National Audit Office

Big Science: Public investment in large scientific facilities

REPORT BY THE COMPTROLLER AND AUDITOR GENERAL | HC 153 Session 2006-2007 | 24 January 2007

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Big Science: Public investment in large scientific facilities

A report by the Comptroller and Auditor General

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Comptroller and Auditor General
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15 January 2007

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CONTENTS

Photographs courtesy of Diamond Light Source Ltd, Biotechnology and Biological Sciences Research Council, Council for the Central Laboratory of the Research Councils, Engineering and Physical Sciences Research Council, Medical Research Council and Natural Environment Research Council.

EXECUTIVE SUMMARY

1 The Government invests in a range of large scientific facilities to support and develop the nation's science base. Since 2000 the Department of Trade and Industry's (the Department) Office of Science and Innovation has established new arrangements to co-ordinate planning for large facilities. The main components are a road map describing large facilities which UK scientists are likely to need in the next 10 to 15 years, and a central fund (the Large Facilities Capital Fund) of around £100 million per year to support investments in such facilities by Research Councils. The Research Councils are the Arts and Humanities Research Council (AHRC), Biotechnology and Biological Sciences Research Council (BBSRC), Council for the Central Laboratory of the Research Councils (CCLRC), Economic and Social Research Council (ESRC), Engineering and Physical Sciences Research Council (EPSRC), Medical Research Council (MRC), Natural Environment Research Council (NERC) and Particle Physics and Astronomy Research Council (PPARC).

2 The Department has earmarked £830 million from the central fund to 15 prioritised projects as set out in **Figure 1 on page 6**. Once prioritised, these projects progress by presenting science and business cases to secure project approval. To date 10 projects have received Departmental approval. Part 1 of this report evaluates the strength of current processes for the identification, appraisal and prioritisation of potential investments in large scientific facilities. Part 2 evaluates performance in delivering those facilities prioritised for support. Ten projects examined in detail in this report are outlined in **Figure 2 on pages 8 and 9**. In total they have a capital budget of £1 billion. The study methods are summarised at Appendix 1.

3 Ultimately, the value for money to be obtained from these facilities will depend on the scientific discoveries they help make and the effective exploitation of that science. Our study concludes that, though such outcomes will always remain uncertain, the current arrangements should deliver a significant contribution to the development of the nation's scientific infrastructure. The arrangements include the development of a common plan known as the road map. This is co-ordinated by Research Councils UK – a partnership of the research councils – which addresses priorities which cut across scientific disciplines. The road map has allowed scientific priorities to be considered in a more systematic way across disciplines. Working within HM Treasury's Green Book guidance on project appraisal and evaluation,[1] special attention now needs to be paid to strengthening the information available to support choices between large facility projects.

4 The projects we examined had generally been established in accordance with good practice principles and standards as set out in methodology advocated by the Office of Government Commerce for managing projects, called PRINCE2.[2] More consistent application of that Office's Gateway reviews to the key stages of every project, would ensure all teams benefit from wider sources of advice on areas such as project management, project costing and funding and procurement options.

5 It is still early to assess fully the portfolio of projects against delivery to time and budget. To date, performance against the approved capital budgets suggests some good budget management, for example on the James Cook research ship, but also projects where forecast capital costs already exceed budget even though still at an early stage. More significantly, some project teams have significantly underestimated the likely running costs of facilities once they are delivered. In addition, more work is needed by Research Councils to examine the potential impact of these facilities on the future demand for research funding, their capacity to support any new demand, or the effect of doing so on other areas of activity. Full use of these facilities will depend on research ideas competing successfully for research funding, through peer review, against other calls on limited Research Council budgets. As the new facilities come on stream, the Research Councils will need to monitor the impact on the demand for research funding and ensure lessons are learned for the appraisal of similar facilities in the future.

6 Our detailed conclusions are as follows:

- Current arrangements identify potential projects over a sensible planning horizon, allow prioritisation across the science base, and are delivering a significant programme of new or replacement large scientific facilities. The road map approach was pioneered by the United Kingdom and has been widely commended and adopted by other countries.
- Prioritisation and assessment strongly reflect the primary policy objective of advancing scientific knowledge, but economic potential and possible exploitation by industry are less fully analysed.
- Current arrangements concentrate attention on availability of capital funding to build facilities but there are significant weaknesses in assessing their ongoing costs, and the impact (normally in future spending review periods) of meeting those costs on the balance of Research Council funded activities.
- At prioritisation estimates of costs and assessments of benefits are preliminary, yet priorities are not reviewed if costs or benefits are significantly revised as business cases are prepared. Opportunities to maximise the overall science benefits of the portfolio of projects may thus be missed.
- Procurement strategies have been adapted to the particular circumstances of each project. Future projects can benefit from better sharing of experience and lessons learned.
- More attention needs to be given to specifying from the start how the success of individual projects will be assessed and measured, drawing on examples from some current and existing projects. This should enable a fuller assessment of value for money to be made once facilities are operational and inform appraisal of future potential projects.

1 Sixteen large scientific facilities have been prioritised, of which 15 have received, or been earmarked, for support[1]

Project[2]	Year of prioritisation	Lead Research Council	Large Facilities Capital Fund Allocation[3] (£ million)	Research Council Capital Funding[3] (£ million)	Other Capital Funding[3] (£ million)	Total Capital Budget[3] (£ million)	Status as at autumn 2006
Diamond Synchrotron (Phases I and II)[3, 4]	Before the 2003 road map	CCLRC	308.6	21.0	53.6	383.2	Commissioning
Royal Research Ship James Cook		NERC	25.0	15.0	0.0	40.0	Post delivery commissioning
ISIS 2nd Target Station and first suite of instruments		CCLRC	127.9	7.7	10.0	145.6	Under construction
Energy Recovery Linac Prototype	2003 road map	CCLRC	10.1	8.0	3.2	21.3	Under construction
Halley Antarctic Research Station[5]		NERC	20.0	6.2	0.0	26.2	Contracts awarded
HECToR (High End Computing)		EPSRC	52.0	13.0	0.0	65.0	In negotiations with preferred bidders
Muon Ionisation Cooling Experiment (Phase I)		PPARC	7.5	2.2	13.0	22.7	Under construction
Laboratory of Molecular Biology		MRC	67.0	88.0	0.0	155.0	Preparing procurement strategy
Institute for Animal Health[6]		BBSRC	31.0	23.0	67.0	121.0	Principal contractor appointed
Research Complex including infrastructure		MRC/CCLRC	32.4	1.1	0.0	33.5	Preparing procurement strategy
National Institute for Medical Research[1]	2005 road map	MRC	Budget and funding not yet determined				Prioritised in road map
European X-Ray Free Electron Laser (XFEL)[7]		CCLRC	31.5	0.0	618.5	650.0	Funding earmarked
European High Performance Computing Service[8]		EPSRC	44.8	19.2	327.0	391.0	Funding earmarked
Household Panel Survey		ESRC	12.5	17.5	0.0	30.0	Funding earmarked
ISIS 2nd Target Station – second suite of instruments		CCLRC	21.8	68.2	0.0	90.0	Funding earmarked
Oceanographic Research Ship		NERC	38.5	16.5	0.0	55.0	Funding earmarked
Total			**830.6**	**306.6**	**1,092.3**	**2,229.5**	

Source: National Audit Office analysis of Research Council data

NOTES

1 The Office of Science and Innovation is awaiting development of the National Institute for Medical Research's business case before taking a view on earmarking of funds to the project from the Large Facilities Capital Fund.
2 The ten projects in blue text were prioritised from the 2003 road map or before the 2003 road map and were examined in detail for this report.
3 The allocations and current budgets are as at autumn 2006. The figure for the Large Facilities Capital Fund Allocation for Diamond Phase I and II, includes allocations made directly by the Office of Science and Innovation to the project as well as others that passed through the Large Facilities Capital Fund.
4 The Diamond Synchrotron is being built, and will be operated, by Diamond Light Source Ltd – a joint venture with the Council for the Central Laboratory of the Research Councils and the Wellcome Trust as shareholders. Wellcome are the source of the other capital funding of £53.6 million.
5 The figures for Halley include the capital funding for constructing a new Antarctic station but exclude the non-capital funding of £8.5 million for decommissioning the existing station Halley V.
6 £67 million for the redevelopment of the Institute for Animal Health is being provided by the Department for the Environment, Food and Rural Affairs.
7 The XFEL project is being led by Germany which will bear 60 per cent of the construction cost. It is planned that other countries will contribute the remainder of the funds with the UK providing 11 per cent of the total non-German contribution.
8 The European high performance computer project plans to share costs of £192 million between the UK, France and Germany with the balance of around £200 million coming from the European Commission and industry.

Recommendations

1 The Office of Science and Innovation, Research Councils UK and individual Research Councils should strengthen project appraisal by:

- ensuring the production of more consistent estimates of costs and assessments of benefits at the initial point of prioritisation; and
- ensuring that if a project's expected costs or benefits at business case are significantly different from those initially anticipated, its priority is reconsidered at the next available opportunity.

2 The Office of Science and Innovation, Research Councils UK and individual Research Councils should give greater attention to the future financial sustainability of projects. Project proposals should be based on realistic estimates of their ongoing costs, the sources of funding available to cover those costs and any implications for other activities funded by Research Councils.

3 Research Councils UK should ensure that the road map differentiates projects where there is a choice of location from those where no such choice is practically available. Research Councils UK and the Office of Science and Innovation should provide Research Councils with guidance to aid preparation of comparisons of different locations where a choice is available.

4 To improve the transparency of investment decisions, and provide a better opportunity for scrutiny or challenge by scientific and industrial stakeholders, Research Councils UK should publish the outcomes of and rationale behind the prioritisation of proposals as part of the large facilities road map. The rationale should include commentary on the implications for the overall research programme of supporting the construction and operation of prioritised projects.

5 The Office of Science and Innovation, Research Councils UK and individual Research Councils should:

- ensure an evaluation of the nature and scale of the economic impacts derived from building and operating large scientific facilities, once they have been brought into service, is undertaken; and
- provide guidance to project teams on assessing and presenting anticipated economic impacts of large facility proposals.

6 The Science and Technology Facilities Council, which will be established in April 2007, should:

- promote awareness of knowledge and lessons from planning, procurement and operation of large scientific facilities by bringing project teams or members together to share experiences and training;
- develop and promote a consistent means of applying the science performance management framework developed by the Office of Science and Innovation in 2005 to large facilities planning and operation; and
- use its own skills base and partnerships with external providers to improve other Research Councils' access to high-grade project management skills for large projects.

7 The Department of Trade and Industry should work with Research Councils to ensure the Government-wide Gateway review process is applied to large facility projects consistently and with a level of independence appropriate to their assessment of risk.

