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2nd Report of Session 2013–14

Scientific Infrastructure

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See Appendix 1

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References in footnotes to the Report are as follows:

Q refers to a question in oral evidence;

Witness names without a question reference refer to written evidence

SUMMARY

For many areas of research, scientific infrastructure underpins the UK's reputation for research excellence. From the Diamond Light Source, the UK's national synchrotron facility, to the ice-strengthened polar research ships used by the British Antarctic Survey, the UK has a range and quality of scientific infrastructure which enables it to compete globally across many disciplines. As knowledge advances, however, requirements change and UK researchers and industry need ongoing access to internationally competitive infrastructure in order to make new discoveries and stimulate innovation.

While the overall picture is a largely positive one, our inquiry has identified some shortcomings in the provision of scientific infrastructure which need to be addressed if the UK is to remain competitive in the long term. The key shortcomings which we identify are: the lack of a long term strategy and investment plan for scientific infrastructure; and a failure to provide adequately for operational costs at infrastructure facilities.

First, on planning, some useful work has been conducted in terms of mapping current and future infrastructure needs, but this does not constitute a prioritised, costed, long term strategy. The production of a strategy and an underpinning investment plan, looking 10 to 15 years ahead and beyond, is essential, especially as the recent Comprehensive Spending Review made a welcome long term commitment to the capital science budget. A strategy and an investment plan, setting clear priorities based on the budget available, which are reviewed and updated at clearly defined periods so that they are responsive and flexible, will help to ensure that resources are used to maximum effect and the UK's scientific infrastructure remains internationally competitive. To date, a series of ad hoc announcements has militated against long term planning. We therefore recommend that the Department for Business, Innovation and Skills (BIS) Director General for Knowledge and Innovation (DGKI) is given responsibility for producing a strategy and an underpinning investment plan, and that he establishes a time-limited ad hoc advisory group, with independent expertise, to assist in its development.

Second, on operational costs, there is a marked lack of adequate provision for operational costs at scientific infrastructure facilities. This has meant that the UK has not been extracting maximum value from its assets. We recommend that the BIS DGKI, in developing a strategy and an investment plan, examines how capital investment and the funding for operational costs can be tied together in one sustainable package.

In addition to making recommendations in these two main areas, we also address a range of other issues. On the UK's involvement in European scientific infrastructure projects, we conclude that there are opportunities for the UK to be more engaged, take a more proactive role and establish a far clearer external face. On the role of Public Sector Research Establishments (PSREs), which provide national capabilities and are often custodians of data, expertise and facilities, we are concerned that these public goods could be eroded by an over-emphasis on profit margins and an uncertainty over long term funding. Finally, we identify a need to do more to maximise economic benefits and ensure access to infrastructure for industry, as well as a need to improve monitoring and evaluation of the economic outputs of scientific infrastructure.

Scientific Infrastructure

CHAPTER 1: INTRODUCTION

1. The UK's international stature in research is founded in part on the availability of internationally competitive scientific infrastructure. For many areas of science, it is vital that both UK researchers and industry have access to scientific infrastructure, enabling them to be at the forefront of scientific discoveries and pioneering innovation. This might mean, for example, having access to the most up to date microscope or a new high performance computer, capable of handling massive data sets, such as the supercomputer used by the Met Office, which can do more than 100 trillion calculations a second, and was able to predict the path of the recent St Jude's storm.
2. Scientific infrastructure needs may change rapidly. For example, across many fields, increasingly advanced computing power (termed e-infrastructure) is now needed to handle complex data sets and run simulations. Crucially, large facilities can take decades to plan and build before they become operational. It is therefore important that a long-term strategy is in place to enable effective prioritisation and timely investment. Likewise, national expertise and data may take many decades to establish, but could be lost rapidly without appropriate investment. The key purpose of this inquiry was to determine whether an effective long-term strategy exists for investment in internationally competitive scientific infrastructure in the UK.
3. Scientific or research infrastructure has been defined by the European Strategy Forum on Research Infrastructures (ESFRI) as: “ ... *major equipment or sets of instruments, in addition to knowledge-containing resources such as collections, archives and data banks. Research Infrastructures may be “single-sited”, “distributed”, or “virtual” (the service being provided electronically).*”¹ In addition, to meet the ESFRI definition, infrastructure must apply an “Open Access” policy for basic research, *i.e. be open to all interested researchers, based on open competition and selection of the proposals evaluated on the sole scientific excellence by international peer review.*”
4. For the purposes of this inquiry, however, we went beyond ESFRI's definition because we also wanted to consider the provision of mid-range scientific infrastructure. This inquiry therefore focused on large, international or national scientific infrastructure, where only one facility exists in the world, in Europe, or in a country, and mid-range infrastructure, shared between users at university or at a regional level. We include within the definition of infrastructure, not only large and mid-range facilities, but also data and national capabilities such as those in Public Sector Research Establishments (PSREs), for example, the British Geological Survey and the Institute for Animal Health. In all cases, such infrastructure requires substantial initial expenditure, often demanding capital investment, and has significant operational or recurrent costs.

¹ European Strategy Forum on Research Infrastructures, *Strategy report on research infrastructures: Roadmap 2010*, March 2011. Available online: http://ec.europa.eu/research/infrastructures/pdf/esfri-strategy_report_and_roadmap.pdf#view=fit&pagemode=none.

5. We would like to thank everyone who gave evidence to us, both at oral evidence sessions, which we held across June and July, and in writing. We also wish to thank our Specialist Adviser, Professor Brian Collins, who greatly assisted our work.

CHAPTER 2: KEY ISSUES

Scientific Infrastructure: Planning and Governance

Availability of scientific infrastructure

6. The evidence we received drew attention to a variety of internationally competitive scientific infrastructure. Much of the evidence referred to the infrastructure required to support research in fields such as physics and astronomy, reflecting the importance of large scientific infrastructure to these research areas. The importance of large infrastructure, such as the Diamond Light Source (see Box 1), to a whole range of research areas, was also apparent from the evidence. The value that industry places on access to large infrastructure was made clear to us, for example in the area of drug discovery.²

BOX 1

The Diamond Light Source³

Opened in 2007, the Diamond Light Source is the UK's national synchrotron facility. It is located at the Harwell Research and Innovation Campus near Oxford and employs over 400 people. Synchrotrons accelerate electrons to an extremely high speed, generating light of exceptional brightness and quality, which is used to investigate the structure and function of materials.

Application areas range: from pharmaceuticals (designing new and better drugs), to studying engineering materials for real world applications (such as aero-engines); from investigating and helping preserve ancient artefacts (such as the Mary Rose) to helping with environmental impact (such as designing more efficient catalytic converters for cars, or understanding ways of cleaning up contaminated waterways).

The Diamond Light Source represents a major investment in scientific infrastructure. It is the largest science facility to have been built in the UK in 40 years. There have been three phases of development, costing a total of £500 million. It has an unusual funding model insofar as Diamond Light Source Ltd is a joint venture limited company funded by the UK Government through the Science and Technology Facilities Council (STFC) and the Wellcome Trust. The Government and the Wellcome Trust own 86% and 14% of the shares respectively. Diamond is heavily used and over-subscribed by a factor of 2-3 on most beamlines.

7. The evidence we received also pointed to the importance of scientific infrastructure for a range of other disciplines, for example, environmental monitoring (see Box 2) and medical research (see Box 3). In addition, the importance of e-infrastructure, enabling effective handling and analysis of increasingly large data sets, was brought to our attention. The Computing Advisory Panel at the Science and Technology Facilities Council told us that they could foresee an explosion in the amount of data being produced in the

² Heptares Therapeutics.

³ Diamond Light Source Ltd.

so-called ‘Big Data’ era’. The e-infrastructure needed to handle this is not only a question of scale (how many hundreds of peta-bytes) but must also include the facilities to curate the data and make it openly available for future exploitation.⁴

BOX 2

Understanding the Natural Environment

Scientific infrastructure is required for monitoring and understanding the natural environment. The Natural Environment Research Council (NERC) funds six research centres: the British Antarctic Survey, the British Geological Survey, the Centre for Ecology and Hydrology, the National Centre for Atmospheric Science, the National Centre for Earth Observation and the National Oceanography Centre. Together, these centres host significant and diverse scientific infrastructure which provide national capabilities:

NERC have bases at some of the most hostile places on the planet. NERC run a fleet of research ships and aircraft and invest in satellite technology to monitor gradual environmental change on a global scale. NERC provide forewarning of, and solutions to, the key environmental challenges facing society.⁵

To give just one example of the varied and sophisticated infrastructure funded by NERC, polar science infrastructure, run by the British Antarctic Survey⁶, includes research ships, ski-equipped aircraft, permanently occupied Antarctic multi-disciplinary research stations and specialised laboratories – all of which are used to monitor environmental change in the polar regions. Major challenges for NERC funded infrastructure are the cost of fuel, high operational costs and ongoing staffing and maintenance costs.

BOX 3

Understanding the Genome

The Wellcome Trust Sanger Institute⁷ is a non-profit genomic research centre, primarily funded by the Wellcome Trust, and run by the charity, Genome Research Limited (GRL). A leader in sequencing the human genome, the Institute is today studying the role of genetics in health and disease. It aims to advance research into, and investigation of, the human genome and publish results in order to aid scientific and medical research and create resources of lasting value to biomedical research. E-infrastructure is crucial to the Institute’s work and it hosts and develops a range of software and data resources, which include, for example:

DECIPHER – used around the world to identify and study chromosomal abnormalities in children with developmental defects;

COSMIC – a database of information on cancer-associated mutations and the response of cancer cell-lines to anticancer drugs.

⁴ Computing Advisory Panel (CAP), Science and Technology Facilities Council (STFC).

⁵ Natural Environment Research Council (NERC).

⁶ The British Antarctic Survey receives additional funding from the Foreign and Commonwealth Office.

⁷ See: <http://www.sanger.ac.uk/about/>.

The Sanger Institute is now the lead organisation on ELIXIR, a major pan-European project to improve and coordinate e-infrastructure across the life sciences.

8. Although it is clear that the UK has much competitive scientific infrastructure, the evidence we received highlighted gaps in provision. For example, the Institute of Physics, the Wellcome Trust and the Royal Society of Chemistry pointed to X-ray science and nuclear magnetic resonance spectroscopy:

ì A gap in provision is that the UK is currently lacking access to an X-ray free electron laser (XFEL). These machines are revolutionising X-ray science and technology by providing the means for new avenues in nano- and bio-imaging, drug discovery and energy science. All of our main competitors are either operating such facilities (i.e. USA, Germany, Italy, Japan), or are at an advanced stage in commissioning or construction (i.e. China, Korea, Switzerland). To compete in this area the UK urgently needs to implement a strategy that leads to either the construction of our own facility, or to the UK joining one of the international consortia such as Euro-XFEL.ì⁸

ì NMR [nuclear magnetic resonance] spectroscopy provides one of the most versatile methods for the analysis of materials at the molecular level and has an increasing impact in drug discovery as it has become a method of choice for small molecule screening and provides the basis for many existing and potential collaborations between academia and industry.

There is concern that infrastructure and facilities for high-end imaging projects in the UK are not keeping pace with demand. The acquisition of state-of-the-art NMR instrumentation is now beyond the budgets of most Higher Education Institutions and so there is an urgent need for the UK to improve the provision of NMR instrumentation, particularly as the next generation of higher field NMR instruments come on stream.ì⁹

ì Ö it now appears that the UK is falling behind the rest of the world in some areas. For example, the UK has just one high-field solid-state NMR instrument above 800 MHz, in Warwick, while France has a network of five, Germany has three, while the Netherlands has one, with a state-of-the-art 1.2 GHz machine in development.ì¹⁰

9. The UK must ensure that it retains competitive scientific infrastructure and keeps pace with developments, for the benefit of both research in the UK and to enable international collaboration. The UK should be regarded as a partner of choice. Other countries are undertaking ambitious infrastructure programmes and there is no guarantee that the UK's strong position is secure for the long term. Securing the UK's competitiveness will require sustained and effective investment. In this regard, we acknowledge the commitment the Government have made to investment in science and their recognition of the importance of science to society and economic growth. We also note that, reflecting this, the Government have made an important commitment to

⁸ Institute of Physics.

⁹ Wellcome Trust.

¹⁰ Royal Society of Chemistry.

ring-fence the science budget. Nonetheless, as described below, there have been impacts on scientific infrastructure from recent funding decisions.

