovative technology businesses experience severe difficulties in obtaining access to public sector markets in the UK. There is a natural risk-averse nature to public sector purchasing which makes it extremely difficult for them to procure new technology from smaller early-stage UK firms – the risk is simply too great for them. It is much easier and safer to buy less innovative technology from large, usually US-based, corporations. Examples exist of highly innovative medical informatics companies that suffered from these difficulties. Both have now established themselves internationally and are beginning to gain sales in the UK, but only after years of US-based "early adopters" buying their technology.

17.4 The MOD's procurement, sustained over decades, has given the UK its world-class industry in defence and aerospace but there is still room for improvement and better co-ordination. Nevertheless, the same or greater success could be achieved in other areas. There needs to be special measures which specifically drive public sector procurement to encourage the purchase of innovative UK technology from smaller early-stage companies. Organisations with experience in science and technology support e.g. defence procurement, can play a role in helping visionary procurement in other departments, such as healthcare or transport.

Q18 How can Government best secure greater synergies between research funding investment and strategies across different public programmes, and link the Government's overall objectives for research outputs with the capabilities in the UK science base?

18.1 Government must be more honest and open in communicating its objectives and must be prepared to fund "Big Vision" programmes that best utilise the latent science base. The DTI role needs to be much sharper and responsive at this level.

Q19 How can the Government and the Regional Development Agencies and their equivalents in the Devolved Administrations help integrate funding of science research on a predominantly national basis with development and delivery of regional economic strategies? In particular how can Government and RDAs strengthen partnership working to facilitate more effective knowledge transfer and research collaboration?

19.1 Although there is a concern over the potential for the addition of more unhelpful layers of committees and bureaucracy, there is a great need for improved DTI/RDA joined-up thinking. They must do better. Again the selection of a national plan makes co-ordination difficult at present. RDAs and DTI do not always appear to have the essential data on research/capabilities in that region. It is proposed that the increasing role of Regional Science Councils should be encouraged.

19.2 There is mismatch between the metrics of DTI grant calls and their aspirations with regard to innovation. For example, the current DTI call for projects under the MicroNanoTechnology Capital Scheme requires (wishes) sustainable payback after 3 years! This type of unrealistic requirement dumbs-down innovation and will produce poor long-term value. For this area of technology a 5 year timescale is needed.

Q20 ***Are there barriers facing business and the science base in effective engagement with EU research programmes? How can the UK more effectively influence and benefit from EU research funding and policies? In what ways can action at Community level add value to UK science and innovation policies? How can national and community funding complement each other more effectively?***

20.1 There is much scope for collaborative work across national boundaries as science does not stop at the boundary line. Co-operation should be seen not only as a way of exploiting administrative links within the EU but as a way of creating new international institutions that bring together the world's best scientific minds.

20.2 The barriers to effective engagement with EU research programmes include bureaucracy and funding. The continued difficulty in executing EU programmes and delays in their administration (eg. contract negotiation phase) causes frustration and financial planning problems for SMEs and larger corporations. The mechanism of EU research grants and those of Research Councils are difficult to synchronise. There may, however, be a case for combining major facilities under the European Research Area (EU initiative) that could bring greater value to the UK government? The low overheads paid and the cost of acquisition of funds mean that most researchers join for networking rather than the research programme. Another issue is the complex and intertwined EU objectives. The most effective US innovation sponsoring agencies are often staffed and driven by technology entrepreneurs on short tenures. R&D to meet federal needs is supported fully in areas such as defence and healthcare. These are backed continuously through to full demonstration and adoption by government service providers and consequently achieve market entry more rapidly.

20.2 Continental industry appears to be more engaged with EU research programmes than UK industry. More worryingly for the UK our universities have relatively greater involvement with EU research programmes and one must suspect that knowledge transfer will pass outside the UK, denying UK industry innovation opportunities. From history, it is evident that the danger of insufficient resources, skills and incentives is that of encouraging innovation, together with its potential benefits, to escape from the UK; liquid crystal display innovation is an example of such a lost opportunity for the UK. Other European organisations e.g. Fraunhofer Gesellschaft, VTT and TNO receive substantial government grants and are able to catalyse bidding consortia capable of securing EU research funding beneficial to their national industries. The UK has no equivalent incentives for its nearest counterpart technology intermediary, QinetiQ.

20.3 The EU has demonstrated its willingness to accept inputs from its constituent bodies. In the case of Aerospace, an Advisory Council (ACARE) was set up three years ago with representatives from the Member states, Industry and the Research establishments. It has produced a Strategic Research Agenda for Europe which is providing the basis for future decisions on allocation of funds. Similar bodies in other sectors could perform a similar function.