8 Large facility project teams should build on procurement lessons from previous projects to secure improvements in value for money. Across the portfolio of projects there is scope:

- to undertake a deeper analysis of risks so that project teams can separate those which should be transferred to a contractor and those which should be retained;
- to make greater use of incentives to encourage the timely delivery of key components or project milestones;
- to extend the use of pain/gain share conditions in contracts, thereby increasing the incentives for contractors to contain costs;
- to improve the packaging of work by considering the separation of those elements where there is a limited pool of potential suppliers from less demanding elements; and
- for more active promotion of the work on offer to potential suppliers who might otherwise be deterred from bidding by the scientific nature of the overall project.

2 The National Audit Office looked at ten projects in detail[1]

Diamond Synchrotron (Diamond Light Source Ltd)

Diamond is a 24 cell, 3 giga electron volt, 3rd generation synchrotron light source producing intense x-rays and shorter wavelength emissions for research in the biological, physical, environmental and engineering sciences. The synchrotron is being built by, and will be operated by, a joint venture company Diamond Light Source Ltd, partly owned by the Council for the Central Laboratory of the Research Councils and partly by the Wellcome Trust.

Location: Harwell Science and Innovation Campus, Oxfordshire.

Budget and Funding: £383.2 million for Phases I and II, with £308.6 million from the Large Facilities Capital Fund.

Delivery: Phase I, including the first seven beamlines, is due to begin operations in January 2007 and Phase II, including the next 15 beamlines, is due to be completed in 2011.

Royal Research Ship James Cook (Natural Environment Research Council)

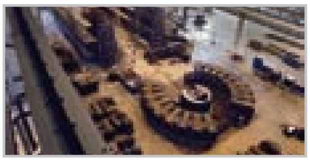
The RRS James Cook is a replacement for the RRS Charles Darwin and is sponsored by the Natural Environment Research Council. Its users will be marine scientists based, for example, at UK universities and the Research Council's National Oceanographic Centre in Southampton.

Location: Worldwide but mainly Atlantic waters – built in Poland and Norway.

Budget and Funding: £40 million, of which £25 million will come from the Large Facilities Capital Fund.

Delivery: The ship was delivered to the National Oceanographic Centre in August 2006.

ISIS Neutron Source, Second Target Station (Council for the Central Laboratory of the Research Councils)



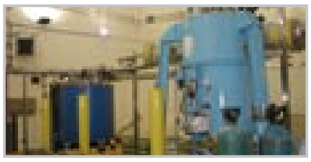
The ISIS Neutron and Muon Scattering Facility is the most powerful neutron producer of its kind in the world. The first phase of the project involves supplementing the existing facilities with a second target station and the installation of a first suite of instruments. It will enable the ISIS science programme to attract new users from the key research areas of soft matter, advanced materials and bio-science.

Location: Harwell Science and Innovation Campus, Oxfordshire.

Budget and Funding: £145.6 million for the first phase, with £127.9 million from the Large Facilities Capital Fund.

Delivery: The experimental programme is set to begin in October 2008.

Energy Recovery Linac Prototype (Council for the Central Laboratory of the Research Councils)



The Prototype is phase one of the 4th Generation Light Source (4GLS) project. The project will use free electron lasers and synchrotron radiation covering the terahertz to soft X-ray energy regimes for ultra fast dynamic studies of matter. The first phase has been designed to address some of the principal technical challenges that would be faced in a full 4GLS facility.

Location: Daresbury Science and Innovation Campus, Cheshire.

Budget and Funding: £21.3 million, with £10.1 million from the Large Facilities Capital Fund.

Delivery: Full operational energy recovery by April 2007.

Halley VI Antarctic Research Station (Natural Environment Research Council)

The project involves the building of the Halley VI Antarctic research station and the removal of the existing station, Halley V. Halley provides a unique location for monitoring climate, ozone and space weather and forms a key part of the UK's regional presence. The primary users of Halley VI will come from within the British Antarctic Survey, an institute of NERC.

Location: Antarctic Ice Shelf.

Budget and Funding: £34.7 million for both construction of Halley VI (£26.2 million) and decommissioning of Halley V (8.5 million). The Large Facilities Capital Fund is providing £20 million for construction.

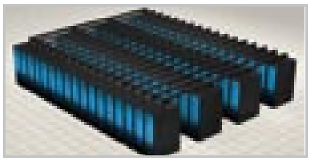
Delivery: Delivery of Halley VI and decommissioning of Halley V by end of 2009-10 Antarctic summer.

Source: National Audit Office

NOTES

1 Project summaries set out the position as at autumn 2006. More detail on each of the ten projects is provided in Appendix 3.
2 £67 million for the redevelopment of the Institute for Animal Health is being provided by the Department for Environment, Food and Rural Affairs.

High End Computing Terascale Resource (HECToR) (Engineering and Physical Sciences Research Council)



HECToR is the next generation of high performance computer. It is the responsibility of Engineering and Physical Sciences Research Council and will succeed the CSAR and HPCx computer services. Users will span several fields of science including computational chemistry, physics and climate modelling.

Location: dependent on tenderers' proposals.

Budget and Funding: £65 million in total; £52 million from the Large Facilities Capital Fund.

Delivery: Phase I scheduled to start in September 2007.

Muon Ionisation Cooling Experiment (MICE) (Particle Physics and Astronomy Research Council is the lead council. The experiment is hosted by the Council for the Central Laboratory of the Research Councils)

The Muon Ionisation Cooling Experiment is a step towards the possible creation of a neutrino factory which would aid the understanding of the properties of neutrinos – one of the fundamental particles which make up the universe. MICE seeks to demonstrate that "muon cooling" – making a tightly focused muon beam – is possible through a process of ionisation.

Location: Harwell Science and Innovation Campus, Oxfordshire.

Budget and Funding: Phase I of MICE will cost £22.7 million. Of this, the UK will fund £9.7 million, of which £7.5 million will come from the Large Facilities Capital Fund.

Delivery: Phase I is set to be complete by November 2007.

Laboratory of Molecular Biology (Medical Research Council)

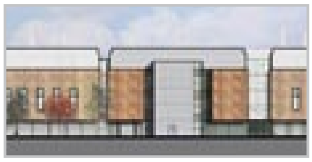
The Laboratory of Molecular Biology opened in 1962 and is acknowledged as one of the world's leading biochemical laboratories with users from the fields of immunology, cancer biology and biotechnology. The LMB project will provide a new, modern laboratory building on the current hospital campus.

Location: Addenbrooke's Hospital Site, Cambridge.

Budget and Funding: £155 million, of which £67 million will come from the Large Facilities Capital Fund.

Delivery: building due to be available May 2011.

Institute for Animal Health (Biotechnology and Biological Sciences Research Council)



The Institute is responsible for research, diagnostics and surveillance on epizootic (fast spreading) viral diseases of farm animals. The project involves building a new laboratory for the Institute's staff and employees of the Virology Department of the Veterinary Laboratories Agency (part of the Department for Environment, Food and Rural Affairs).

Location: Pirbright, Surrey.

Budget and Funding: Current approved cost is £121 million with £31 million from the Large Facilities Capital Fund.[2]

Delivery: The main laboratory building is scheduled for delivery in December 2009.

Research Complex (Medical Research Council) and **Essential Infrastructure** (Council for the Central Laboratory of the Research Councils)

The project will provide a research laboratory, hostel accommodation and other infrastructure to enable scientists to make optimum use of the Diamond Synchrotron, ISIS and other facilities at Harwell.

Location: Harwell Science and Innovation Campus, Oxfordshire.

Budget and Funding: £33.5 million for the Complex and infrastructure, with £32.4 million from the Large Facilities Capital Fund.

Delivery: The main element of the infrastructure programme – a new hostel for visiting scientists – was delivered in July 2006. The Research Complex is set for completion in June 2009.

PART ONE

Prioritising investments in large scientific facilities

1.1 This Part examines the effectiveness of the arrangements put in place to choose between potential investments in large scientific facilities. It focuses on:

- responsibilities for investment;
- processes for prioritising and funding potential investments;
- evaluating scientific benefits of proposals;
- evaluating economic benefits of proposals;
- evaluating costs of proposals;
- handling international collaborations; and
- managing the demand for funds.

Responsibilities for investment in large scientific facilities

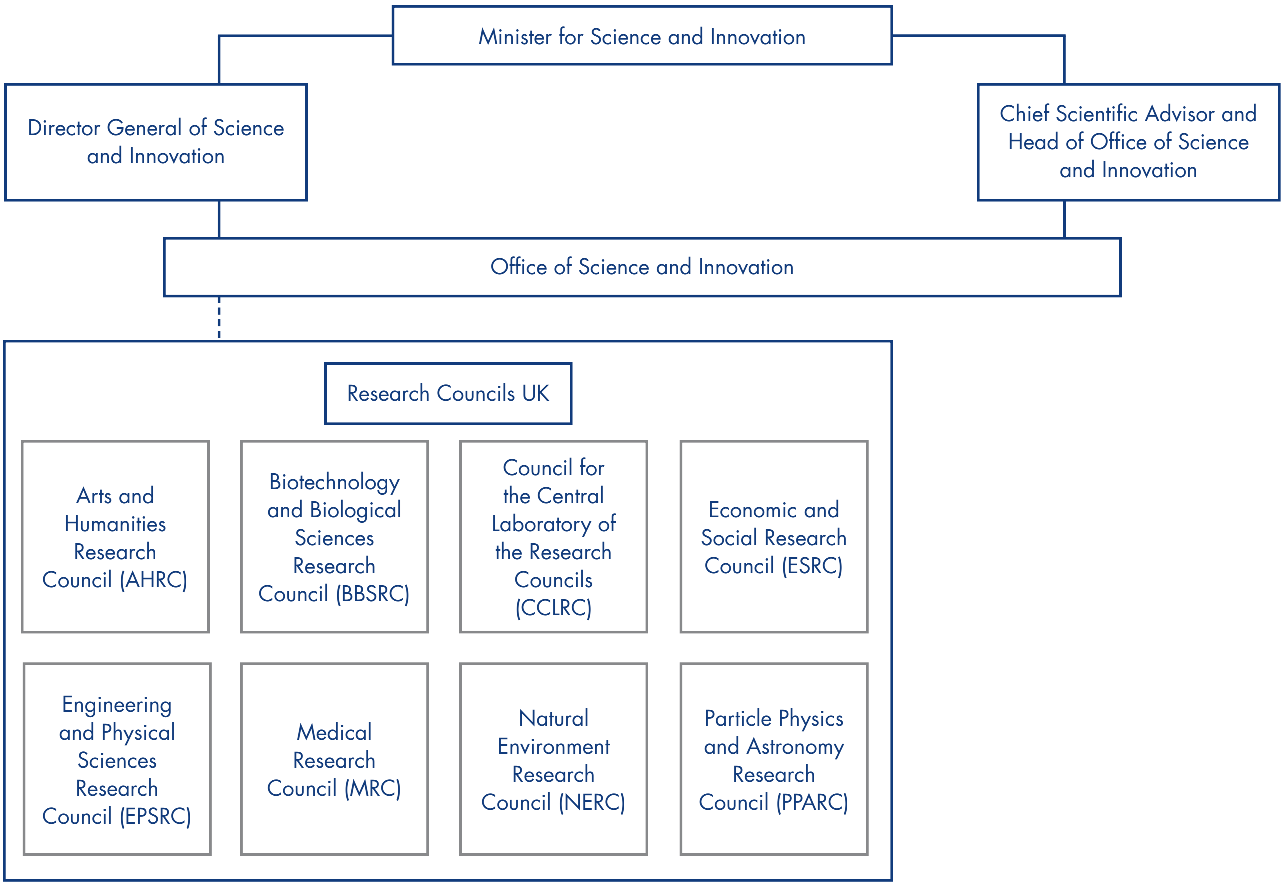
1.2 The Office of Science and Innovation, part of the Department of Trade and Industry (the Department), is the lead body responsible for UK science policy. The Office and the eight Research Councils aim to strengthen the UK's science base, and maximise its contribution to UK economic development. The Research Councils are the main public investors in civil research in the UK. Each Research Council is responsible for deciding the research priorities within their particular field, in line with overall policy set by the Office of Science and Innovation. Priorities cutting across scientific disciplines are addressed by Research Councils UK **(Figure 3)**. Research Councils UK is a strategic partnership led by an executive group made up of the chief executives of each Research Council. The group's primary purpose is to define the overall strategic framework for research, training and knowledge transfer funded by the Research Councils, and to provide input into the wider strategy for the whole science budget.