Investment following the 2010 Comprehensive Spending Review

10. In the 2010 Comprehensive Spending Review (CSR), the Government announced a 'flat-cash' settlement for the science budget. Changes were made, however, to the areas defined as falling within the science budget. This included moving Higher Education Funding Council research funding inside the ring-fenced budget, whilst capital spending was excluded. As shown in Table 1, capital funding was cut substantially. These figures, provided by the Department for Business, Innovation and Skills, use the intended 2010-11 investment of £872 million* as a flat-cash reference. If this level of investment had been maintained each year over the 2011-15 period, the total capital spend would have been £3,490 million. The 2010 CSR cut this by 46%, with only £1,896 million committed to capital funding. To an extent this was offset over the next two years by a series of ad hoc announcements. These announcements restored science capital funding to 94% of what it would have been under a flat cash settlement. This funding was allocated through the Research Councils, HEFCE and the UK Space Agency to specific projects on the basis of business cases. Additional information on how this funding was allocated and on historic capital funding levels can be found in Appendix 4.

TABLE 1

Science capital announcements at and following the 2010 CSR

£ million	2010–11	2011–12	2012–13	2013–14	2014–15	SR Total	% of flat cash
Baseline Science Capital funding allocation as announced at the 2010 Comprehensive Spending Review	872*	514	449	416	517	1896	54%
Subsequent announcements:							
Budget 2011		100				100	
October 2011 (e-infrastructure and graphene)		145	9	29	12	195	
Autumn Statement 2011			61	69	45	175	
Budget 2012			20	50	30	100	
October 2012 (Space and RPIF)				130	190	320	
Autumn Statement 2012 (eight great technologies)			4	239	266	509	
<i>Total additional funding announced 2011 & 2012</i>		245	94	517	543	1399	
Total	872	759	543	933	1060	3295	94%

11. BIS provided the inquiry with separate figures for innovation capital funding. At the 2010 CSR, £149 million of innovation capital funding was announced. This was primarily allocated through the Technology Strategy Board (the National Measurement Office received £25 million). Over the following two years, two further announcements increased the total committed to innovation capital by £197 million (Table 2). Further information about how the ad hoc funding was allocated is provided in Appendix 4.

TABLE 2

Innovation Capital Expenditure announced at the 2010 Comprehensive Spending Review and in the subsequent announcements (2011–2015)

£ million	2011–12	2012–13	2013–14	2014–15	SR Total
Baseline innovation capital as announced at the 2010 Comprehensive Spending Review	39	23	42	44	149
Autumn Statement 2011 (SME package/Open Data Institute/Demos)	0	37	42	27	106
Autumn Statement 2012 (eight great technologies)	0	6	43	42	91
<i>Total Additional Funding Announced 2011 & 2012</i>	<i>0</i>	<i>43</i>	<i>85</i>	<i>69</i>	<i>197</i>
Total	39	66	127	113	346

12. While the ad hoc announcements on capital investment in scientific infrastructure have been very welcome, this short-term approach has caused problems with planning and the allocation of funding. This was a recurring theme of the evidence we received:

‘The ad hoc nature of funding, whilst vital, has because of its unpredictability presented a number of challenges. Planning for operating costs and investment in skills has been more complex than if there had been sustained long term capital funding alongside recurrent.’¹¹

‘Since the last Comprehensive Spending Review (CSR), a series of additional announcements have been made on investment in scientific infrastructure. This funding is very welcome, enabling new projects with particular goals that attract new partnership money. However, the reduced focus on developing the broad research infrastructure has damaged the UK’s ability to plan strategically and to instil confidence in the UK research base, so that the country may continue to attract and maintain world-leading scientists. The irregular appearance of capital to be allocated at short notice tends to militate against sustainable strategic investments in research infrastructure.’¹²

‘While these tranches of funding were welcome, the short period of time between announcement and deployment made it challenging for

¹¹ Research Councils UK (RCUK).

¹² University of Oxford.

Research Councils to ensure that the funding was properly allocated. It is not clear that the spending decisions by government were based on detailed and validated consultation or evidence collection. ‘Stop-go’ investment is likely to favour established groups which happen to have a list of desired facilities waiting for such opportunities. There must be short-medium and long term investments available to ensure the UK and its knowledge economy stays abreast with international competitors in this fast moving environment.¹³

13. During this inquiry, however, at the June 2013 Spending Review, the Government committed to:
 - i) increasing science capital funding in real terms from £0.6 billion in 2012–13 to £1.1 billion in 2015–16 and committing to set an overall science capital budget which grows in line with inflation each year to 2020–21.¹⁴
14. Through the ad hoc announcements, the total science capital budget for 2013–14 had already been increased to £933 million. The science capital budget for 2014–15 was already £1060 million (see Table 1). This announcement that £1.1 billion a year will be allocated to science capital from 2015–16, and will increase in line with inflation, represents a real increase in funding relative to the intended £872 million of 2010–11, which was used as the flat-cash comparator.
15. We welcome this commitment from the Government, which should provide a real opportunity to move to a more long term, strategic approach to investment in scientific infrastructure; the development of a long term strategy and an investment plan is both practical, as funding levels are now known, and desirable, as it will ensure the best use of resources. This is of great importance given the evident difficulties caused by ad hoc announcements and the broader contention, which we discuss below, that decisions have not been sufficiently far sighted or strategic.

Long term planning and governance arrangements

16. We received a great deal of evidence arguing that there is a need for enhanced long-term planning. Planning is of paramount importance because:
 - (a) Large infrastructure has a long planning and implementation phase:
 - i) The timescales for planning, building and commissioning science infrastructure is generally very long – of the order of 10 years at ILL [Institut Laue-Langevin],¹⁵ so a long-term vision is essential if the UK is not to be left behind in some key areas.¹⁵
 - ii) Building infrastructure takes time. Analysis of the current UK success stories (e.g. Diamond, but also high power lasers) shows that this rests upon decades of planning, construction and competitive implementation and optimisation. Long term planning for operation, upgrades, expansion and decommissioning may extend the timescale to 50 years.¹⁶

¹³ Royal Academy of Engineering.

¹⁴ Department for Business, Innovation and Skills (BIS).

¹⁵ Professor Andrew Harrison, Institut Laue-Langevin.

¹⁶ Diamond Light Source Ltd.

- (b) National capabilities, including data and expertise, can take decades to establish, but could be lost rapidly without appropriate investment. In some cases, only later developments, such as a new disease outbreak, might reveal the lack of national capability.

ì Scientific research cannot be switched on and off at will; it requires a long-term commitment. The experiment of starving research institutes and universities of infrastructural resource was carried out in the 1980s and early 1990s with severe consequences. The JIF/SRIF funds rescued the institutions though many outstanding researchers were lost to the UK.î¹⁷

- (c) Long term planning and clear governance structures provide certainty for the scientific community, industry and third sector investors. Planning horizons, we were told, are too short term in the UK. Other countries have long-term plans:

ì France and Germany are the two other countries about which I have the greatest knowledge. In general they do adopt a longer term view. The term is over-used, but they tend to develop a roadmapó landscape documents that try to articulate where they need to go scientifically and what tools they need to develop for much longer periods of time.î¹⁸

ì We would hope that we can move to a state in which planning for research investment should be made over a longer period. For example, in January 2013, China approved its 18-year medium to long-term plan for investment in scientific infrastructure, set alongside shorter 5-year plans.î¹⁹

17. At present, there is no single long-term investment strategy or plan for scientific infrastructure in the UK. There are various documents setting out proposed investment needs, but there is no single document or forum which sets strategy. As the Government themselves told us:

ì There is no single national strategy for national scientific infrastructure in the UK. This is in contrast to some other countries such as France and Germany where a national strategy is managed by a single Government Department.î²⁰

18. The Government maintain that: ì the UKís scientific excellence thrives under the current governance modelî²¹; however, the evidence we received suggests that planning and governance could be improved upon. Our attention was repeatedly drawn during this inquiry to the Research Councils UK publication, *Investing for Growth: Capital Infrastructure for the 21st Century*,²² but equally, we were made aware that this document, quite deliberately, did not set priorities and does not therefore constitute a national strategy or investment plan (see Box 4).

¹⁷ Babraham Institute.

¹⁸ Q 536 Professor Andrew Harrison, Institut Laue-Langevin.

¹⁹ University of Cambridge.

²⁰ BIS.

²¹ Ibid.

²² Research Councils UK (2012) *Investing for Growth: Capital Infrastructure for the 21st Century*. Available online: <http://www.rcuk.ac.uk/documents/publications/RCUKFrameworkforCapitalInvestment2012.pdf>.

BOX 4

Current planning and governance mechanisms

The Department for Business, Innovation and Skills (BIS) has responsibility for the largest share of public spending on scientific infrastructure. This is mostly delivered through the Higher Education Funding Councils and the Research Councils. BIS allocates resources and the Research Councils and Higher Education Funding Councils govern the distribution of resources to specific projects.^{23,24}

The Higher Education Funding Councils (HEFCs) distribute public funding for higher education institutions (HEIs). Higher education is a devolved area and separate councils undertake this function in England, Scotland, Wales and Northern Ireland. The Higher Education Funding Council for England (HEFCE) told us that their funding and policy work aims: i to develop and sustain a dynamic and internationally competitive research sector that makes a major contribution to economic prosperity, national wellbeing and the expansion and dissemination of knowledge.²⁵

There are seven²⁶ Research Councils with responsibility for different disciplines who invest around £3 billion each year in research.²⁷ In November 2012, Research Councils UK (RCUK), an umbrella organisation which coordinates the activities of the Research Councils, published *Investing for Growth: Capital Infrastructure for the 21st Century*.²⁸ This document aimed to provide a strategic framework against which the Councils could plan future investments in the UK's capital infrastructure for research. It identified areas of opportunity, in sectors critical to the economy, where strategic investment in scientific infrastructure could enable the UK to become a world-leader. It did not, however, present prioritised funding requests as the availability of funding was not known at the time.

One of the Research Councils, the Science and Technology Facilities Council (STFC) is a key funder of large scientific infrastructure in the UK. The STFC is responsible for funding national facilities: the Central Laser Facility, the Diamond Light Source and the ISIS pulsed neutron and muon source. STFC runs two campuses at Harwell and Daresbury. In addition, the STFC is responsible for managing the UK's subscription to international infrastructure facilities and training.

The Technology Strategy Board (TSB) is a non-departmental public body, sponsored by BIS, which provides the primary means through which Government incentivises business-led technology innovation. The majority of the funding provided by TSB is matched by business. TSB allocates capital funding and its allocation will rise to £91 million in 2013–14.

²³ Q 25.

²⁴ See Appendix 4 for further information about capital spending.

²⁵ Higher Education Funding Council for England (HEFCE).

²⁶ The Science and Technology Facilities Council (STFC), the Natural Environment Research Council (NERC), the Medical Research Council (MRC), the Economic and Social Research Council (ESRC), the Engineering and Physical Sciences Research Council (EPSRC), the Biotechnology and Biological Sciences Research Council (BBSRC) and the Arts and Humanities Research Council (AHRC).

²⁷ See RCUK website: <http://www.rcuk.ac.uk/research/Pages/home.aspx>.

²⁸ Research Councils UK (2012) *Investing for Growth: Capital Infrastructure for the 21st Century*. Available online: <http://www.rcuk.ac.uk/documents/publications/RCUKFrameworkforCapitalInvestment2012.pdf>.

19. Recent announcements on capital investment have been informed by the ‘eight great technologies’ identified by the Government. The Chancellor of the Exchequer, Rt Hon George Osborne MP, first set out the eight great technologies in a speech to the Royal Society in November 2012.²⁹ In this speech, he challenged the scientific community to lead the world in these areas.
20. In the 2012 Autumn Statement, the Government announced an additional £600 million of science and innovation capital funding (see Tables 1 and 2). In January 2013, the Minister for Science and Universities, Rt Hon David Willetts MP, announced that this would be spent on the eight great technologies and connected projects³⁰ (Table 3).