1.3 Increasingly, the facilities used by scientists in many disciplines have become larger and more complex. This has necessitated levels of capital investment beyond the normal means of a single research institution and, in the case of the largest facilities, requiring cooperation amongst a number of countries. Failure to make such investment risks loss of scientific leadership and the international standing of UK science. Within the UK, planning and providing access to large facilities is the responsibility of the Research Councils.

1.4 Since 2000, the Department has significantly increased investment in large scientific facilities. As shown in Figure 1, fifteen projects with a total capital budget of £2,230 million are currently committed and/or earmarked for support of £1,140 million from the Department and Research Councils, with a further £70 million coming from other UK public bodies. Contributions from charitable institutions or other countries make up the bulk of the remaining funding.

1.5 In July 2006 the Department announced that a new Science and Technology Facilities Council is to be created by a merger of the Council for the Central Laboratory of the Research Councils (CCLRC), the Particle Physics and Astronomy Research Council (PPARC) and the nuclear physics responsibilities of the Engineering and Physical Sciences Research Council (EPSRC). This new body, which will be established in April 2007, is intended, amongst other things, to create a more integrated approach to large facilities, including international negotiations for long term projects involving several countries.[3]

3 Research Councils and the Office of Science and Innovation are responsible for investments in large scientific facilities



Source: Office of Science and Innovation and the National Audit Office

Processes for prioritising and funding large scientific facilities

1.6 Prior to 2000 proposals for investments in large scientific facilities had been prepared and submitted to the Department by individual Research Councils as part of the spending review process. There was no explicit mechanism for deciding priorities between the various bids. Since 2000 the Office of Science and Innovation and the Research Councils have worked together to draw up and prioritise a road map of new or replacement facilities which United Kingdom scientists will need access to over the next 10 to 15 years. In addition, the Office of Science and Innovation introduced a Large Facilities Capital Fund in 2002-03 to help fund projects judged to be of sufficient priority. This supplemented funds already allocated to Phase I of the Diamond Synchrotron. By 2003-04, the total funds available to Diamond Phase I and other large facilities through the Fund amounted to around £100 million per annum and funding has continued at this level.

1.7 The road map is intended to include projects fulfilling one or more of the following conditions: over £25 million capital cost; representing a high proportion of an individual Research Council's budget; serving the research communities of more than one Research Council; or having an international dimension. The road map was first published in 2001 and was updated in 2003 and 2005. The road map is prepared on the basis of submissions from individual Research Councils. Projects are subsequently prioritised by the research directors group of Research Councils UK, which makes recommendations via that body's executive group to the Director General of Science and Innovation. The Office of Science and Innovation considers the recommended priorities and seeks to earmark available resources from the Large Facilities Capital Fund to priority projects.

1.8 The road map, and the criteria for its assembly, have been successful in capturing proposals from across the science base. Proposals from all Research Councils, except the Arts and Humanities Research Council, are included in the latest road map and serve a wide range of scientific disciplines ranging from astronomy to oceanography and the social sciences. Of the 62 senior scientists working in the public or private sectors responding to a questionnaire prepared by us (see Appendix 1), only four identified projects which they felt should have been captured by the road map but which had been omitted – with animal testing facilities, central open access materials testing facilities, ultra-high field Nuclear Magnetic Resonance and space projects being mentioned. A further two scientists believed computer facilities – which are in the road map – should have been considered as proposals customised or dedicated to specific user communities, for example to perform biological modelling and computation.

1.9 The road map approach has been commended by evaluative reviews by the United States National Science Foundation as well as the Australian and Canadian governments,[4] and a road map has been developed by the European Strategy Forum on Research Infrastructure (ESFRI)[5] describing the scientific needs across Europe for large research infrastructures for the next 10 to 20 years. In particular, the studies cited above have commended the road map process as a vehicle for decision-making, including analysis of scientific opportunities and objectives for large facilities.

1.10 The 2005 road map was published as an unprioritised list of proposals, with commentary on the criteria which would be applied to prioritise that list. The outcomes of prioritisation and earmarking were only publicised once the recommendations from those processes had secured support from the Department. Our interviews with research directors of Research Councils, and Office of Science and Innovation, indicated that these key players were fully engaged with and aware of the process and rationale behind the prioritisation outcomes. But the wider scientific and industrial communities did not have the opportunity to scrutinise or challenge the prioritisation before the earmarking of funds.

Evaluating scientific benefits

1.11 The Office of Science and Innovation expects Research Councils putting forward bids for new facilities to submit proposals to the executive group of Research Councils UK setting out the scientific justification for the proposed facility supported by details of the indicative costs. In practice, each Research Council will have carried out its own review of bids within its particular field prior to submitting its preferred options to the executive group of Research Councils UK. Current guidance from Research Councils UK is that proposals should show timescale, cost estimates and funding profile, and should address the following criteria:

- importance of science knowledge delivered;
- contribution to international position of UK science and science strategy;
- timeliness – including impact of delay;
- breadth of science base that will benefit;
- opportunity for knowledge and technology transfer or wider benefits;
- scope for partnership with other funders;
- scope for training and production of trained people.

The role of Research Councils UK is to collate individual proposals for large facilities into the road map, and then to prioritise them using these criteria. The criteria map onto the core Office of Science and Innovation objectives of strengthening the science base and maximising its contributions to economic development and quality of life. The strongest weighting is given to the contribution to strengthening of the science base. This emphasis was reflected in the perceptions of the scientists responding to our questionnaire. Forty five of the 62 senior scientists felt that contribution to basic scientific knowledge was the most important factor in selecting projects for investments. A further 12 felt that contribution to the international standing of UK science was most important.

1.12 Our work suggested that whilst the prioritisation process focused on science benefits, Research Councils generally needed to do more to meet the requirements of HM Treasury's Green Book and consider the full range of potential impacts that a new large facility might have. Large facilities with large capacities imply, in some instances, that more or larger research teams will have to use the facility if its full capacity is to be utilised. Of the ten projects earmarked for funding up to 2003, the nature of the research communities likely to use the new facilities were specified, but the current size of those communities, or the prospective increase in demand, on which the scale and scope of the proposal was based, were generally not set out. Similarly for the replacement or the refurbishment of an existing facility, the factors driving the size of the replacement, such as the numbers of internal and visiting staff it needed to accommodate, were generally not specified in any detail.

1.13 Once a project has been prioritised, the project team must prepare a case setting out the project's scientific value. The science case must be endorsed by Research Councils UK before the project goes on to prepare a business case and seek formal approval. At the end of 2003, the Office of Science and Innovation enhanced procedures and required all new projects prioritised for support to arrange an independent review of their science case. The criteria to be considered in the science case are the same as those for initial proposals. By autumn 2006, three projects – HECToR, Diamond Phase II and the Research Complex – had presented their science cases to the Research Councils UK executive group since this new requirement was introduced. These cases described in greater detail the areas of science which will benefit, and statements of the current demand for comparable facilities were included for HECToR and Diamond Phase II. But forecast levels of demand, and the assumptions behind those forecasts, were still not specified.

Evaluating economic benefits

1.14 The Office of Science and Innovation and Research Councils are increasingly wishing to maximise the economic impact of their activities including the use that is made of large facilities. In May 2005, the Council for the Central Laboratory of the Research Councils' delivery plan[6] identified active marketing of the research capabilities of its major facilities to businesses as a key theme. This theme was reinforced in its March 2006 neutron strategy[7] which announced further steps to broaden industry access to large facilities. The case for establishing the Science and Technology Facilities Council is based partly on the argument that a more integrated management structure will maximise the economic impact of public investment in this area.[8]

1.15 Regional bodies, including the regional development agencies, are increasingly advocating or promoting the location of new large scientific facilities in their regions as a means of assisting regional economic performance. To date, most of the projects underway have offered little choice in terms of where they are located, for example a number have involved extending existing facilities. Where projects have offered the possibility of a choice of location, the supporting options analysis has either been insufficiently independent or its lateness has delayed the decision-making process. For the Diamond Synchrotron, for example, approved before the introduction of the road map and Large Facilities Capital Fund, the assumption that the facility would be located at Daresbury meant that analysis of options occurred late in the design process and delayed the decision to proceed. For new facilities, or even wholesale redevelopment of existing facilities, there may be a realistic choice of potential locations. To ensure appropriate analysis is undertaken at an early stage, the development of the road map in the future should identify those facilities where an appraisal of the potential location options will be required as part of the formal approval of the business plan.

1.16 The analysis of potential economic benefits supporting bids for new facilities is challenging but needs to be further developed. The proposals we examined did not identify all the main sources of economic benefit although specific opportunities were identified. Local impacts, such as the effect on the local economy and local businesses during the construction phase are reasonably straightforward to measure. It is more difficult to assess the longer term economic impact of a new facility: the science is by its nature uncertain and the economic benefits can be difficult to estimate. Internationally, there have been few evaluations of the extent to which advances in scientific knowledge supported by large facilities in general, or a particular large facility, are converted into commercial innovation, or the extent to which the benefit of that innovation accrues to the country where the facility is located. The Council for the Central Laboratory of the Research Councils' neutron strategy, published in 2006, has acknowledged this gap in relation to the benefits of hosting international facilities, and has proposed a study to begin to examine some of these potential impacts. Previous work in this area has considered only the relative merit of the UK hosting an international facility rather than contributing to the same facility in another country. Extending this work to address the nature and absolute level of economic impacts of large facility investments, once they have been brought into service, could provide a better and more consistent framework for the presentation and assessment of competing facility proposals in the future.

1.17 Such analysis of economic impacts as is currently undertaken relies heavily on assertions of potential for direct industrial use, industrial use through industry-university collaborations, or knowledge transfer opportunities. These assertions originate from proposers' knowledge of current industrial interest and opportunity and, for some of the projects we reviewed, these were tested within individual Research Councils by presenting the proposal to a panel or committee representing industrial interests. Neither the large facilities road map as a whole, nor the prioritisation of projects within it, is the subject of direct consultation with bodies representing industrial interest in Government science policy.

Evaluating costs

1.18 To date the road map has included indicative capital costs for each project. In some cases, at this early stage, estimates can be relatively basic as they are not based upon detailed designs of the proposed facilities. The estimates are used to "earmark" funds to projects but these funds are not committed until a proper business case has been approved by the sponsoring Research Council, Research Councils UK executive group and the Office of Science and Innovation. Almost inevitably, some of the initial estimates used to earmark funds to the projects prioritised through the 2003 roadmap have proved optimistic. For example, between earmarking and business case the estimates of the capital costs of the Laboratory of Molecular Biology rose by 55 per cent to £155 million as more detailed designs of the facilities were prepared. The additional cost will be funded by the Medical Research Council which will own the facility. In a second case – the redevelopment of the Institute for Animal Health's laboratories including incorporation of the Virology department of the Veterinary Laboratories Agency – cost estimates varied, rising by up to a third, as the project was developed. In 2006 it was decided that the original funding of £121 million, specified when the project was earmarked in 2004, would be used to build a smaller facility, which will house 25 per cent less staff than intended in 2004 and which will no longer include a research hotel for visiting researchers. The main laboratory building is now due to be completed by the end of 2009, a year later than envisaged when the project was prioritised. The project's principal users – the Institute for Animal Health and the Department for Environment, Food and Rural Affairs - have confirmed that the rescoped facility will meet their needs.

1.19 Whilst it is right that the business case and revised costs should form the basis for holding project teams to account for delivery, there is currently no mechanism for reviewing the original prioritisation should the business case cost or proposed project scope and benefits differ significantly from the original proposal in the road map. There are a number of potential consequences should the initial estimate of cost, and thus the earmarked allocation, prove to be too low:

- The basis for prioritisation and allocations from the Large Facilities Capital Fund could be distorted by the uncertainties in the cost information available at earmarking.
- Projects could be delayed, and substantial amounts of project team and management time could be expended, trying to fit projects within the original earmarked allocation or trying to obtain increased funding.
- If a project experiences cost pressure after earmarking but is unable to obtain further funding, or de-scope appropriately, there is a risk that the core science objectives of a project may not be achieved. We are not aware of this risk maturing on any of the projects to date.

Handling international collaborations

1.20 The projects earmarked for funding prior to 2005 were primarily national facilities, with the exception of the £22.7 million Muon Ionisation Cooling Experiment (Phase I) which is hosted in the UK but being taken forward by an international collaboration of scientists. The 2005 road map argues that in many circumstances the UK's interests would be best served by participating in a facility overseas, for example through international subscription or bilateral arrangements with the host country. As the cost of building large facilities increases, the Research Councils expect that co-operation at an international level will become increasingly necessary if projects are to be affordable. Twelve of the 20 new projects in the 2005 road map potentially involve extensive elements of international collaboration.

1.21 The evolution of international collaborations is less predictable or controllable than projects hosted by the UK and primarily serving UK scientists. Indeed the balance of costs and benefits of these collaborations for the UK is likely to change significantly during their evolution. It will therefore be increasingly important to regularly review the priorities for international projects rather than setting them once and reviewing only on an exception basis as currently.

1.22 We reviewed the assessment of international options in projects supported so far. Providing access for UK scientists via other countries' facilities, or establishing research prototypes outside the UK, was not considered in some cases because it would relinquish an important UK presence (Halley Antarctic research station), involve the wholesale emigration of an existing UK research institute (Institute for Animal Health, Laboratory of Molecular Biology), or lose the advantages of co-location with other UK facilities which formed the core rationale (Research Complex). In others it was not pursued because it would take too long to broker agreement (HECToR), lose scientific leadership (Muon Ionisation Cooling Experiment, ERLP), fail to yield sufficient reliable access to meet forecast UK demand (RRS James Cook, Diamond Synchrotron), or a combination of these and excessive cost (ISIS second target station).

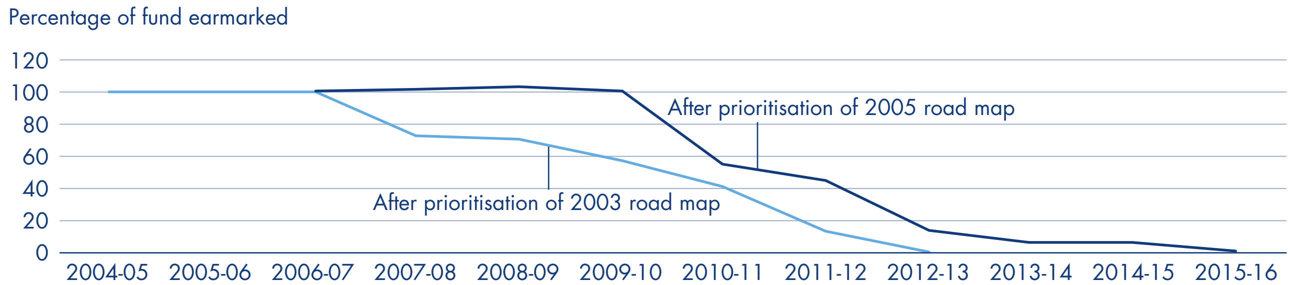
1.23 We do not challenge the over-riding nature of the generally qualitative reasons for rejecting use of other countries' facilities in these cases. Nevertheless as more new facilities go beyond the capacity of individual nations, the choice between providing a facility in the UK scaled to meet demand from UK scientists, and contributing to the construction of an international facility in another country scaled to meet international demand, are likely to become more complex and finely balanced. In such circumstances more detailed analysis of the costs and benefits of these alternatives may be required than has been evident – or necessary – for the projects approved so far.

Managing the demand for funds

1.24 Demand for new funds remains strong despite the extent of allocations already made. The number of new project proposals in the road map has risen from 14 in 2001, to 20 in 2005, five of which were prioritised for funding. Following prioritisation of the 2005 road map, and earmarking of resources based on that prioritisation, the Large Facilities Capital Fund was fully allocated for four years to 2009-10 **(Figure 4)**.

1.25 The lack of short to medium-term headroom results firstly from the level of demand as the fund has developed, and secondly from decisions to earmark 100 per cent of funding several years ahead. The continuing gap between funding availability and investment aspirations increases the importance of requiring consistent project proposals which clearly address prioritisation criteria and facilitate the difficult but necessary choices between very different types of investment.

4 Following prioritisation of the 2005 road map, the Large Facilities Capital Fund was fully earmarked to 2009-10



Source: National Audit Office analysis of Research Council UK data

NOTE

During the prioritisation of the 2005 road map the National Institute of Medical Research, for which the Medical Research Council requested £140 million from the Fund, was identified as a priority. However, the Office of Science and Innovation decided to await development of the Institute's business case before taking a view on earmarking of funds to the project from the Large Facilities Capital Fund. This project is therefore not reflected in the above diagram.

PART TWO

Delivering projects

2.1 Once projects have received earmarking and their science case has been reviewed, the project teams established by the host or sponsoring Research Council take the proposals forward. This Part examines the effectiveness of the arrangements put in place to prepare business cases ahead of project approval and subsequently manage the delivery of projects. It focuses on:

- the application of the Office of Government Commerce's Gateway review process to projects of this type;
- the acquisition and application of project management skills;
- the specification of project outcomes and outputs in business cases;
- the delivery of projects against approved budgets for capital costs and costs in-use and approved completion dates;
- the procurement strategies adopted by teams; and
- the plans made for operating the facilities.

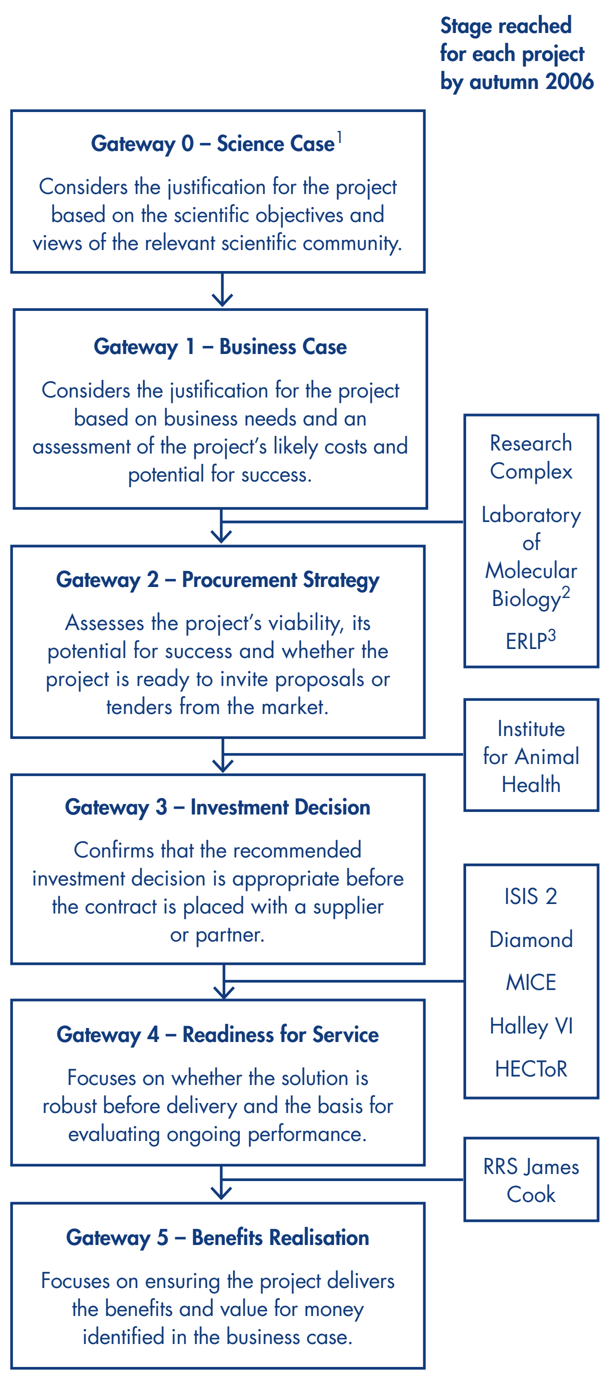
Using the Gateway review process

2.2 All earmarked projects are required by the Office of Science and Innovation to be reviewed in line with Government-wide guidelines for the Gateway review process. **Figure 5** summarises the process. As at autumn 2006, six of the projects we visited had proceeded beyond Gateway 3 (the investment decision), and thus substantial funds had or were being committed. The other five projects had at a minimum proceeded beyond Gateway 1, the point at which business cases are reviewed. Summaries of the ten projects are provided at Appendix 3.