TABLE 3
Allocation of £600 million of science and innovation capital funding

“Eight Great Technologies”	£ million
Big data	189
Space	25
Robotics and autonomous systems	35
Synthetic biology	88
Regenerative medicine	20
Agri-science campuses	30
Advanced materials	73
Energy	30
Other areas	
Research campuses	35
The Advanced Metrology Laboratory	25
Transformative equipment and infrastructure	50
Total	600

21. Rt Hon David Willetts MP told the inquiry how the eight great technologies had been identified, citing RCUK’s Investing for Growth, along with other reports:

I am rather proud of the eight great technologies. They were a classic example of how the interplay between experts and lay politicians works, because the eight great technologies were essentially a distillation of the advice that was coming up through officials to me. As I say, that is a distillation of three things: there is Technology Strategy Board’s emerging technologies report; there was the Government Office for Science’s Technology and Innovation Futures, a report in 2010 which

²⁹ Speech by the Chancellor of the Exchequer, Rt Hon George Osborne MP, November 2012. Available online: <https://www.gov.uk/government/speeches/speech-by-the-chancellor-of-the-exchequer-rt-hon-george-osborne-mp-to-the-royal-society>.

³⁰ Speech by the The Minister for Science and Universities Rt Hon David Willetts MP, January 2013. Available online: <https://www.gov.uk/government/speeches/eight-great-technologies>.

they refreshed in 2012; plus the Research Councils UK. So you read those documents and, as a lay man, you try to make sense of them and organise them in your head. In the exercise I led, I said, 'Look, behind this there is a kind of pattern', which we summarised in the eight great technologies.'³¹

22. The £600 million of capital funding for the eight great technologies is committed until 2014-15. Appendix 4 provides the current information available from BIS. It is unclear whether the eight great technologies will continue to provide a focus for investment after this point, or whether other criteria will be used to allocate capital funding.
23. The research community facing Research Councils are well placed to map out scientific infrastructure needs, and *Investing for Growth* is to be commended for its effective consultation with the research community. However, it represents a 'wish list' of projects without costs, time-lines or priorities; it does not constitute an over-arching strategy and there is no underpinning investment plan. This is not a criticism of the Research Councils, which are not well placed to prioritise and make such decisions because they are not in control of setting the overall budget. The Government needs to take the initiative and think for the long term. As Professor John Womersley, the Chief Executive of the Science and Technology Facilities Council, when asked to comment on current planning and governance arrangements, told us:

'Is it effective in the sense that it has delivered good science and good facilities? Yes, it absolutely has. Is it absolutely optimal? Probably not. We have put a strong emphasis in the UK, through the application of the Haldane Principle and through the Research Councils that are key to specific subject areas, on being reasonably close to the individual research subjects. The priorities tend to be set in consultation with those research areas, and they reflect the UK's strengths.

They then get fed up into a system in BIS and, as your previous questioning showed, that has some elements of expediency when funding is very tight. What we have lost over the past few years is the long-term vision that used to come from having a large facility capital fund - a funding envelope against which one could plan. Things have become a bit more short term, a bit more expedient, a bit more related to what could be spent in the time that is defined by the Spending Review, rather than reflecting what is best for the country in the long term.'³²

24. Many witnesses made the case for improved long term planning and a more clearly defined strategy. The following examples are indicative:

'Our members feel that there is scope for a National Science Infrastructure Strategy to outline a long-term timetable of continuous replacement and improvement of capital research facilities, devised and consulted on by input from the Research Councils, higher education, government, professional bodies and other user communities of each of the national facilities.'³³

³¹ Q 81.

³² Q 42.

³³ Science Council.

ï The most efficient approach to investment for UK science as a whole is to develop and follow a well-defined national strategy, based on discussion and consensus, for continuous replacement and improvement of our scientific infrastructure Ö

The strategy should include elements of resource planning and a timeline and should not be simply a catch-all öwish listí, which is what the RCUKís published strategic framework for capital investment, ðInvesting for Growthí, is to a certain extent.í³⁴

ï A longer-term perspective would also fit with business planning cycles. Businesses typically look five or more years ahead in making major capital investments so the longer lead-time universities have to talk to business about potential investments, the better quality of bids that can be put forward, the wider universities will be able to look for partners, and the more likely that they will be of strategic importance.í³⁵

25. The current lack of a sufficiently long term overarching strategy and investment plan means that resources may not be used to best effect. It also impairs the UKís ability to attract international and industry investment in infrastructure and decreases the associated commercial activity. It is our view that there is a need for a long term strategy and an underpinning investment plan for scientific infrastructure, which sets out clear priorities, based on the budget available, and is reviewed and updated at clearly defined periods. The development of the strategy and underpinning investment plan should be led by the BIS Director General for Knowledge and Innovation (DGKI) and supported by the establishment of an ad hoc advisory group.
26. The development of the strategy should also include reviewing the operation of the Large Facilities Steering Group (LFSG) as the evidence we received suggested that there are specific problems with the LFSG. Established in 2011 and comprising of members of the Research Councils and a representative from the Wellcome Trust, the LFSG is responsible for overseeing and determining the overall level of funding for the sustainable operation of large scale facilities: the Central Laser Facility, the Diamond Light Source and ISIS. It makes recommendations to STFC, which then allocates funding. In several pieces of evidence, problems were reported with the LFSGís governance arrangements,³⁶ and while the role of LFSG was praised in some quarters, it would seem appropriate that it is reviewed in the context of developing a long term strategy for scientific infrastructure.
27. **Scientific infrastructure plays a vital role in underpinning the UKís research excellence and its translation into wealth creating outcomes. We recommend well planned, sustained and efficient future investment in scientific infrastructure in order to ensure that UK research is able to remain internationally competitive. It is imperative that a level of stable investment is achieved that keeps the UK at the forefront of science and technology.**
28. **Efficient investment in scientific infrastructure requires long-term planning and clear and transparent decision making. We therefore**

³⁴ Institute of Physics.

³⁵ Russell Group.

³⁶ See, for example, submission from Professor Robert McGreevy, Director, ISIS Facility, STFC Rutherford Appleton Laboratory.

recommend that the BIS Director General for Knowledge and Innovation (DGKI) is charged with the responsibility of producing a long term strategy and underpinning investment plan for scientific infrastructure. This should take a comprehensive view of scientific infrastructure needs across the UK, extending beyond the jurisdiction of the Research Councils, and including the needs of industry. It should set out clear investment priorities for the next ten to fifteen years, based on the budget available, and include an indicative plan for a longer time frame. It should be reviewed and updated at clearly defined intervals. The principle of awarding funding for scientific infrastructure on the basis of independent, expert scientific advice about the UK's relative position and the opportunities and benefits that could accrue must be upheld.

29. **We recommend that the BIS DGKI establishes a time-limited, ad hoc advisory group. This group should advise on the development of the long term strategy and underpinning investment plan, and on the response to other recommendations contained in this report, The membership of the group might include independent experts, HEFC, PSRE and Research Council Chief Executives, and representatives from industry and business. Independent experts on the advisory group might include, for example, representatives with a strong record in working on scientific infrastructure overseas. Recommendations for membership of the advisory group should be sought from the National Academies. The development of this strategy should include reviewing the Large Facilities Steering Group. The strategy and investment plan should be published within twelve months of the establishment of the advisory group.**

Not just machines

Operational costs

30. We received evidence that operational costs are often not being well provided for. Too frequently, it seems as though the appeal of new initiatives comes at the expense of fully exploiting existing facilities. The lack of provision for operational or recurrent costs and upgrades has seen facilities not being used to maximum capacity. The problem is that capital investment and operational costs are governed and allocated differently without a process for determining their interrelationship.
31. For example, a large body of evidence referred to the ISIS pulsed neutron and muon source. ISIS produces beams of neutrons and muons that allow scientists to study materials at the atomic level. It is located at the Rutherford-Appleton Laboratory near Oxford and is owned and operated by the Science and Technology Facilities Council (STFC). ISIS is used by researchers from a wide range of disciplines from materials science to biology. This centre, however, is running under capacity as insufficient funding has been made available to cover operational costs.

ⁱ We comment on electricity operating costs. It has been a long standing problem that although injections of capital for upgrades have by and large been available (although not always in the most timely way), unfortunately recurrent electricity operating costs are not consistently planned for at the same time. This is due to the disjoint between

‘capital’ and ‘recurrent’ costs which pervades UK infrastructure provisioning. This leads to significant uncertainties at times, and to ad hoc short-term solutions which can disrupt the competitive environment for UK scientists.³⁷

32. The consequences of this are tangible and very concerning, in terms of reduced scientific output – the loss of experiments and publications – and the consequential decline in competitiveness:

‘Over the last few years, ISIS operated for just 120 days per year, rather than the optimum historic value of 180 days per year. Scientific output scales with number of days of operation, but the cost saving in running for fewer days is marginal. The saving comes mainly from electricity costs above the base-line costs of providing the facility, and it equates in financial value (~£3M) to a large research grant to a single group in a University. Based on the current 120 days use per year rather than the optimal, and desired 180 days per year, the scientific output is reduced by one third. The current and historical research output from ISIS in papers from UK scientists is higher than for any of the other UK-funded large facilities, with about one third of these in high-impact journals according to the ILL criteria. However, an inevitable consequence of reducing operational access will be that hundreds of experiments are lost affecting many research groups in Universities including industrial projects and hundreds of publications are lost. This substantially affects the international competitiveness of UK research, and jeopardizes government and industry funded research that relies on having sufficient access to neutron facilities. In one year ISIS proposals were linked to 91 grants of value ~£100M from one Research Council. Very often these experiments are crucial elements of a PhD student’s thesis. Thus the damage to the research base in UK Universities across a number of disciplines is out of all proportion to the cost saving.

There is even a threat to reduce the number of operational days further, and this represents terrible value for money for the UK taxpayer. The fact that this coincides with a planned 10 month shut-down of the ILL demonstrates calamitous planning.³⁸

33. A further example is provided by the Hartree Centre, a High Performance Computer (HPC) centre located at Daresbury Science and Innovation Campus near Manchester and also run by the STFC. The Hartree Centre was established in 2012 as a result of £37.5 million of Government investment. While such investment was very welcome, insufficient provision was made for the operational costs. Professor John Womersley, Chief Executive, the Science and Technology Facilities Council, explained the consequences of this:

‘The short-term issues are that the resource investments to support new capital have not been provided at the same time as the capital. We are extremely grateful, again, for something like £50 million for high-performance computing at the Hartree Centre at Daresbury, but that comes with a significant electricity bill that we had not anticipated. Of course, the capital is only useful if you turn the computer on, so there is

³⁷ STFC.

³⁸ ISIS User group.

a resource-matching issue. It is been difficult to invest in the routine maintenance and upkeep of existing facilities, because Ministers very naturally are interested in new initiatives and transformative change in entirely new projects. What we used to fund out of the ring-fenced component of capital included rather boring things like repairing the roof on the office building.³⁹

34. A further operational cost which is not being adequately provided for, software maintenance, was also brought to our attention:

ì We note that a lack of investment in software maintenance does not allow best use to be made of the UK's existing scientific infrastructure. This is an operational cost that has been diminished in successive refreshes of the scientific hardware, and yet much scientific software (e.g. meteorological and climate models, computational chemistry codes) is required to run on many generations of hardware. Software is the infrastructure, and hardware the consumable. Maintenance is required when there are hardware, operating system and software library changes.⁴⁰

35. These examples reflect a worrying, wider picture. It is a source of concern that operational costs are not being adequately provided for, and that, as a result, facilities are being under-exploited. As Professor Gabriel Aeppli FRS, Quain Professor of Physics and Director of the London Centre for Nanotechnology, put it to us:

ì I think the immediate needs are to sweat the existing assets more. When we are not running very expensive machines with capital costs in the hundreds of millions or even billions of pounds, and we are saving a few million in electricity bills every year, that is not a reasonable economic strategy.⁴¹

36. We were told by the Government that provision for operational costs was for the Research Councils, HEFCE and other funding agencies to establish:

ì Yes. There is an endless iteration between the two, but when it comes to that type of current cost, they have to allocate the money. We set the budget for each research council, and after that how much they allocate to the operational costs of these facilities is for them.⁴²

37. Balancing the requirement to provide operational costs against the requirement to invest in new infrastructure is far from straightforward, and evidence we took from BIS acknowledged this point:

ì It is a perennial challenge, especially when the running costs vary within the budget that is set. I wish I had a better answer for this, and I am afraid I do not, but it weighs on our minds continually. I do not think that we have an ideal solution.⁴³

38. In our view, the provision of operational costs needs a thorough examination. While we acknowledge the difficulties inherent in meeting varying operational costs, it must be a priority to ensure that facilities are exploited to

³⁹ Q 45.

⁴⁰ Software Sustainability Institute.

⁴¹ Q 17.

⁴² Q 79.