2.3 Projects have generally benefited from Gateway reviews with review teams making actionable recommendations to assist teams in areas such as project management, project costing and funding and procurement options. The RRS James Cook project was encouraged to adopt an output based specification at Gateway 1 – an approach it was already considering – and doing so has helped the project avoid cost increases due to design flaws which are the shipyard's responsibility. The HECToR project addressed critical issues regarding the phasing of funding and the handling of depreciation following recommendations from the Gateway 1 review team. The Diamond team produced updated costings for the second phase of the project shortly after the Gateway 2 review recommended greater attention to this phase.

2.4 Not all projects, however, have been subject to appropriate Gateway reviews at relevant stages. The Laboratory of Molecular Biology project has not been subject to a separate Gateway 1 review. The project team after consulting the Office of Science and Innovation decided to combine the Gateway 1 and 2 reviews in order to expedite project delivery. The Energy Recovery Linac Prototype business case has not been subject to Gateway review in its own right, even though the Prototype was estimated to cost £12.9 million when it was approved. The project team in this case viewed the Prototype as a stage of the bigger 4th Generation Light Source from which it was derived and which was subject to a Gateway 1 review in 2002. In general the composition of review teams was consistent with Office of Government Commerce guidance. However, the Halley VI project has relied on internal reviews led by the project board, until Gateway 3, which was undertaken by a team external to both the board and the project's sponsoring research institute. For projects, such as Halley, which are judged by project teams and or Research Councils as low risk, Office of Government Commerce guidance still recommends that review teams should be independent of the project.

5 Projects are required to go through the Gateway review process



Source: National Audit Office drawing on Office of Government Commerce and Research Councils UK documents

NOTES

1 Gateway 0 – the "science case" – is an Office of Science and Innovation requirement (see paragraph 1.13) rather than the Office of Government Commerce Gateway 0, which is a review of a programme of related projects.

2 Project has not been through a separate Gateway 1 – a combined Gateway 1 and 2 review is planned.

3 ERLP has not been through the Gateway process in its own right – but the project team anticipate outcomes of the prototype feeding into the Gateway 2 for the bigger 4th Generation Light Source project.

Project management

2.5 Project teams have been established in accordance with good practice principles and standards as set out in the PRINCE2 methodology advocated by the Office of Government Commerce for managing projects. This included governance arrangements, the appointment of a senior responsible owner, access to professional advice, establishment and maintenance of project documentation, and control procedures. Many of these features are common across major public sector projects and feature prominently in the NAO's gold standard for project control in defence projects.[9] Where Gateway reviews identified shortcomings in the management of large scientific facilities, they were addressed by project teams.

2.6 Concerns about the level of project management support available to teams have featured in Gateway reviews of 4th Generation Light Source, the HECToR computer, the research ship James Cook, the Institute for Animal Health and the Muon Ionisation Cooling Experiment. Projects have sought to obtain project management skills from a variety of areas within Research Councils or Institutes, as in the case of the Muon Ionisation Cooling Experiment; from direct recruitment of an experienced project manager as in the case of Halley VI; or from procuring external project management expertise. The RRS James Cook project, for example, following an abortive attempt at direct recruitment due to lack of suitably qualified candidates, procured a project manager from a consultancy company at a cost of approximately £1 million for the design and delivery phase. The research ship was delivered, within the original capital budget, by August 2006. This was three months after the timetable specified in the business case when the project was approved but by the contract delivery date. We recognise the value of high quality project management support to this and other projects, but believe that developing and sharing the collective project management skills of the Research Councils more effectively, drawing in external expertise as appropriate, could make this expertise available more readily and more economically.

2.7 There was a good deal of stability of key personnel within the majority of teams taking forward projects - this applied to the Muon Ionisation Cooling Experiment, ISIS, and to a large degree the Halley VI Antarctic research station and the Research Complex. However, projects such as the Institute for Animal Health had experienced substantial change to the composition of its project team, partly because it had identified the need for people with greater experience of managing and delivering large complex projects. Our interviews with project managers suggested they had close contact with colleagues operating similar facilities in the UK and overseas but would welcome more frequent opportunities to discuss project management issues amongst colleagues in similar positions but working in different research fields. There may be a role for the new Science and Technology Facilities Council in facilitating access to, and the sharing of, project management experience.

Defining target outcomes and outputs

2.8 To be able to assess whether a project has achieved its objectives, business cases should include, as recommended by the Office of Government Commerce, success criteria covering the outcomes or outputs of the project. Where possible, criteria should be specific, measurable, achievable, realistic and timebound thus aiding project monitoring and evaluation. In May 2005, the Office of Science and Innovation established a new performance management framework for the science budget as a whole, covering the twin priorities of strengthening the science base and improving its exploitation to the benefit of the economy and public well-being.[10]

2.9 The majority of business cases we examined described success factors which could be used to help judge the worth and success of projects. The value of some of these factors was reduced as they were not specified in a way which would readily facilitate measurement. Where success factors were likely to be directly measurable they tended to focus on two areas. Firstly, measures of the satisfactory completion of the project, and secondly measures of the services or the capability that the new facility would provide, such as the number of people that could be accommodated on the new Halley VI Antarctic research station. Relatively few measures were proposed for either the extent of scientific activity undertaken on a new facility once it was operational or, the most difficult area to capture, the impact of that activity including the degree of exploitation, for example, by industry and public policy-makers.

2.10 There were, however, examples of good and emerging practice from both current and previous projects **(Figure 6)** which could be more widely applied by project teams. Bibliometric measures – numbers of publications and citations – are widely used to measure research outcomes within the scientific community as a whole and can also be captured for science conducted on large facilities. The outcomes of peer review of research proposals can be used to judge quality of demand for large facilities. A consistent approach to capturing, recording and reporting such measures would help in judging the performance of large facilities, choosing proposals for new investments and undertaking any evaluation of the programme of investments supported by the Large Facilities Capital Fund as a whole. Business cases for new facilities could incorporate the expected or target levels of such measures, as well as anticipated levels of demand, utilisation and technical performance.

Delivering on budget - capital costs

2.11 In preparing business cases and seeking project approval, most project teams revisited the capital cost estimates available at earmarking. For example, the Institute for Animal Health, Laboratory of Molecular Biology and Research Complex commissioned designs, or more detailed designs, of the buildings they required. These helped the project teams provide more robust cost estimates. The project teams also used benchmark data on the cost of building new laboratories to compare with the estimates they were proposing. Gateway reviews of the business cases of three further projects recommended action that teams could take to improve the completeness and robustness of costings, and this was acted upon.

6 Current and previous projects yield examples of performance measures

Research Complex. The project team proposed in its business plan a series of measures covering the number of high quality researchers (as judged by peer review) attracted to work at a facility, the demand for the facility compared to capacity and the number and impact of scientific outputs as measured by publication outcomes.

HECToR. In response to comments received through the Gateway review of their business case, the team taking forward HECToR improved the range and specification of success factors. The factors now cover the project's contribution to scientific research, training and UK industry. The latter will be addressed by measures of the proportion of teams using the facility which include an industrial collaborator and a survey of users as a way of assessing the level of technology transfer and thus the impact of the facility.

ISIS. The original ISIS neutron scattering facility has established and developed a range of performance measures since opening in 1985. These cover technical performance, demand for instrument time, machine availability, user satisfaction and publication outcomes. Examples of the levels and trends of some of these measures are illustrated in Appendix 2.

Council for the Central Laboratory of the Research Councils. The Council has developed an outputs metric framework applying the new performance management framework developed by the Office of Science and Innovation (paragraph 2.8) to management of its existing large facilities and those that are currently being built. This covers, for example, assessments of the quality of the research conducted by facility users, the international benchmark standing of its large facilities, facility utilisation rates and trends in peer review judgements on the research quality of applications for use of large facilities.

2.12 By autumn 2006, capital expenditure on the ten projects underway was forecast to exceed their overall budgets at approval of £950 million by around £60 million (six per cent) **(Figure 7)**. The only project to be completed to date – the RRS James Cook – was delivered within budget in August 2006. Phase I of the largest project - the Diamond Synchrotron - is due to begin operations in early 2007. At autumn 2006, the project team was forecasting that Diamond Phase I will cost £263 million. This is four per cent above the original budget, which did not include a contingency provision, set when Diamond was approved in 2001. The other projects will not be ready until the end of 2007, at the earliest, and in some cases will not be operational until 2009 or 2011, and thus they may well encounter further cost pressures.

7 Estimated capital costs of some projects have increased since approval

	Capital budget at approval £ million	Year capital budget approved	Latest forecast as at autumn 2006 £ million[1]	Percentage change	Main reasons for change
Diamond Phase I	253.2	2001	263.2	4	Addition of contingency (+£10m)
Diamond Phase II[2]	100.0	2001	120.0	20	Updating of base beamline estimate (+£8m), additional equipment (+£3.5m), addition of test beamline (+£3.5m) and addition of programme to improve detectors (+£5m)
RRS James Cook	40.0	2002	40.0	0	
ISIS second target station with first suite of instruments	133.1	2003	145.6	9	Increase in the cost of the first suite of instruments for the target station (+£12.5m)
Energy Recovery Linac Prototype	12.9	2003	21.3	65	Addition of contingency (+£1m), extension of period of project (+£2.5m), full costing of prototype (+£2m), extra equipment components funded by North West Development Agency (+£2.9m)
Halley VI[3]	34.0	2003	38.0	12	Building contract tender higher than expected (+£16m) partly offset by subsequent efforts to reduce costs (-£12m)
HECToR	65.0	2004	59.4	–9	Cost reduction mainly due to project procuring hardware at a lower cost than expected
Muon Ionisation Cooling Experiment Phase I	9.7	2004	9.7	0	
Laboratory of Molecule Biology	155.0	2005	164.0	6	Main cost increase has arisen from inflationary pressures as project delivery has slipped since approval
Institute for Animal Health	121.0	2006	121.0	0	
Research Complex (excluding infrastructure)	26.4	2006	26.4	0	
Total	**950.3**		**1,008.6**	**6**	

Source: National Audit Office analysis of Research Council data

NOTES

1 Latest forecasts are those available in autumn 2006. Budgets and estimates are on a consistent cost basis for individual projects. However, there are differences in cost bases between projects. For some projects, such as Diamond Phase I and II, budgets have now been increased to cover the increase in forecast expenditure. For other projects, teams and Research Councils are still considering ways of covering funding gaps arising from increases in forecast expenditure.

2 The first two phases of Diamond have been separated to differentiate between the cost pressures experienced.

3 Figures include the capital cost of constructing Halley VI and the non-capital costs of approximately £9 million of decommissioning Halley V.