⁴³ Q 39.

the full. In essence, provision for operational costs must be budgeted for in conjunction with the decision to allocate capital.

39. **There is substantial evidence of a damaging disconnect between capital investment and the funding for operational costs. We recommend that the BIS Director General for Knowledge and Innovation, in the development of the strategy and an underpinning investment plan (paragraph 28), reviews the current situation to determine how capital investment and the funding for operational costs can be tied together in one sustainable package.**

People and skills

40. In addition to the provision of operational costs, maximising infrastructure assets also depends on having a suitably skilled workforce. Much of the evidence we received stressed this point. Professor Alex Halliday FRS from the University of Oxford told us that the UK must invest in, and prize, technical skills, which industry needs, an area in which the UK compares unfavourably with its European competitors:

‘The UK needs to invest in the technically brilliant people who can develop and maintain advanced instrumentation. We struggle in this area and UK instrumentation companies find it hard to recruit. It is well known that the UK has not supported strongly those career models aimed at building technical skills, even though industry needs them. Rather these individuals and careers have been viewed as second class relative to more ‘academic’ individuals, courses and career paths. This viewpoint is different in our main competitor European countries in terms of science and engineering, Germany and Switzerland. In both countries the technically clever individual is seen as a key and prized contributor to the infrastructure, economy and society. The UK needs to move more in this direction of investing in the training of such people if we are to continue to lead in science. Industry will be supportive of this.’⁴⁴

41. In a similar vein, the Engineering Professors’ Council drew attention to the need for skilled software developers and technicians and the development of attractive career paths:

‘In many areas, particularly high-performance computing, big data etc, it seems there is a willingness to make capital investment, but a reluctance to balance this with investment in the people needed to run the equipment. The traditional model of having postdoctoral researchers develop and maintain equipment and software is unsustainable. Skilled software developers and technicians are crucial to modern scientific endeavour so developing appropriate and appealing career paths and incentives and allocating appropriate operational budgets, taking these into account at the investment decision stage, and then committing to deliver them, are essential.’⁴⁵

42. The provision of operational costs and the development of skilled technicians with well plotted career paths, it seems to us, have been deemed to be second order issues, and have been relegated by the lure of new projects and

⁴⁴ Professor Alex Halliday FRS, University of Oxford.

⁴⁵ Engineering Professors’ Council.

initiatives. This should not be the case. A failure to address these issues means that the UK's infrastructure is not being exploited to the full.

43. **We recommend that the training and other costs, as well as the value of the skilled workforce needed to operate scientific infrastructure, are fully taken into account in developing the strategy and an underpinning investment plan (paragraph 28). To maximise the return on investment, ways to facilitate viable career paths must be found.**

Shared benefits

44. This section examines the importance of investment in scientific infrastructure at all scales, from regional to international, including the role of Public Sector Research Establishments (PSREs). It also highlights the importance of partnerships with industry. Sharing infrastructure has important benefits for users in terms of efficiency savings and the cross-fertilisation of ideas.

Public Sector Research Establishments

45. Public Sector Research Establishments (PSREs) are a diverse collection of public bodies which carry out research and monitoring; they include a huge range of different kinds of organisations and governance models. They are very much part of national infrastructure, providing repositories of data and expertise and national capabilities. They also have the potential to play an important leadership role in developing national science capabilities. Indeed, this is the role they fulfil elsewhere in the world.
46. There are around 40 PSREs associated with Government Departments across science and the arts.⁴⁶ This includes the National Physics Laboratory, the Met Office, the UK Atomic Energy Authority and the Animal Health and Veterinary Laboratory amongst others. In addition, there are 18 Research Council affiliated PSREs. Five Science and Technology Facilities Council (STFC) establishments are classed as PSREs, two of which are due to close in 2014-15; the Isaac Newton Group of Telescopes and the Joint Astronomy Centre. Five Biotechnology and Biological Sciences Research Council (BBSRC) affiliated establishments were transferred to the private sector in 2011. The final BBSRC PSRE, the Pirbright Institute, is expected to follow in the near future. The status of the Natural Environment Research Council's (NERC) PSREs is currently under review. The PSREs which have been transferred to the private sector have heterogeneous business models.
47. The inquiry heard that PSREs in the UK are under-valued and under-funded in comparison to those in other countries:

‘NPL's current position amongst the top three National Measurement Institutes (NMIs) in the world has been acknowledged at ministerial level but this is becoming increasingly difficult to sustain. The budgets of NPL's peer group NMIs, PTB (Germany) and NIST (USA), have seen above-inflation growth over the last decade whilst the NPL budget has

⁴⁶ Letter from Sir Mark Walport, Chief Scientific Advisor to HM Government and Head of the Government Office for Science, to Andrew Miller MP, Chair of the House of Commons Science and Technology Committee, 16 May 2013. Available online: <http://www.parliament.uk/documents/commons-committees/science-technology/130516walportpsres.pdf>.

continuously decreased over the same period. At present the PTB budget is nearly 4 times larger than that of NPL with a staff complement three times that of NPL. Remarkably, the scientific output of both laboratories is comparable, but this position cannot be sustained. Also the budgets of the BRICS countries are all well in excess of the NPL budget. It is clear that maintaining NPL's position in the top three of the world will be impossible without a considerable uplift in budget: NPL needs to maintain the funding for its core NMI activities whilst at the same time funding strategic partnerships with academic organisations and industry to a level at which it can be truly world-leading.⁴⁷

France's scientific infrastructure is dominated by large bodies such as the CEA and CNRS rather than the universities. Those large bodies have large laboratories that they expect to anchor with large facilities. There is a drive within the structure of French sites that is rather different. My organisation is 1,100 people now; it used to be 30,000 people at the height of British atomic activity. We do not have those big organisations any more, and it is less likely that somebody in a university group would see that as directly their interest.⁴⁸

48. Professor Cowley also told us of the importance of National Laboratories in conceiving, designing, project managing and delivering new large facilities, and the huge skills sets required to do so. He agreed that the UK may have gone too far in privatising and closing down National Laboratories.⁴⁹
49. In our view, it is important that the Government ensures that the capabilities of PSREs, both their provision of scientific infrastructure and their leadership role, are protected. Some of the PSREs are funded from outside the science budget and they should not be quietly trimmed away. The scientific infrastructure held by PSREs must be maintained as a public good and made available to both the wider scientific and end user communities. Whatever governance arrangements exist, and may be put in place in the future, it is important that the role of PSREs in providing national infrastructure is not eroded.
50. **We are concerned that the ability of Public Sector Research Establishments and National Laboratories to deliver national objectives is being eroded by underfunding and a wide variety of funding and governance models. PSREs are often custodians of data, expertise and mid-range facilities. We recommend that BIS Ministers ensure that the funding and governance mechanisms in place effectively protect the public goods generated by these institutions.**

Mid-range scientific infrastructure

51. Mid-range scientific infrastructure is shared by many different users within, and in some cases between, universities and research institutes. Although such infrastructure requires substantial investment, several similar pieces of equipment are likely to exist at different locations across the country. For

⁴⁷ National Physical Laboratory.

⁴⁸ Q 596 Professor Steven Cowley, Chief Executive Officer, UK Atomic Energy Authority, Head of EURATOM/CCFE Fusion Association.

⁴⁹ Q 63.

example, mid-range infrastructure includes sophisticated microscopes, DNA sequencers and Nuclear Magnetic Resonance (NMR) facilities.

52. The inquiry heard evidence of the importance of mid-range infrastructure from Professor Aeppli, Director of the London Centre for Nanotechnology (LCN). This facility opened in 2006 as a joint venture between University College London and Imperial College London. LCN hosts equipment required for experimental research in nanotechnology and also theoretical and computational techniques.⁵⁰
53. Research in nanotechnology requires specialist, high-value capital equipment. The largest items of infrastructure at LCN are funded by the Research Councils and private charities. Equipment, such as specialist microscopes costing millions of pounds, is easily accessed by researchers from University College London and Imperial. In addition, technical expertise to support the use of equipment is also shared.
54. The LCN is just one example of mid-range scientific infrastructure. The inquiry heard about several examples of the importance of access to, and sharing of, mid-range infrastructure. This included evidence from Dr David Payne from Imperial College London, who told the inquiry that he was in the process of setting up a medium-scale facility:
 - i The instrument that I have recently had funded is a high pressure photoelectron spectrometer. 20% of that user time is for open access, and the EPSRC has provided funds to enable this and to enable users to come to my lab, to my department, and use the instrument. This is a new model that has really been pushed forward in the last few years.⁵¹
55. Evidence we received stressed the importance of investment in mid-range infrastructure. Large and mid-range infrastructure fulfil different functions, but investment in one does not preclude investment in the other. Research Councils UK described an 'infrastructure pyramid' in which scientific infrastructure at all scales needs to be supported. This view was echoed by the University of Nottingham:
 - i National facilities cannot be used to their full capability unless mid-range equipment/facilities for training of researchers and the testing of samples are available at the home institution. For example, samples are tested at the home laboratory and optimised before they are taken to Diamond for data collection. This ensures that precious time at the national facility is used efficiently and the majority of time can be spent collecting good quality data.⁵²
56. We received several pieces of evidence pointing to difficulties with funding mid-range infrastructure. This included evidence which indicated a particular problem in funding for NMR facilities (see paragraph 8). The Research Councils noted that there is still insufficient investment in mid-range infrastructure, despite efforts to address this through innovative sharing initiatives.⁵³ Following recommendations made by the 2010 Wakeham Review, the Research Councils and the Higher Education

⁵⁰ See London Centre for Nanotechnology website: <http://www.london-nano.com/about>.

⁵¹ Q 14.

⁵² University of Nottingham.

⁵³ RCUK.

Funding Council for England (HEFCE) have been supporting regional equipment sharing initiatives between universities.⁵⁴ Regional alliances have been established, which include the M5 group of five research intensive universities in the Midlands, and the N8 group in the north of England. Several similar initiatives exist around the UK. Regional alliances are intended to support collaboration, equipment sharing and co-fund capital investments.

57. The regional alliances show promise in enabling sharing of scientific infrastructure and improving access for researchers. Several pieces of evidence we received, however, raised issues which remain to be resolved with these newly established initiatives:

i HEFCE recognises that there are a number of barriers to collaboration and sharing of infrastructure that need to be overcome, including transaction costs and VAT implications, logistical barriers and broader cultural considerations around ownership and trust.⁵⁵

58. The Engineering Professors' Council suggested that the way in which the HEFCE Research Excellence Framework incentivises universities to own research infrastructure needed to be addressed:

i Ö while total grant funding won and ownership of infrastructure rather than the efficient use of existing facilities remains as one of the indicators of a high quality research environment (HEFCE Research Excellence Framework) and hence university research reputation and allocation of quality-related research funding, each individual university will want its own research centres and equipment. Addressing this particular disincentive would be helpful and certainly, more innovative approaches to equipment i sharingi could be developed.⁵⁶

The University of Nottingham suggested that specific funding for equipment which is suitable for sharing within a regional alliance would be appropriate.⁵⁷

59. It is important that mid-range scientific infrastructure is well provided for. A complete picture of what is available, where it is located and how heavily it is used is needed. It is important that universities collaborate effectively to collate this information and HEFCE should take a leadership role in actively facilitating this. This information can be used to ensure that best use is made of mid-range infrastructure and facilitate sharing by researchers across different universities and other organisations. It should also help to avoid duplication where the same equipment is unnecessarily purchased by more than one organisation in situations where it could be shared.
60. We welcome the work to establish equipment sharing initiatives. It is important that such initiatives continue to be supported and further developed. It is equally important that these initiatives create the widest possible access to scientific infrastructure. We note that whilst equipment sharing initiatives are clearly of benefit, they do not constitute an alternative

⁵⁴ Financial sustainability and efficiency in full economic costing of research in UK higher education institutions: Report of RCUK/UUK Task Group, Chair: Sir William Wakeham, June 2010. Available online: <http://www.rcuk.ac.uk/documents/reviews/fec/fECReviewReport.pdf>.

⁵⁵ HEFCE.

⁵⁶ Engineering Professors' Council.

⁵⁷ University of Nottingham.

to sustained capital investment. In addition, initial barriers to setting up equipment sharing initiatives will need to be overcome. We welcome the indication from the Research Councils and HEFCE that work is underway to address these difficulties. The evidence suggests that the Research Councils and HEFCE need to take urgent steps to support universities in solving administrative challenges and to assist in sharing best practice where effective approaches are established.