2.13 Most projects had included contingency within the capital budget specified when the project was approved. For projects such as the Muon Ionisation Cooling Experiment their contingency had been sufficient to cover cost pressures experienced by autumn 2006. However, the contingency allowed by five projects had not proved sufficient and thus teams were forecasting that their costs would exceed the capital budget set at approval (see Figure 7). There have been four main causes of these pressures:

a **Use of early incomplete estimates has created costs pressures of approximately £20 million.** When the ISIS second target station was approved in 2003 it was envisaged that £27.5 million would be needed to fund seven new instruments. As more detailed plans for the instruments were worked up with user groups, cost estimates were revised to £40 million. Some £10 million of the extra funding to meet the higher costs will come from international sources. For the Energy Recovery Linac Prototype, costings were produced quickly in response to the option of establishing a prototype rather than moving ahead immediately with a full 4th Generation Light Source. As a consequence, the initial estimate of £12.9 million for the original concept proved too low, and £2 million was added to the project's cost despite the team containing costs by, for example, using concrete shielding already on site and re-using equipment from other laboratories. A contingency of £1 million has also been added to the Energy Recovery Linac Prototype budget since the project was approved.

b **Optimistic assumptions of project timing and duration have resulted in cost pressures of around £10 million.** For example, the redevelopment of Laboratory of Molecular Biology has been delayed by around two years, partly because the developer of the wider site where the Laboratory is to be located has not secured planning permission as quickly as expected. The delay has created inflationary pressure contributing much of the £9 million increase in the cost of the project as forecast at autumn 2006.

c **Enhancements made to projects after approval have added £15 million to costs.** For example, on Diamond Phase II, enhancements costing £12 million are planned. These include a test beamline and a programme to improve the detectors which capture data from beam line experiments.

d **Higher than expected tender prices.** In the case of Halley VI the tender price for building the new Antarctic research station was £16 million (or 75 per cent) higher than expected and could not be covered by the project's budget. The project team responded by revisiting the phasing and scale of the project and identified and costed a wider range of options for delivering the science objectives. The team has contained the level of cost growth of the overall project to £4 million by cutting the size of the new facility and by combining construction with demolition of the existing Halley V station. As a result of combining the two phases some science will be suspended whilst Halley VI is built.

Delivering on budget – costs in use

2.14 The eventual cost of operating some new facilities is likely to exceed the initial capital cost of a facility, for example, the costs of operating the Diamond Synchrotron, which is likely to cost around £380 million to build Phases I and II, are predicted to be in the region of £32 million per annum when the first seven beamlines are operational which should be in 2007. When the second set of beamlines become operational in 2011, the project team predicts that the cost of operating the facility, which should still have an operating life of over 20 years, will rise to around £46 million per annum. When operational, the host Research Councils will have to meet the staff, electricity and other direct operating costs of large facilities from their annual budgets. They will also incur annual depreciation charges which are in addition to an annual charge for the cost of capital, which is incurred as soon as funds are tied up in the capital facility.

2.15 More detail could have been included in business cases to aid the assessment of affordability. For example, the original business cases prepared for the Institute for Animal Health and the Halley VI Antarctic research station did not provide estimates of their operating costs. The ISIS business case provided a figure for operating costs but did not set out what cost elements had been included or key assumptions such as the number of operating days. Given the difficulties of predicting future operating costs, teams could have done more to explain the main drivers and uncertainties in their estimates and give a feel for the likely range of costs, by drawing on sensitivity analysis, rather than specifying a single figure.

2.16 By autumn 2006, five of the six most mature projects had revisited their approved business case estimates of annual operating costs and were forecasting significantly increased operating costs **(Figure 8)**. The most significant impact will be on the Council for the Central Laboratory of the Research Councils which is hosting both the Diamond Synchrotron and the second ISIS target station. The anticipated total increase in its operating costs is in the region of £25 million per annum at 2006-07 prices or around 12 per cent of the Council's current annual operating expenditure. If the Council does not secure additional resources, this degree of cost growth could exacerbate existing constraints which, for example, limit the number of days the Council operates the existing ISIS target station to 180 days. This is some 40 days less than the 220 days that could be accommodated within the timetable required for maintenance and other work.

2.17 Three main factors have pushed up the operating costs of these five projects:

- Some cost elements have increased at unexpectedly high rates. Each of the projects will be adversely affected if the rise in fuel and electricity prices that has occurred since their approval is sustained.
- Benchmarks proved difficult to apply to the Diamond Synchrotron project. Original estimates of the running costs for Diamond drew on UK experience of running the existing synchrotron at Daresbury and knowledge of other synchrotron sources. However, the project team has found that inadequate allowance was made for the much larger Diamond infrastructure and its consequent impact on power consumption, staff requirements and premises costs.
- The HECToR team's experience indicates that it can be difficult to predict the price of IT support services at business case.

2.18 The opening of large facilities will increase the opportunities available to scientists to undertake research in these areas. Many of the users of these new facilities will be funded through grants provided by Research Councils. For these facilities to be fully utilised, scientists will need to compete successfully for research funding, by peer review, against other calls on limited Research Council budgets. Our review suggested more work is needed by Research Councils to examine the potential impact of these facilities on the future demand for research funding, their capacity to support any new demand, or the effect of doing so on other areas of research activity. As the new facilities come on stream, the Research Councils should monitor the impact on the demand for research funding and ensure lessons are learned for the appraisal of future proposed facilities.

8 Estimated annual operating costs of some projects have increased significantly[1]

	Expected life years	Estimate in approved business case £ million per annum	Latest estimate at autumn 2006 £ million per annum	Percentage change
Diamond Phase I and II	25	24.4	46.1	89
RRS James Cook	25	2.8	3.5	25
ISIS second target station[2]	15	5.4	9.9	83
HECToR[3]	6	5.4	8.2	52
Muon Ionisation Cooling Experiment	3	1.6	1.8	12

Source: National Audit Office analysis of Research Council data

NOTES

1 All estimates are at 2006-07 prices and exclude depreciation and capital charges. It was not possible to compare costs estimates for the other five projects we visited. By autumn 2006, two projects – the Research Complex and Institute for Animal Health – had not revisited estimates made when the projects were approved early in 2006, although the Institute was in the process of doing so. Neither the Laboratory of Molecular Biology nor Halley VI had prepared a full estimate of annual operating costs at the time the projects were approved. The capital budget for Energy Recovery Linac Prototype is intended to cover the cost of research and development of the Prototype. As at autumn 2006 there was no approved programme for exploiting the Prototype once it has been developed and thus there were no associated operating costs for the project.

2 Figures are for the cost of operating a full suite of 18 instruments on the second target station. The latest estimate reflects planned savings to be achieved by discontinuing the operation of two instruments on the existing station.

3 As at autumn 2006, HECToR had not finalised contracts for service provision so the latest estimate is based on updated predicted prices.

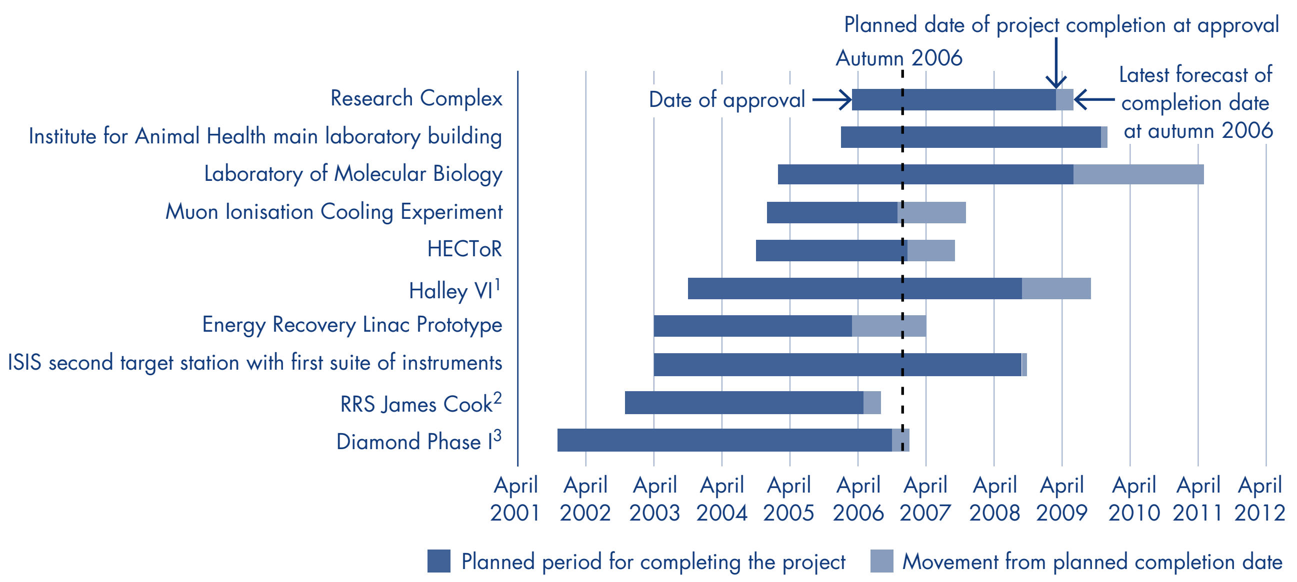
2.19 Opportunities to trade off capital costs against operating costs were rarely extensively explored. An exception is the Laboratory of Molecular Biology. This considered a range of chilling plant options to give the best lifetime cost solution and the Laboratory will include interstitial floors. These provide separate space to assist, and thus minimise the impact and costs, of maintenance and reconfiguration of the new laboratory. The project team also recognised that introducing robotics could reduce the lifetime costs of sample handling and thus the building has been designed to allow for this.

Delivering on time

2.20 Figure 9 shows that progress to date against delivery dates specified when projects were approved has been mixed. Good progress has been made with Diamond and RRS James Cook – the two most mature projects. As mentioned in paragraph 2.6 RRS James Cook was delivered in August 2006 and, despite missing a number of milestones, Diamond is forecast to commence operations in January 2007. Although this is four months after the original date set in 2001, it is the date specified when Diamond Light Source was created and took responsibility for building and operating the synchrotron in 2002. In contrast, three other teams – Laboratory of Molecular Biology, Halley VI and the Energy Recovery Linac Prototype – are now predicting delivery dates which are a year or more later than the approved date. Further risks remain to the completion of these projects and the other undelivered projects, two of which are still at an early stage.

2.21 The time required to undertake the procurement process and let the contracts for the Halley project was longer than had been allowed for in the approved business case. This has pushed back the starting date for operations on the new Halley VI research station by a year, although the project team reported that the forecast delivery date for the overall project which includes decommissioning the existing research station Halley V remained unchanged (Antarctic summer 2009-10). The Energy Recovery Linac Prototype project has also been extended mainly because the team decided more time was needed for design and testing of what is a prototype for a larger potential project. The project has also suffered further slippage due to delays in the delivery of key components. The Muon Ionisation Cooling Experiment encountered problems in getting adequate staff to take forward initial project work.