61. **There is evidence of some difficulties in the funding of mid-range scientific infrastructure. The establishment of university consortia and equipment sharing initiatives is a welcome step forward in terms of efficiency savings and improved access to mid-range infrastructure. We recommend that the Research Councils and HEFCE continue to support these initiatives, expand their scope where possible, and work with universities to find effective means for removing barriers and resolving administrative issues. The Research Councils and HEFCE should publish a regular report on progress with these initiatives. We note that such initiatives are also being undertaken in the devolved administrations and we invite the respective Higher Education Funding Councils to take similar steps where appropriate.**

National scientific infrastructure

62. National infrastructure is shared by users throughout the UK and beyond. In many cases, national infrastructure is not located at university campuses, but at low cost sites, which, on occasion, can be difficult to access and join up across the country. In deciding where new investments in scientific infrastructure should be located, it is important to consider access for users. Professor Alex Halliday FRS, Oxford University, stressed the importance of connectivity:

‘Large advanced facilities like those at Harwell and Culham also need excellent transport and communications. There has to be a national and regional strategy to support this connectivity. The road and rail links need to be efficient with adequate frequency and ease of access.’⁵⁸

63. Some submissions raised issues with geographic distribution and the availability of scientific infrastructure, noting concentration in the south east of England, which has implications for connectivity.^{59,60} We heard evidence of the local benefits associated with the location of scientific infrastructure. Professor Womersley, Chief Executive, the Science and Technology Facilities Council, told us that the Synchrotron Radiation Source at Daresbury, which operated successfully over 28 years, had brought tangible benefits to the local area:

‘Something like £1 billion was spent in the local area from the construction costs, the visits from all the users and the interaction with industry.’⁶¹

⁵⁸ Professor Alex Halliday FRS, University of Oxford.

⁵⁹ Engineering Professor's Council.

⁶⁰ Dr Thomas Forth.

⁶¹ Q 50.

64. **We recommend that the scientific infrastructure strategy and underpinning investment plan (paragraph 28) take into account local and regional benefits, the importance of national and regional connectivity (real and virtual), and wider facilitation of access for users.**

European and International

65. A large amount of the evidence we received described the importance of European and international scientific infrastructure projects. In many cases, the scale of the scientific infrastructure required exceeds the capabilities of an individual nation and collaborative investment is needed. Reflecting this, global research infrastructure was flagged as a priority area for increased international collaboration at the meeting of G8 Science Ministers in June this year.⁶²
66. The Minister for Science and Universities, Rt Hon David Willetts MP, told us that the Government was very much alive to opportunities to be involved in international scientific infrastructure projects:
- I should have mentioned earlier the European Space Agency moving its telecoms and satellite research capability to Harwell, deliberately shifting to the UK from the Netherlands, where it is currently located. We are quite active in trying to seize these international opportunities, but we certainly need to keep our eye open and aim to secure more in the future.⁶³
67. In some cases, the UK is committed to financing projects through international treaties: the European Space Agency (ESA), CERN and the European Southern Observatory (ESO) and conventions: the Institut Laue-Langevin (ILL) Convention and the European Synchrotron Radiation Facility (ESRF) Convention. Professor Tejinder Virdee, one of the founding members and leaders of the CMS experiment at CERN, told us that the UK is viewed favourably as a partner in providing sustained, stable and timely funding for CERN.⁶⁴ The UK realises the benefits of its investment through the success of UK researchers in gaining access to the scientific infrastructure at CERN on the basis of scientific excellence, following peer review of project proposals.

BOX 5

CERN

The CERN convention was signed in 1953 and now has 20 member states as signatories, all of whom contribute to capital and operating costs. Infrastructure funding depends on Gross National Product and the UK currently contributes approximately 14% of the costs. Experiments are funded by a larger number (approximately 40) of contributing member states. Researchers are awarded access to the scientific infrastructure at CERN on the basis of scientific excellence, following peer review.

⁶² G8 Science Ministers Statement, London, 12 June 2013. Available online: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/206801/G8_Science_Meeting_Statement_12_June_2013.pdf.

⁶³ Q 90.

⁶⁴ Q 58.

The CERN laboratory, which straddles the Franco-Swiss border near Geneva, hosts the Large Hadron Collider, the world's largest and most powerful particle accelerator. Particles are made to collide together at close to the speed of light, providing physicists with clues about how the particles interact, and, in turn, giving insights into the fundamental laws of nature.

Some 10,000 visiting scientists, from over 113 countries – half of the world's particle physicists – come to CERN to conduct their research.⁶⁵

68. We heard, however, that where there is no international treaty in place, the UK's commitment to international infrastructure projects is less consistent. We were told that there is scope for the UK to be more involved in infrastructure projects identified by the European Strategy Forum on Research Infrastructures (ESFRI).⁶⁶ ESFRI is a key tool for scientific infrastructure governance at the European level. It aims to provide a strategic approach to policy making on scientific infrastructure in Europe and to facilitate multilateral initiatives.⁶⁷ The 27 European Member States are represented by senior science policy officials at meetings held approximately four times a year. In 2010, ESFRI published an updated roadmap on research infrastructures.⁶⁸ Thirty-eight infrastructure preparatory phase projects are listed in the roadmap. The UK leads on only four of these projects, whereas Germany and the Netherlands each lead on five and France leads on eight. There is a perception that the UK lags behind its European counterparts, where Government funded organisations drive involvement, when it comes to hosting large scientific infrastructure.⁶⁹ Professor Harrison, Director, Institut Laue-Langevin (ILL), put it to us that the UK was perceived as detached and somewhat disengaged:

It tends to be regarded as a country that waits to see if a project has got off the ground and is successful, and then jumps in with the funding. That is what happened with ILL and it looks like that is what is happening with the ESS [European Spallation Source], though caution is sometimes well-founded. It is regarded as being very pragmatic but not always particularly collegiate when it comes to getting something off the ground. That comes back to the issue of the extent to which we actually jump in and make a commitment to international facilities.⁷⁰

Professor Cowley, Chief Executive Officer, UK Atomic Energy Authority, and Head of EURATOM/CCFE Fusion Association, argued that the UK was not getting in there, mixing it up and being part of proposals.⁷¹

69. The University of Nottingham suggested to us that a lack of alignment between UK and EU funding structures hampered UK involvement in

⁶⁵ See CERN website: <http://home.web.cern.ch/about>.

⁶⁶ Q 586 Professor Steven Cowley, Chief Executive Officer, UK Atomic Energy Authority, Head of EURATOM/CCFE Fusion Association.

⁶⁷ See ESFRI website: http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=esfri.

⁶⁸ ESFRI (2010) Strategy Report on Research Infrastructures, Roadmap 2010. Available online: http://ec.europa.eu/research/infrastructures/pdf/esfristrategy_report_and_roadmap.pdf#view=fit&pagemode=none.

⁶⁹ Q 596 Professor Cowley and Professor Harrison.

⁷⁰ Q 58.

⁷¹ Q 58.

European projects.⁷² We were also told that the UK funding structure, which gives a strong role to the Research Councils, meant that the UK did not always have a clear external face in international fora.⁷³ In addition, we heard that there is a lack of clarity about where leadership should come from for pursuing international projects,⁷⁴ and, moreover, that there is a lack of clarity about where the responsibility lies for decisions about whether or not to be involved in international scientific infrastructure projects. More widely, we heard that, in general, there is a lack of co-ordination within Europe between those who actually provide the funding.⁷⁵ Separately, the OECD has noted that responsibility for the negotiation of international scientific infrastructure agreements is in some cases delegated to officials who do not have the authority to make decisions, causing unnecessary delays.⁷⁶ This is an unsatisfactory state of affairs and should be rectified.

70. When the UK does get involved in European and international infrastructure projects, it often does so with great success. For example, the UK leads in the ELIXIR project which provides e-infrastructure for life science data (see Box 3), and we heard that the UK benefits from having such a resource physically located in the UK.⁷⁷ Professor Cowley told us that the benefits that the UK received from hosting Joint European Torus (JET) far exceeded the 12.5% of funding provided.⁷⁸ Moreover, the wages of local technicians and engineers are paid from this fund, which has the added benefit that: i Culham has produced a base of technicians and engineers who work at the various highest levels of technology and spin off into the local economy.⁷⁹ JET's successor project, the ITER, will be hosted in France. The evidence we received, including from the Minister for Science and Universities, Rt Hon David Willetts MP, was unclear as to why the UK had not bid to host the project. The decision, the Minister told us, had been taken long before he took office.⁸⁰

BOX 6

Examples of international infrastructure projects hosted in the UK

Based in Reading, **the European Centre for Medium-Range Weather Forecasts** (ECMWF) was established in 1975 and employs around 260 staff. It is an international intergovernmental organisation supported by 34 states. The scientific infrastructure hosted by ECMWF includes a state-of-the-art supercomputer, data archive and network. ECMWF pools the scientific and technical resources of Europe's meteorological services and institutions for the production of medium-range weather forecasts.⁸¹

⁷² University of Nottingham.

⁷³ Q 426 Professor Womersley and Professor Loughhead.

⁷⁴ Q 546 Professor Cowley.

⁷⁵ Q 576 Professor Harrison.

⁷⁶ Organisation for Economic Co-operation and Development, Global Science Forum (2010) *Establishing Large International Research Infrastructures: Issues and Options*.

⁷⁷ Q 326 Anne-Marie Coriat, Chair of Research Councils UK Research Group, Head of Science Programmes, Medical Research Councils (MRC).

⁷⁸ Q 54.

⁷⁹ Q 54.

⁸⁰ Q 82.

⁸¹ ECMWF.

The **Joint European Torus (JET)** for magnetic fusion research is hosted at the UK Atomic Energy Authority's Culham Laboratory.⁸² It began operating in 1983 and is used by over 350 scientists from Europe and beyond each year. 28 states are signatories to the European Fusion Development Agreement. JET is the largest operating magnetic fusion device in the world and the largest EU-funded scientific device in the UK. The goal of JET is to develop fusion energy as a new energy source for the future.⁸³

The **European Bioinformatics Institute (EBI)**, located at the Wellcome Trust's Genome Campus near Cambridge, is part of EMBL, Europe's leading laboratory for the life sciences. EMBL-EBI provides freely available data from life science experiments across the complete spectrum of molecular biology. EBI is a non profit intergovernmental organisation funded by EMBL Member States. Its 500 staff are made up of 43 different nationalities.⁸⁴

71. We also heard more widely of the local economic benefits of spin-outs in terms of building industrial capacity and stimulating innovation:

i There is a huge host benefit. CERN is a good example. If you drive around Switzerland and the part of the Haute-Savoie, which is the part of France that is adjacent to CERN, you see a lot of little hightech companies that clearly have their original origin in being subcontractors for CERN and now will export precision machines and special purpose electronics throughout the world. The host countries, which are France and Switzerland, have of course benefited far more than the other people who have paid in.⁸⁵

72. Professor Cowley noted the importance of such projects for retaining the project skills needed to build large infrastructure projects within the UK:

i One of the dangers when we are not building new facilities in the UK is that people cannot learn on smaller facilities how to do this. You are not going to give the LHC [Large Hadron Collider] to somebody who has never done a project before.⁸⁶

73. In addition to the direct employment and skills benefits, witnesses concurred that locating large facilities in the UK had an inspirational impact in terms of attracting the next generation into careers in science, technology and engineering. The examples of specific cases provided in evidence point to the extensive benefits which were derived from hosting large facilities. Dr Graeme Reid, Head of Research Funding, Department for Business, Innovation and Skills, however, considered that the cost benefit analysis was in fact unclear.

i Ö there are quite clearly benefits from having major infrastructure located in the nation, but there are also considerable costs, both direct and indirect, from that. My sense is that the country does very well in

⁸² See Culham Centre for Fusion Energy website: <http://www.ccfef.ac.uk/>.

⁸³ See CCFE website: <http://www.ccfef.ac.uk/JET.aspx>.

⁸⁴ See EBI website: <http://www.ebi.ac.uk>.

⁸⁵ Q 216 Professor Aeppli FRS, Quain Professor of Physics and Director of the London Centre for Nanotechnology.

⁸⁶ Q 63.

terms of participating in international collaboration through large infrastructure.⁸⁷

74. Beyond anecdotal reports, there is a paucity of evidence about the costs and benefits of hosting European and international projects, and we recommend that further information is collected to support future investment decisions in this area. The need for improved monitoring and evaluation of the impacts of scientific infrastructure projects is discussed in the final section of this report.
75. Nevertheless, in our view, it emerged clearly from the evidence that the UK needs an improved and more transparent strategy for engagement in European and international scientific infrastructure projects. Further steps must be taken to ensure that the UK is sufficiently engaged in European and international infrastructure projects and able to commit funding in a timely manner. Establishing a long term strategy and investment plan will help to bring necessary focus on the UK's European and international ambitions.
76. **The DGKI should commission a review of the costs and benefits of hosting European and international infrastructure in the UK and use this as an evidence base for the development of the strategy and an underpinning investment plan (paragraph 28). The investment plan should clearly set out the UK's ambitions, objectives and budget for involvement in European and international projects, and establish procedures and processes to ensure that that the UK can be engaged, proactive and well-coordinated, with a clear external face, within the EU and internationally.**

Industry

77. Scientific infrastructure is often extremely important to industry. We heard evidence of how access to publicly funded scientific infrastructure was particularly beneficial to small and medium sized enterprises (SMEs), which would be unable to fund capital investment in such equipment.⁸⁸ Heptares Therapeutics, a spin-out from the MRC Laboratory of Molecular Biology in Cambridge, and a heavy user of the Diamond Light Source, told us:

i SMEs, many of which are spin-outs from universities, rely on being able to access large pieces of capital equipment via universities or research Institutes. Such infrastructure provides an invaluable kick start to new companies and will directly stimulate the economy.⁸⁹

BOX 7

Heptares Therapeutics

Heptares Therapeutics is a biotechnology firm based in Hertfordshire, employing more than 60 scientific staff. Heptares uses X-ray protein structures for drug design in the areas of neurological and metabolic disease. It uses the Diamond Light Source at least monthly and is one of the largest industrial users in the biomedical area, generating 90% of its structural data there. For example, using the Diamond Light Source, Heptares has characterised a key protein in the brain involved in memory. Using this knowledge, the firm is now working to develop

⁸⁷ Q 32.

⁸⁸ Q 136 Professor Brown, Director of Structural Biology, Argenta Discovery and Professor of Structural Biology, University of Kent.

⁸⁹ Heptares Therapeutics.

treatments for Alzheimer's disease. Heptares is applying the same approach in the development of drugs for schizophrenia, migraine, depression, alcohol and smoking addiction and insomnia. Access to the Diamond Light Source has contributed to the ability of Heptares to obtain partnerships with major pharmaceutical companies.⁹⁰

78. The evidence from Heptares provides an indication of the societal and economic benefits of investment in scientific infrastructure if it is effectively used by industry. Another example is provided by the whole life economic study of the Synchrotron Radiation Source at Daresbury, which was used by 200 business customers, 11 of the top 25 companies in the UK R&D scoreboard⁹¹

79. In other cases, however, there seems to be a lack of awareness in industry about the availability and potential uses of scientific infrastructure. The Minister for Science and Universities, David Willetts MP, accepted that SMEs are not accessing some of the research and development support that is available to them.⁹² Industry is typically charged when using large facilities to undertake proprietary research, but may be able to access scientific infrastructure at universities free of charge. We heard that arrangements can be highly variable:

Currently there are schemes for SMEs to access university equipment. However these are highly variable in their arrangements, with different universities and departments within universities having different attitudes with regard to access to small-medium sized pieces of capital equipment.⁹³

The Royal Academy of Engineering considered that charges are usually reasonable, but emphasised that:

It is important that fees are not raised without wider consideration of impact on the full range of users, including SMEs, who make use of facilities.⁹⁴

The evidence also suggested that, in some cases, charging full economic cost may deter industry from making use of scientific infrastructure.⁹⁵ We were told that high charges for using infrastructure are particularly a problem in the UK:

It is clear that in the USA, our competitors benefit significantly from free or low cost access to HPC for advanced simulation and large scale data analytics (big data). It is important that UK companies have the playing-field levelled.⁹⁶

The Engineering Professors' Council noted that the charging situation is highly inconsistent with some areas, such as tomography, priced beyond affordability of most users:

⁹⁰ Heptares Therapeutics.

⁹¹ Q 50.

⁹² Q 85.

⁹³ Heptares Therapeutics.

⁹⁴ Royal Academy of Engineering.

⁹⁵ Professor Attfield, University of Edinburgh.

⁹⁶ Rolls Royce.

it is currently cheaper to fly to the US for 3 days of synchrotron tomography beamtime rather than using a laboratory instrument in the UK.⁹⁷

80. There seems to be some complexity and a lack of clarity about the charging arrangements for industry access to scientific infrastructure. Steps should be taken to simplify arrangements and communicate them to industry more effectively. There are, in our view, clear benefits to the UK economy of industry using publicly funded scientific infrastructure, and the economy is likely to benefit if any barriers associated with charging practices are removed. It is important that the UK's international standing and competitiveness are not jeopardised through inappropriate charging arrangements. In addition, it is crucial that steps are taken to raise industry's awareness as to what scientific infrastructure is available and how it can be used.
81. **The strategy and underpinning investment plan for scientific infrastructure (paragraph 28) should include consideration of measures to encourage and facilitate further access to scientific infrastructure for industry. This should include reviewing the charges for access and improving the clarity of communication about charging. Consideration should also be given to how facilities can be encouraged to market infrastructure for external use more proactively.**
82. The Government has taken steps to encourage industry to co-invest in scientific infrastructure. The UK Research Partnership Investment Fund (UKRPIF) was set up in 2012 as a tool for encouraging collaborative industry investment in scientific infrastructure. The UKRPIF fund provides £10 million to £35 million for universities to invest in long-term capital projects, which leverage in at least double the amount of private investment. The Minister for Science and Universities, Rt Hon David Willetts MP, told us that the scheme had proved very popular and had attracted £855 million of private investment.⁹⁸ At the June Spending Review, the Government announced £100 million per year for the RPIF until 2016/17.
83. HEFCE told us that, following cuts to its capital fund at the 2010 Comprehensive Spending Review, the UKRPIF had been the only major injection of capital.⁹⁹ The evidence suggested that whilst this new scheme is welcome, and showing encouraging commitment from industry, further optimisation of the terms under which it operates may still be needed:
- RPIF has undoubtedly been very useful in securing outside investments, but a more strategic approach to RPIF could be achieved with a longer-term and more flexible initiative having either an open-ended time period for putting forward proposals, or at least a clear set of proposal closing dates known well in advance. If business is to be encouraged to engage more extensively in future rounds of RPIF, then a lower proportion of matching may be required and/or sufficient

⁹⁷ Engineering Professors' Council.

⁹⁸ Q 86.

⁹⁹ HEFCE.

flexibility allowed to include more in-kind and other non-financial contributions.¹⁰⁰

the need to match research to economic activity at substantial scale may have constrained some potential projects from being proposed. In addition, the scale of co-investment requires significant strategic partnerships with companies that can take time to nurture through to full commitment stage. The challenges for institutions and their partners could be eased through long term commitment from Government (longer lead in times to develop propositions) and consideration of smaller scale projects.¹⁰¹

84. The Government's commitment to ongoing funding for the UKRPIF scheme is welcome. It is important that this programme remains sustainable once big business has had its needs met. Government should therefore review and carefully consider the terms of the scheme and determine whether more could be done to encourage the involvement of SMEs. Longer lead in times are also important. More proactive marketing and improved information for businesses about this funding may also be needed.
85. **We congratulate the Government on the launch of their Research Partnership Investment Fund and their commitment to funding until 2016–17. We recommend that the Government take steps to extract maximum value from the scheme. To achieve this, the DGKI, in developing the strategy and an underpinning investment plan (paragraph 28), should review whether the scheme should be made more flexible and whether funding calls need to be open for longer to enable collaborative partnerships to be developed.**

Monitoring and evaluation

86. Much of the evidence received during this inquiry pointed to the importance of scientific infrastructure, not only for supporting scientific research, but also for stimulating innovation and economic growth. In some cases, studies have been undertaken to characterise the impacts of past investment in scientific infrastructure.¹⁰² It is, however, rare that attempts are made to monitor and evaluate the impacts of investment in scientific infrastructure. A recent report, commissioned by the Government, reviewed the information available on the link between large facilities and innovation.¹⁰³ It concluded that little information was available, and more needed to be done to develop evaluation practices for large facilities.
87. Evidence on the impact of past investments would be useful in supporting future investment decisions. There is a need to gather evidence on the return on investment more effectively and embed mechanisms for monitoring and evaluation from the point of funding. This should extend to an examination of economic benefits, training and skills, and societal benefits. The outcomes should be used to inform a long-term strategy and inform future investment

¹⁰⁰ Russell Group.

¹⁰¹ HEFCE.

¹⁰² Science and Technology Facilities Council, *The social & economic impact of the Daresbury Synchrotron Radiation Source (1981–2008)*. Available online: <http://stfc.ac.uk/resources/PDF/SRSImpact.pdf>.

¹⁰³ Technopolis Group, *Big science and innovation*, July 2013. Available online: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/249715/bis-13861-big-science-and-innovation.pdf.

decisions. There is, correspondingly, a need to convey better the impact of investment in scientific infrastructure to industry, commerce and policy makers.

88. **We recommend that all future funding of large and mid-range scientific infrastructure includes provision for an ongoing monitoring and evaluation mechanism to determine the impact and return on investment and provide an evidence base for future decision making. Monitoring and evaluation processes should be embedded from the point of investment and outcomes should be published and clearly communicated to industry, policy makers and the scientific community.**

CHAPTER 3: CONCLUSIONS AND RECOMMENDATIONS

Scientific Infrastructure: Planning and Governance

89. Scientific infrastructure plays a vital role in underpinning the UK's research excellence and its translation into wealth creating outcomes. We recommend well planned, sustained and efficient future investment in scientific infrastructure in order to ensure that UK research is able to remain internationally competitive. It is imperative that a level of stable investment is achieved that keeps the UK at the forefront of science and technology. (paragraph 27)
90. Efficient investment in scientific infrastructure requires long-term planning and clear and transparent decision making. We therefore recommend that the BIS Director General for Knowledge and Innovation (DGKI) is charged with the responsibility of producing a long term strategy and underpinning investment plan for scientific infrastructure. This should take a comprehensive view of scientific infrastructure needs across the UK, extending beyond the jurisdiction of the Research Councils, and including the needs of industry. It should set out clear investment priorities for the next ten to fifteen years, based on the budget available, and include an indicative plan for a longer time frame. It should be reviewed and updated at clearly defined intervals. The principle of awarding funding for scientific infrastructure on the basis of independent, expert scientific advice about the UK's relative position and the opportunities and benefits that could accrue must be upheld. (paragraph 28)
91. We recommend that the BIS DGKI establishes a time-limited, ad hoc advisory group. This group should advise on the development of the long term strategy and underpinning investment plan, and on the response to other recommendations contained in this report, The membership of the group might include independent experts, HEFC, PSRE and Research Council Chief Executives, and representatives from industry and business. Independent experts on the advisory group might include, for example, representatives with a strong record in working on scientific infrastructure overseas. Recommendations for membership of the advisory group should be sought from the National Academies. The development of this strategy should include reviewing the Large Facilities Steering Group. The strategy and investment plan should be published within twelve months of the establishment of the advisory group. (paragraph 29)

Not just machines

92. There is substantial evidence of a damaging disconnect between capital investment and the funding for operational costs. We recommend that the BIS Director General for Knowledge and Innovation, in the development of the strategy and an underpinning investment plan (paragraph 28), reviews the current situation to determine how capital investment and the funding for operational costs can be tied together in one sustainable package. (paragraph 39)
93. We recommend that the training and other costs, as well as the value of the skilled workforce needed to operate scientific infrastructure, are fully taken into account in developing the strategy and an underpinning investment plan

(paragraph 28). To maximise the return on investment, ways to facilitate viable career paths must be found. (paragraph 43)