9 Progress against original planned delivery dates has been mixed – three projects are predicting delivery a year or more later than originally planned



Source: National Audit Office analysis of Research Council UK data

NOTES

1 The dates shown for Halley are for the opening of the new Halley VI research station rather than the completion of the project which also involves decommissioning Halley V.

2 The planned date for RRS James Cook – May 2006 – is that specified when the project's business case was first approved in 2002. When the contract for the ship was awarded in 2004 a delivery date of August 2006 was agreed. This date was achieved.

3 The planned date shown for Diamond Phase I – September 2006 – is that specified when the project's business case was first approved in 2001. By 2002, when Diamond Light Source took responsibility for building and operating the synchrotron, the date for commencing operations was January 2007.

2.22 Project slippage can increase the pressure on cost budgets. For example, Research Council staff may charge their time to a project over a longer period and project teams may need to give new suppliers shorter periods to deliver equipment and services and this may push up prices. Ultimately, slippage will delay the benefits that will flow from new facilities and could thus reduce their value. For most of the projects we visited, however, there is little evidence that the degree of slippage experienced to date will significantly threaten their longer term contribution to science.

2.23 Further delays in projects, however, could be problematic. For the Halley project, any significant slippage means a year's delay (because of weather constraints). This would increase the risk that the project would not be completed before any breaking and separation of the ice-shelf where the current Halley station is located. For the Laboratory of Molecular Biology, further delay beyond 2011 could have a detrimental impact on the recruitment and retention of staff and thus the institute's international scientific position. Whilst if phases I and II of the Muon Ionisation Cooling Experiment are not completed until 2010 it could significantly compromise the experiment's prime objective of informing the international design of a "factory" capable of producing a very intense and focused beams of neutrinos. Consequently, the project team has sought to tackle risks to those parts of the project being undertaken overseas, as well as those being undertaken in the UK. For example, in early 2006 the team provided around £60,000 to help overseas partners to purchase equipment essential for the progress of the experiment. In return, the partners have agreed to take on increased responsibility for other equipment that the project will require at a later date. The team recognises, therefore, that in assisting international partners it must strike a balance between ensuring good project progress and maintaining strong incentives for international partners to deliver their planned contributions.

Procurement strategies

2.24 Eight of the ten projects we examined have designed their procurement strategy and the position for each is characterised in **Figure 10**. Contracts were open to UK and overseas companies with, for example, a Norwegian company winning the contract to build the RRS James Cook.

10 Description of project procurement strategies and outcomes[1]

Feature	Diamond Phase I and II	RRS James Cook	ISIS second target station	Energy Recovery Linac Prototype	Halley VI	HECToR[2]	Muon Ionisation Cooling Experiment	Institute for Animal Health main building programme
Transfer of design risk	Low	High	Low	Low	Medium	High	Low	Medium
Level of competition for main procurement/s	Strong	Strong	Strong	No main contract	Weak	Mixed	No main contract	Mixed
Level of competition for direct component procurements	Mixed	All in main contract	Mixed	Mixed	All in main contract	All in main contracts	Mixed	All in main contract
Pain/gain share	Some	No	No	No	Yes	Subject to negotiation	No	Subject to negotiation
Significant delay in contract milestones in the period from contract award to autumn 2006	Yes	No	Yes	Yes	Yes	-	Yes	No

Source: National Audit Office

NOTES

1 Figure excludes the Laboratory of Molecular Biology and the Research Complex as they had not prepared a procurement strategy which had passed through Gateway 2 (see Figure 5) by autumn 2006.

2 By autumn 2006 preferred bidders had been identified but contracts had not been awarded for the main components of HECToR.

2.25 Where design risk has been retained by the Research Council this has normally been because of a belief that the skills to address technical design issues are more readily available to the Research Council than prospective contractors, and/or a desire to retain and develop in-house technical skills and knowledge for later operation of the facility. In general, more design risk is transferred for the building construction element of each facility than the machine components (where applicable) which are generally procured and installed directly by the Research Council in line with their own design. Where design risk has been transferred it has been in a proportionate rather than wholesale fashion with, for example, the RRS James Cook project using a Statement of Requirements supported by quality and outfitting standards, and a list of accredited suppliers for key components.

2.26 The degree of competition for the main contracts was variable. There was strong competition for the main buildings for both Diamond and ISIS, and for the research ship James Cook. For Halley VI, competition was strong for design but only one compliant company expressed an interest in constructing the new Antarctic research station. For HECToR, competition for the hardware component was strong but competition for computational support and engineering, and the provision of facilities management, was weak. The Halley VI project had conducted some market engagement prior to finalising its procurement strategy. HECToR had engaged in extensive market engagement which had indicated suppliers in each sector (hardware, computational science and engineering, facilities management) favoured being appointed as leads for the overall procurement rather than bidding for components separately though the latter approach was acceptable for most. In the event separate tenders for each component were invited, albeit with the possibility of the facilities management provider taking on the winning hardware bidder's contract.

2.27 Levels of competition for direct procurement of specific components were mixed. In some cases a limited response was because the number of potential suppliers of specialised equipment was limited. In others, companies' perceptions of the technical nature of the facility, rather than the demands of a particular work package, was a more likely explanation. The Diamond Synchrotron project, for example, received only three compliant bids to construct and supply services to four beamline experimental cabins. This was despite the fact that the work was not especially technically demanding and that 96 companies had expressed an interest in some or all of the work when it was first announced by Diamond.

2.28 Provisions for liquidated damages for the impact of delivery delays is a widely used form of incentive for large facilities projects. They are incorporated in many of the Diamond Synchrotron project's contracts for machine component procurements, and on the main building delivery dates. The project also sought to introduce additional damages on the main building contract for missing access dates for machine installation after the specification for the building had been issued and tenders had been received and evaluated. The successful contractor proposed a bonus for meeting access dates or a contract cost increase and the matter was not pursued. Delays in gaining access to the new building by the due dates, to allow installation of machinery, has proved problematic and has meant machine installation progressing alongside building works for longer than intended. Practice on liquidated damages varies on an item by item basis elsewhere, balancing the likely price premium against the impact of delivery slippage. No delivery penalties were included in contracts for the supply of components for the Energy Recovery Linac Prototype, for example, and there have been significant delays in some components. The contract for Halley VI incorporates pain/gain share provisions.

2.29 **Figure 11** summarises some of the lessons to be learned from the early projects.

11 Future projects could benefit from lessons of earlier investments

- Deeper analysis of design risks to separate:
  - those which can and should be transferred to a contractor; and
  - those which could be transferred but are likely to:
    - lead to a disproportionate price premium;
    - deter bidders altogether;
    - cause the contractor to fail; or
    - transfer valuable technical learning which is needed for facility operation.
- Greater consideration of the incentives for delivery dates of key components or milestones and use of pain/gain sharing.
- Identification of work with a limited pool of suppliers and work with less demanding requirements. This will allow packaging of work components to maximise potential market interest across the project's work content. Such packaging should have regard to early market engagement which would indicate whether specialist suppliers will be reluctant to bid unless work within their specialism is packaged with other components.
- More active promotion and market engagement for those work packages where perceptions of the scientific nature of the overall project carry a risk of deterring capable bidders unfamiliar with work on such facilities.

Source: National Audit Office

Planning for operations

2.30 Two projects are currently approaching the operational phase – the Diamond Synchrotron and the research ship James Cook. The Diamond Synchrotron project has established a user office and procedures for users to access the facility. The first call for academic proposals, covering the period January to September 2007, was issued in September 2006, with a deadline for submissions of 1 November 2006. The project has also established the Diamond Industrial Science Committee (DISCo) to advise the project on opportunities for industry to be engaged in research at Diamond, and the best means for promoting such opportunities.

2.31 The Natural Environment Research Council has designed the scientific cruise programme for RRS James Cook, which begins with the first science cruise in March 2007. As at autumn 2006, the existing RRS Charles Darwin crew had been transferred to the new vessel and were engaged in commissioning trials, training and familiarisation. Publication outcomes from Natural Environment Research Council research vessel cruises are not tracked and this will need to be addressed for the cruise programme as a whole, including the RRS James Cook.

2.32 Both projects have sought to generate public interest in the projects through press releases, and the Diamond Synchrotron project has its own communications team for this purpose. At the time of our audit there were no detailed plans yet in place for educational programmes or materials associated with the facilities, despite their potential interest to the public at large.

APPENDIX ONE

Study methods

Review of existing literature

1 The study team reviewed English and French language literature on existing large scientific facilities around the world, using internet search engines, the electronic catalogues of the London School of Economics and the Wellcome Trust, and the online enquiry systems of scientific journal publishers. The literature review covered evaluative studies of decision making processes, and the scientific and wider economic impacts of public investment in research in general and large scientific facilities in particular. The purpose was to both test our findings against comparable evaluative work and learn how UK processes compare with others.

2 The study team reviewed previous NAO reports on groups of large capital projects, including the annual major defence projects report for lessons on methodology and general programme and project management. The team also drew on the NAO's gold standard for project control in defence projects. This is part of the NAO's on-going programme of work to better understand what drives the performance of major defence projects. A summary of the gold standard is at www.naodefencevfm.org/downloads/pdf/gold_standard_poster.pdf.

Review of road map and prioritisation documentation

3 The study team reviewed documentation associated with the assembly of the large facilities road map, the prioritisation of projects within the road map, and the earmarking of funds to prioritised projects. This gave the team an understanding of the current form of the system and how it has developed since introduction, and allowed us to identify and review the content of key elements such as initial project proposals.

Project visits

4 The study team reviewed in detail the evolution, status and plans of all ten projects prioritised for support from the Large Facilities Capital Fund prior to the 2005 road map.[11] The purpose was to ensure that findings were based on a wide view of the nature of projects and the issues experienced, including the evidence supporting their bid for prioritisation. It was considered especially important to cover all ten projects given their very different nature, and the consequent risks of relying on a small sample.

5 The study team visited the site of each project for three days and conducted semi-structured interviews with key personnel. These included but were not limited to the project sponsor, the project manager and relevant finance staff. Interviews covered the progress of the project to-date; project management arrangements; the chosen procurement strategy and where relevant, any changes to the agreed cost, specification or delivery since the project was agreed. Project visits also included review of project documentation, a list of documentation requirements sent well in advance to project managers, and a standard feedback form provided to each project manager three to four weeks after each visit.

Semi-structured interviews and discussions with Research Councils and the Office of Science and Innovation

6 The study team interviewed research directors of six Research Councils representing both providers and users of large scientific facilities (PPARC, MRC, CCLRC, BBSRC, NERC and EPSRC). These interviews were on a semi-structured basis and sought to capture views on the strengths and weaknesses of the current prioritisation and funding system and opportunities for improvement. A similar interview was conducted with the Assistant Director responsible for the Large Facilities Capital Fund at the Office of Science and Innovation. Preliminary conclusions were presented verbally to, and discussed with, finance directors of Research Councils. The purpose of these discussions was to test emerging conclusions and recommendations with those having most knowledge of current systems and procedures.