Shared benefits

94. We are concerned that the ability of Public Sector Research Establishments and National Laboratories to deliver national objectives is being eroded by underfunding and a wide variety of funding and governance models. PSREs are often custodians of data, expertise and mid-range facilities. We recommend that BIS Ministers ensure that the funding and governance mechanisms in place effectively protect the public goods generated by these institutions. (paragraph 50)
95. There is evidence of some difficulties in the funding of mid-range scientific infrastructure. The establishment of university consortia and equipment sharing initiatives is a welcome step forward in terms of efficiency savings and improved access to mid-range infrastructure. We recommend that the Research Councils and HEFCE continue to support these initiatives, expand their scope where possible, and work with universities to find effective means for removing barriers and resolving administrative issues. The Research Councils and HEFCE should publish a regular report on progress with these initiatives. We note that such initiatives are also being undertaken in the devolved administrations and we invite the respective Higher Education Funding Councils to take similar steps where appropriate. (paragraph 61)
96. We recommend that the scientific infrastructure strategy and underpinning investment plan (paragraph 28) take into account local and regional benefits, the importance of national and regional connectivity (real and virtual), and wider facilitation of access for users. (paragraph 64)
97. The DGKI should commission a review of the costs and benefits of hosting European and international infrastructure in the UK and use this as an evidence base for the development of the strategy and an underpinning investment plan (paragraph 28). The investment plan should clearly set out the UK's ambitions, objectives and budget for involvement in European and international projects, and establish procedures and processes to ensure that that the UK can be engaged, proactive and well-coordinated, with a clear external face, within the EU and internationally. (paragraph 76)
98. The strategy and underpinning investment plan for scientific infrastructure (paragraph 28) should include consideration of measures to encourage and facilitate further access to scientific infrastructure for industry. This should include reviewing the charges for access and improving the clarity of communication about charging. Consideration should also be given to how facilities can be encouraged to market infrastructure for external use more proactively. (paragraph 81)
99. We congratulate the Government on the launch of their Research Partnership Investment Fund and their commitment to funding until 2016/17. We recommend that the Government take steps to extract maximum value from the scheme. To achieve this, the DGKI, in developing the strategy and an underpinning investment plan (paragraph 28), should review whether the scheme should be made more flexible and whether funding calls need to be open for longer to enable collaborative partnerships to be developed. (paragraph 85)

Monitoring and evaluation

100. We recommend that all future funding of large and mid-range scientific infrastructure includes provision for an ongoing monitoring and evaluation mechanism to determine the impact and return on investment and provide an evidence base for future decision making. Monitoring and evaluation processes should be embedded from the point of investment and outcomes should be published and clearly communicated to industry, policy makers and the scientific community. (paragraph 88)

APPENDIX 1: LIST OF MEMBERS AND DECLARATIONS OF INTEREST

Members

Lord Dixon-Smith
 Baroness Hilton of Eggardon
 Lord Krebs (Chairman)
 Baroness Manningham-Buller
 Lord O'Neill of Clackmannan
 Lord Patel
 Baroness Perry of Southwark
 Lord Peston
 Lord Rees of Ludlow
 Earl of Selborne
 Baroness Sharp of Guildford
 Lord Wade of Chorlton
 Lord Willis of Knaresborough
 Lord Winston

Declared Interests

Lord Dixon-Smith
None

Baroness Hilton of Eggardon
None

Lord Krebs (Chairman)
Principal, Jesus College, Oxford
Chairman, Oxford Risk Ltd
Fellow, Royal Society
Fellow, Academy of Medical Sciences

Baroness Manningham-Buller
Governor, Wellcome Trust
Chair, Council of Imperial College London
Non-executive Director, Ark Continuity Ltd (data storage and management)

Lord O'Neill of Clackmannan
None

Lord Patel
Chancellor, Dundee University
Fellow, Academy of Medical Sciences
Fellow, Royal Society of Edinburgh

Baroness Perry of Southwark
None

Lord Peston
None

Lord Rees of Ludlow
Fellow, Trinity College, Cambridge
Astronomer Royal
Fellow, Royal Society
Fellow, Royal Academy of Engineering (Hon)
Fellow, Academy of Medical Sciences (Hon)

Member of various scientific societies

Earl of Selborne

Fellow, Royal Society

Fellow, Society of Biology

Chairman, Foundation for Science and Technology

Chair, Centre for Ecology and Hydrology Advisory Board

Baroness Sharp of Guildford

None

Lord Wade of Chorlton

None

Lord Willis of Knaresborough

Council Member, Natural Environment Research Council (NERC)

Chair, Co-ordinating Committee UK Stem Bank

Chair, Association of Medical Research Charities (AMRC)

Member, Royal Society Policy Committee

Lord Winston

Fellow, Academy Medical Sciences, FREng

Professor Imperial College

Director, Atazoa Ltd (genetic engineering)

Regular speaking engagements

A full list of Members' interests can be found in the Register of Lords Interests:

<http://www.publications.parliament.uk/pa/ld/ldreg.htm>

Professor Brian Collins, Specialist Adviser

Fellow and Council Member, Royal Academy of Engineering

Fellow, Institute of Physics

Fellow Institute of Engineering and Technology

Fellow, Institute of Civil Engineering

Fellow, British Computer Society

Member, Institute of Directors

Fellow, Royal Society of Arts and Manufacturing

Director, Europium Consulting

Trustee, Institute for Sustainability

Professor, University College, London

APPENDIX 2: LIST OF WITNESSES

Evidence is published online at www.parliament.uk/hlscience and available for inspection at the Parliamentary Archives (020 7219 5314)

Evidence received by the Committee is listed below in chronological order of oral evidence session and in alphabetical order. Those witnesses marked with * gave both oral evidence and written evidence. Those marked with ** gave oral evidence and did not submit any written evidence. All other witnesses submitted written evidence only.

Oral evidence in chronological order

*	QQ 1ñ1	Diamond Light Source Ltd
**		Professor Jon Goff, Chair of ISIS User Committee, Professor of Experimental Condensed Matter Physics, Royal Holloway University of London
**		Professor Philip Nelson FEng, University of Southampton
**	QQ 12ñ23	Professor Gabriel Aeppli FRS, London Centre for Nanotechnology
**		Dr David Payne, Imperial College London
**		Professor David Brown, University of Kent
*	QQ 24ñ39	Department for Business, Innovation and Skills (BIS)
*		Research Councils UK
*		Higher Education Funding Council for England (HEFCE)
*	QQ 40ñ52	Science and Technology Facilities Council (STFC)
**		UK Energy Research Centre (UKERC)
**		Professor David De Roure, University of Oxford
*	QQ 53ñ65	Institut Laue-Langevin (ILL)
**		UK Atomic Energy Authority
**		Professor Tejinder Virdee, Imperial College London
*	QQ 66ñ77	Heptares
*		BAE Systems
*	QQ 78ñ90	Rt Hon David Willetts MP, Minister of State for Science and Universities, Department of Business, Innovation and Skills (BIS)

Alphabetical list of all witnesses

	Academic Advisory Group
	ADS (UK aerospace, defence, security and space industries)
**	Professor Gabriel Aeppli FRS, London Centre for Nanotechnology (QQ 12ñ23)

- Association of Medical Research Charities (AMRC)
 Professor J. Paul Attfield, University of Edinburgh
 Australian Institute of Nuclear Science and Engineering (AINSE)
 Australian Neutron Beam Users Group (ANBUG)
 The Babraham Institute
- * BAE Systems (QQ 66ñ77)
 Professor Stephen J. Blundell, University of Oxford
 Professor Jess H. Brewer, University of British Columbia
- ** Professor David Brown, University of Kent (QQ 12ñ23)
 Campaign for Science and Engineering (CaSE)
 Cancer Research UK
 Centre for Plasma Physics (CPP), Queenís University Belfast
 Professor Swapan Chattopadhyay, F Inst. P, FRSA, Universities of
 Liverpool, Manchester and Lancaster
 College of Science and Engineering, University of Edinburgh
 Computing Advisory Panel (CAP) of STFC
 Professor Peter Coveney, University College London
- * Department for Business, Innovation and Skills (BIS) (QQ 24ñ39)
- ** Professor David De Roure, University of Oxford (QQ 40ñ52)
- * Diamond Light Source Ltd (QQ 1ñ11)
 Dr David Dye, Imperial College
 e-Infrastructure Academic User Community Forum
 Engineering in Medicine
 Engineering Professorsí Council
 European Bioinformatics Institute (EMBL-EBI) and ELIXIR
 European Centre for Medium-Range Weather Forecasts (ECMWF)
 Professor Michael Fitzpatrick, The Open University
 Dr Thomas Forth
 Geological Society of London (GSL)
 GlaxoSmithKline (GSK)
- ** Professor Jon Goff, Royal Holloway University of London (QQ 1ñ11)
 GW4
 Professor Alex Halliday FRS, University of Oxford
 Dr Jamie Harle, Department of Medical Physics and Bioengineering,
 University College London
 Professor Stephen Hayden and his research students, University of Bristol
- * Heptares Therapeutics (QQ 66ñ77)
- * Higher Education Funding Council for England (HEFCE) (QQ 24ñ39)
 Higher Education Funding Council for Wales (HEFCW)
 Lord Hunt of Chesterton
- * Institut Laue-Langevin (ILL) (QQ 53ñ65)
 Institute of Physics (IOP)
 Institute of Physics and Engineering in Medicine
 Institution of Civil Engineers (ICE)

Instruct, the European Research Infrastructure for Structural Biology
 ISIS User Committee
 Janet(UK)
 John Innes Centre
 Large Facilities Sub-group (LFS) of the Science and Technology Facilities
 Council's Science Board
 Loughborough University
 M5 Consortium
 Professor Martin McCoustra, Heriot-Watt University
 Professor Robert McGreevy, STFC Rutherford Appleton Laboratory
 Met Office
 The Metcalfe Partnership
 N8
 National Centre for Atmospheric Science (NCAS)
 National Physical Laboratory (NPL)
 National Management Committee of the EPSRC & BBSRC funded UK
 850 MHz Solid-State Nuclear Magnetic Resonance (NMR) Facility and
 the Director of the EPSRC Solid-State NMR Service
 Natural Environment Research Council (NERC)
 Natural History Museum
 Professor Richard J. Nelmes FRS, University of Edinburgh
 ** Professor Philip Nelson FEng, University of Southampton (QQ 1ñ11)
 Professor Amalia PatanĀ, University of Nottingham
 ** Dr David Payne, Imperial College London (QQ 12ñ23)
 The Pirbright Institute
 QMC Instruments Ltd
 * Research Councils UK (QQ 24ñ39)
 Professor Ian Robinson, University College London
 Rolls-Royce
 Professor Steven Rose, Imperial College London
 The Royal Academy of Engineering (RAEng)
 Royal Astronomical Society (RAS)
 The Royal Society
 The Royal Society of Chemistry (RSC)
 Professor Gary Royle, Department of Medical Physics & Bioengineering,
 University College London
 Russell Group
 The Science Council
 * Science and Technology Facilities Council (STFC) (QQ 40ñ52)
 Science and Technology Facilities Council (STFC) DiRAC Project
 Management
 Science and Technology Facilities Council (STFC) Physical Sciences and
 Engineering Advisory Panel (PS&EAP)
 Society for General microbiology (SGM)
 Software Sustainability Institute

- Space Plasma Environment and Radio Science (SPEARS) Physics
Department, Lancaster University
Tokamak Solutions UK Ltd
- * UK Atomic Energy Authority (QQ 53ñ65)
UK Computing Research Committee (UKCRC)
UK Data Forum
 - ** UK Energy Research Centre (UKERC) (QQ 40ñ52)
UK Physical Sciences Electron Microscopy Community
University of Birmingham
University of Cambridge
University of Nottingham
University of Oxford
 - ** Professor Tejinder Virdee, Imperial College London (QQ 53ñ65)
Professor Anthony Watts, Oxford University
Professor Peter Weightman, University of Liverpool
Wellcome Trust
Wellcome Trust Sanger Institute
The Welsh Government
 - * Rt Hon David Willetts MP, Minister of State for Science and Universities,
Department of Business, Innovation and Skills (BIS) (QQ 78ñ90)
York Plasma Institute, University of York

APPENDIX 3: CALL FOR EVIDENCE

24 May 2013

The House of Lords Science and Technology Committee, under the Chairmanship of Lord Krebs, is conducting an inquiry into scientific infrastructure. This refers to large and medium-sized equipment and the e-infrastructure to support scientific research. Such infrastructure requires substantial financial investment and often capital expenditure. It is therefore important that a long-term strategic plan is in place for initial investment, use, operational costs and upgrades.

Scope

This inquiry will collect evidence on the large and medium-sized scientific infrastructure currently available in the UK. It will consider future needs and whether an effective long-term strategic plan is in place to meet these needs. It will consider funding and governance arrangements. Finally, it will consider how effective international partnerships and partnerships with industry can be achieved.

The scope of this inquiry does not extend to investment in scientific infrastructure which could be funded from individual grants or within the budgets of individual universities or institutes. The deadline for written evidence submissions is **Friday, 21 June 2013**.

Questions:

The Committee invites submissions on the following points, with practical examples where possible (please only answer the questions of relevance to you):

Current availability and status of scientific infrastructure

- What scientific infrastructure is currently available in the UK, do UK researchers have sufficient access to cutting edge scientific infrastructure and how does this situation compare to that of other countries?
- Is sufficient provision made for operational costs and upgrades to enable best use to be made of the UK's existing scientific infrastructure? Is it used to full capacity; and, if not, what steps could be taken to address this?
- What substantial increases in scale would allow new areas or domains of science to be explored (analogous to Large Hadron Collider and Higgs boson)?

Long-term needs, setting priorities and funding

- What role should the Government play in ensuring that there is an effective long-term strategy for meeting future scientific infrastructure needs?
- What are the long-term needs for scientific infrastructure and how are decisions on priorities for funding usually made?

- Is it more important to invest in large, national infrastructure or medium infrastructure?
- Since the last Comprehensive Spending Review, a series of additional announcements have been made on investment in scientific infrastructure. How were the decisions on investment reached and what have been the impacts of this approach to funding scientific infrastructure?
- What impact has removing capital spend from the ring-fenced budget had on investment in scientific infrastructure and should the ring-fenced science budget be redefined to include an element of capital spend?
- If the current funding level is maintained or reduced, what would be the longer term impacts on scientific infrastructure in the UK?

Governance structures

- Does the UK have effective governance structures covering investment in scientific infrastructure, how do they compare to those of other countries, and are there alternatives which would better enable long-term planning and decision-making?
- Are effective and fair arrangements in place for access and charging for public and private scientific infrastructure?
- Are effective structures in place for funding of medium-sized scientific infrastructure and enabling sharing among Higher Education Institutes and Research Institutes?
- Are regional research alliances proving effective in enabling access to funding for medium-sized infrastructure? Should more be done to support or incentivise approaches to collaborative funding and sharing of medium-sized infrastructure?

Partnerships

- To what extent do funding structures in the UK help or hinder involvement in EU and international projects, and should the level of UK involvement be improved?
- To what extent are EU and international programmes effective in promoting collaborative investment in scientific infrastructure projects?
- What impact does publicly funded scientific infrastructure have in terms of supporting innovation and stimulating the UK's economy?
- How accessible is publicly funded scientific infrastructure in the UK to industry and small and medium sized enterprises? Is there room for improvement?
- Are Government policies successful in encouraging industry to co-invest in scientific infrastructure?

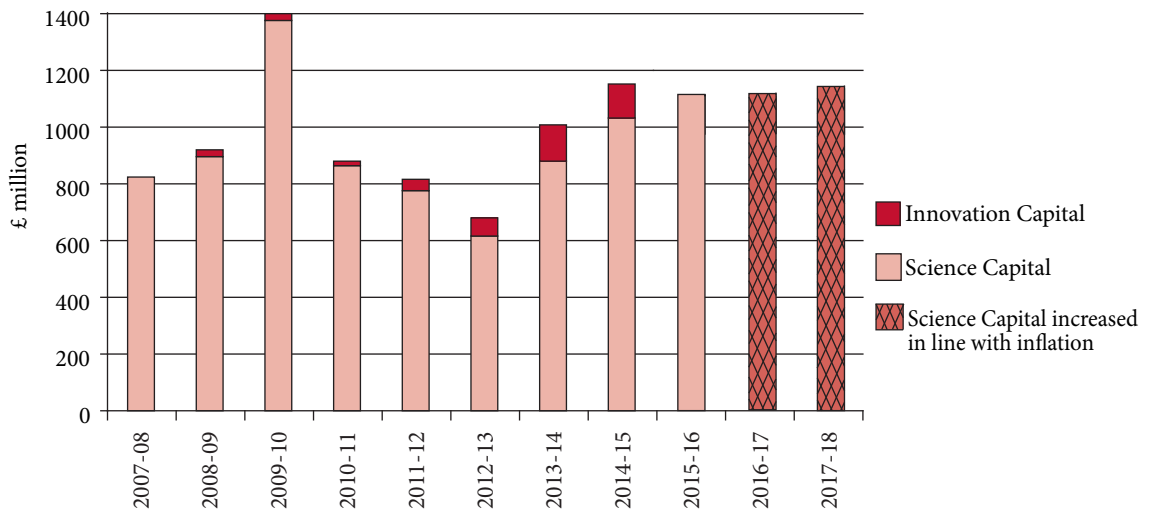
APPENDIX 4: SUPPLEMENTARY DATA

TABLE 4
Allocation of ad hoc funding (information provided by the Department for Business, Innovation and Skills)

Fiscal Events / Change	Funding Project	2011-12	2012-13	2013-14	2014-15	Total
		£ million				
Science & Research Capital	Babraham Campus	44	0	0	0	44
	Norwich Campus	26	0	0	0	26
	Transfer from Large Facilities Computer Fund, ISIS/Daresbury	20	0	0	0	20
	UK Space Agency Budget 2011	10	0	0	0	10
October 2011ó £145m High Performance Computer	EPSRC Archer High Performance Computer	40	0	0	0	40
	Wider improvement to e-infrastructure to support high performance computing	105	0	0	0	105
October 2011ó £50m Graphene	Graphene	0	9	29	12	50
2011 Autumn Statement £200m	Archer High Performance Computer	0	0	13	0	13
	Institute of Animal Health / Development Phase 2	0	23	23	34	80
	Upgrading science laboratories and equipment	0	16	32	11	59
	RCUK Gateway to Research	0	1	1	0	2
	Space	0	21	0	0	21

Fiscal Events / Change	Funding Project	2011-12	2012-13	2013-14	2014-15	Total
Science & Research Capital						
Budget 2012 UK Research Partnership Investment Fund (UKRPIF) £100m	UKRPIFó new	0	20	25	0	45
	UKRPIFó recycled	0	0	25	30	55
October 2012 UKRPIF £200m	UKRPIFó new	0	0	70	130	200
Chancellor November 2012 speechó £120m Space	New European Space Agency investment	0	0	60	60	120
2012 Autumn Statement (eight great technologies)	Space Technology Programme	0	0	10	15	25
	Various new (eight great technology) projects	0	4	229	251	484
Total						1,399
Innovation Capital						
2011 Autumn statement (part of the £200m announcement)	Future Cities Demonstrator	0	10	15	0	25
Autumn Statement 2011	Open Data Institute Small and Medium Enterprises Package		2	2	2	6
		0	25	25	25	75
2012 Autumn Statement (eight great technologies)	Advanced Materials	0	4	23	1	28
	Advanced Metrology Lab	0	2	10	13	25
	Pharmavision	0	0	10	28	38
Total						197

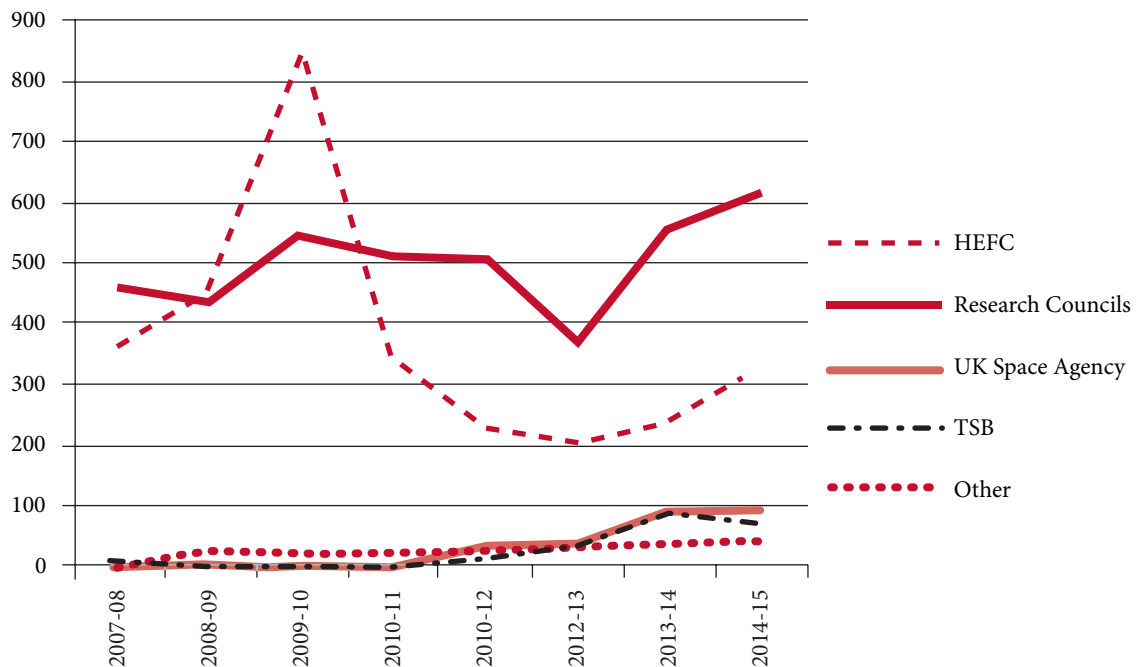
FIGURE 1
Amount of capital committed to science and innovation
per annum 2007–2018



Note: The solid bars show actual science and innovation capital spend up until 2012–13 and forecast spend from 2013–16.

Source: based on figures provided by the Department for Business, Innovation and Skills (BIS).

FIGURE 2
Allocation of science and innovation capital
2007–2015



Source: figures drawn from data provided by the Department for Business, Innovation and Skills (BIS).

APPENDIX 5: SEMINAR HELD AT THE HOUSE OF LORDS

11 June 2013

Members of the Committee present were Lord Dixon-Smith, Baroness Hilton of Eggardon, Lord Krebs (Chairman), Baroness Perry of Southwark, Earl of Selborne and Baroness Sharp of Guidford.

Presentations were heard from:

- Dr Anne-Marie Coriat, Chair, Research Councils UK (RCUK) Research Group; and
- Professor John Womersley, Chief Executive, the Science and Technology Facilities Council (STFC)

APPENDIX 6: ABBREVIATIONS AND ACRONYMS

BIS	Department for Business, Innovation and Skills
CSR	Comprehensive Spending Review
DGKI	Director General for Knowledge and Innovation
EPSRC	Engineering and Physical Sciences Research Council
ESFRI	European Strategy Forum on Research Infrastructures
EU	European Union
HEFCE	Higher Education Funding Council for England
HEFCs	Higher Education Funding Councils
ILL	Institut Laue-Langevin
LFSG	Large Facilities Steering Group
LCN	London Centre for Nanotechnology
NMIs	National Measurement Institutes
NERC	Natural Environment Research Council
NMR	Nuclear Magnetic Resonance
PSREs	Public Sector Research Establishments
RCUK	Research Councils UK
STFC	Science and Technology Facilities Council
TSB	Technology Strategy Board
UKRPIF	UK Research Partnership Investment Fund

APPENDIX 7: RECENT REPORTS FROM THE HOUSE OF LORDS SCIENCE AND TECHNOLOGY COMMITTEE

Session 2007–08

- 1st Report Air Travel and Health: an Update
- 2nd Report Radioactive Waste Management Update: Government Response
- 3rd Report Air Travel and Health Update: Government Response
- 4th Report Personal Internet Security: Follow-up
- 5th Report Systematics and Taxonomy: Follow-up
- 6th Report Waste Reduction
- 7th Report Waste Reduction: Government Response

Session 2008–09

- 1st Report Systematics and Taxonomy Follow-up: Government Response
- 2nd Report Genomic Medicine
- 3rd Report Pandemic Influenza: Follow-up

Session 2009–10

- 1st Report Nanotechnologies and Food
- 2nd Report Radioactive Waste Management: a further update
- 3rd Report Setting priorities for publicly funded research

Session 2010–12

- 1st Report Public procurement as a tool to stimulate innovation
- 2nd Report Behaviour Change
- 3rd Report Nuclear Research and Development Capabilities
- 4th Report The role and functions of departmental Chief Scientific Advisers
- 5th Report Science and Heritage: a follow-up

Session 2012–13

- 1st Report Sports and exercise science and medicine: building on the Olympic legacy to improve the nation's health
- 2nd Report Higher Education in Science, Technology, Engineering and Mathematics (STEM) subjects
- 3rd Report The implementation of open access

Session 2013–14

- 1st Report Regenerative Medicine