7 In addition, an early meeting with the secretariat of Research Councils UK was followed up by further discussions to clarify the nature and practical application of road map and prioritisation processes.

Case studies of previous public investments

8 Two previous investments, the research ship Charles Darwin and the first ISIS target station, were reviewed to identify lessons in performance measurement and monitoring which might be applied to new facilities, or inform judgements on proposals for such facilities. The ISIS project in particular demonstrated a wide set of metrics which are illustrated in Appendix 2 of the report.

Interviews with senior scientists in technology-based companies

9 Semi-structured interviews were held with senior scientists in BAE Systems, BT, Rolls Royce and Unilever. The purpose was to seek parallels with public sector decision-making processes on large technical facility investments. In practice the investments being made were of a different scale and nature to the public sector and assessment criteria were aligned with commercial business unit strategies which had limited parallel in the public sector.

Questionnaire to scientific stakeholders

10 The study team identified a group of individuals whose roles as subject group or thematic chairmen, vice presidents, or equivalent within scientific and engineering societies and academies, or as chief scientists within technology-based companies, made them likely to be aware of issues surrounding access to large facilities for scientists within their communities of interest. This group included – but was not entirely made up of – users and potential users of existing facilities from academic science and industry. A self-completion questionnaire was used to capture their views of current and future investment in UK large facilities.

11 From a target group of 130 individuals, 62 completed questionnaires were returned.

Use of an expert panel

12 In order to provide guidance on the design and preliminary conclusions of the study, an expert panel was recruited. It was made up of an overseas member engaged in facility planning at European level, an expert in science policy analysis, and an expert in managing the development and operation of a large nuclear facility. All three had significant experience as users of large facilities within the physical sciences. A further two members were recruited on the basis of their knowledge and experience of life and earth sciences facility user communities.

Professor Sir Chris Llewellyn-Smith
Director, United Kingdom Atomic Energy Authority, Culham

Dr Jørgen Kjems
Director, Risø National Laboratory, Denmark and member of the European Strategic Forum on Research Infrastructure

Professor Ben Martin
Science Policy Research Unit (SPRU) – Science and Technology Policy Research, University of Sussex

Professor Duncan Wingham
Centre for Polar Observation and Modelling, University College London

Professor David Stuart
Professor of Structural Biology, Wellcome Trust Centre for Human Genomics, Oxford

The panel was consulted before beginning the fieldwork and again when developing the initial findings in order to ensure that key issues were fully and properly considered when designing the study and drawing conclusions.

APPENDIX TWO

Performance measurement case study – the ISIS neutron source

As mentioned in paragraph 2.10 and Figure 6, project teams introducing and managing new facilities might usefully draw on the performance measurement practices used at the existing ISIS facility.

The ISIS facility

The ISIS neutron scattering facility opened at the Rutherford Appleton Laboratory, Harwell in Oxfordshire in 1985. Neutrons are produced by the spallation process. A heavy metal target is bombarded with pulses of highly energetic protons from a powerful accelerator, driving neutrons from the nuclei of the target atoms. There are 18 neutron beam channels which feed different instruments. These include, for example, diffractometers which look at structures – that is the spatial distribution of atoms, molecules, or larger scale structures.

Performance measurement at ISIS

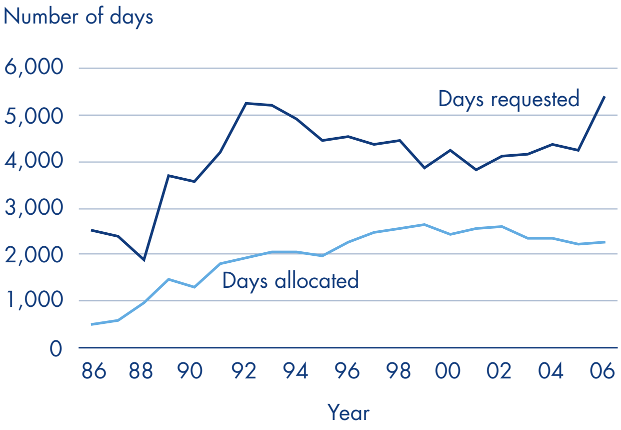
Since the opening of ISIS, measures covering demand, availability, and technical performance have been monitored. Annual surveys of users have also been conducted to monitor satisfaction levels with different aspects of service.

The facility maintains records of all publications associated with scientists' use of the ISIS facility. Identifying these relies on accurate reporting of publication outcomes by facility users. Citation levels of these publications have been analysed on occasion for specific reports but are not routinely monitored.

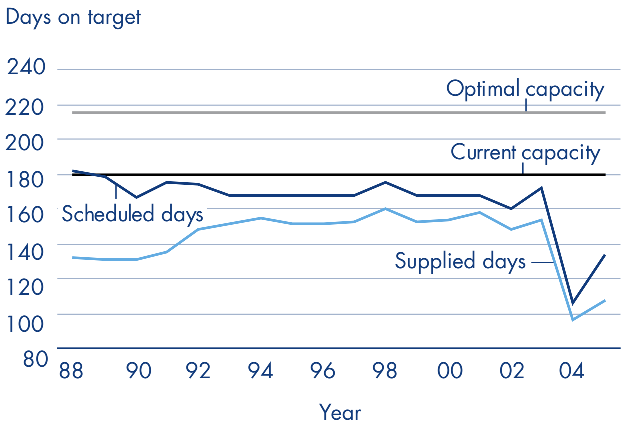
Levels and trends of some of these measures over the lifetime of the facility are illustrated below.

12 Performance measures for the original ISIS facility

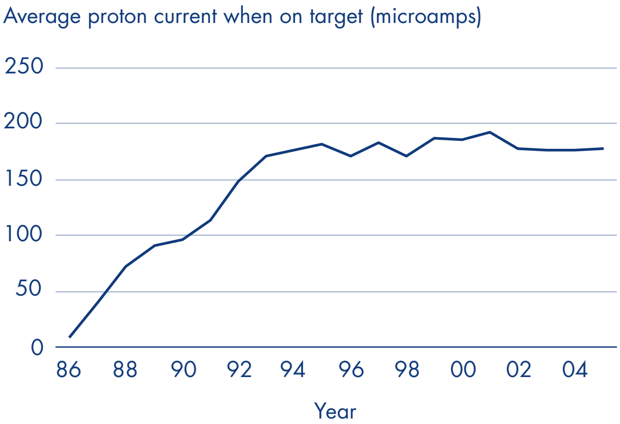
Demand for instrument time



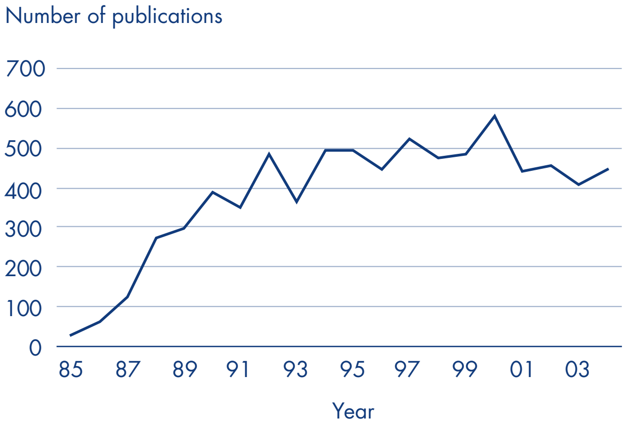
Machine availability



Machine technical performance



Publications arising from use of ISIS



Source: National Audit Office and the Council for the Central Laboratory of the Research Councils

APPENDIX THREE

Project summaries

Diamond Synchrotron – Phases I and II

Lead Research Council

Council for the Central Laboratory of the Research Councils (CCLRC)

Location

Harwell Science and Innovation Campus, Oxfordshire

Facility description

Diamond is a third generation synchrotron radiation source. The facility is based on an accelerator for electrons, a storage ring, and 24 cells with space for up to 40 X-ray beamlines directed at samples. These will enable investigation of materials for the physical, life and environmental sciences. Diamond is being delivered and run by Diamond Light Source Ltd, a joint venture company with Wellcome Trust which is an independent charity which funds research aiming to improve human and animal health. Wellcome Trust holds 14 per cent of the shares in Diamond Light Source and the Council for the Central Laboratory of the Research Councils holds the remaining 86 per cent. Diamond will replace the synchrotron radiation source at CCLRC's Daresbury laboratory in Cheshire.

Phasing

- Phase I – building, accelerator, storage ring and seven beamlines
- Phase II – installation of a further fourteen beamlines and one test beamline
- Phase III – installation of a further ten beamlines

Status at autumn 2006

The project passed Gateway 3 for the main building contract in August 2003. The building housing the administrative office was completed in January 2005. Electrons were first circulated in the Booster in December 2005. Stored beam was achieved in the Storage Ring in May 2006 which allowed the first observation of synchrotron light. The synchrotron building completion was achieved in August 2006 and beamline commissioning began in October 2006. Gateway 4 is scheduled for January 2007.

Capital cost and funding (Phases I and II)

	Phase I	Phase II
Capital cost	£ million	£ million
Budget at project approval in 2001	253.2	100.0
Latest estimate at autumn 2006	263.2	120.0
Variation	+10.0 (3.9 per cent)	+20.0 (20 per cent)
Reasons for variation	Addition of contingency provision	Updating of base beamline estimate (+£8m), additional equipment (+£3.5m), addition of test beamline (+£3.5m) and addition of programme to improve detectors (+£5m)

	Phase I	Phase II
Sources of funding	£ million	£ million
Larges Facilities Capital Fund	–	82.4
Office of Science and Innovation	226.2	–
Wellcome Trust	36.8	16.8
CCLRC	–	7.0
Other Research Councils	–	14.0

Delivery timetable (Phases I and II)

	Phase I	Phase II
At project approval in 2001	September 2006	1 beamline per quarter from quarter 1 2007 to quarter 3 2010 (15 in total)
When Diamond Light Source took responsibility for building the synchrotron	January 2007	as above
Latest estimate at autumn 2006	January 2007	1 beamline per quarter from quarter 2 2007 to quarter 1 2011 (15 in total)
Variation since approval in 2001	+4 months	Start +3 months End +6 months
Reasons for variation	Setting up of joint venture and start of enabling works	Later Phase I start and the addition of a test beamline

Operating costs (Phases I and II)

At project approval in 2001	£24.4 million per annum for Phases I and II
Latest estimate at autumn 2006	£46.1 million per annum for Phases I and II
Variation	+£21.7 million per annum (88.9 per cent)

Reasons for variation – original estimates based on operation of Daresbury synchrotron – a much smaller machine. Also increases in unit energy costs, business rates and commercial insurance.

Diamond Synchrotron – Phases I and II *continued*

Specification

	Electron Energy Giga Electron Volts	Storage Ring Circumference Metres	Number of Cells	Horizontal Emittance (smaller = brighter) Nm rad
Original (1993 Woolfson Report)	3	301	16	30.0
Current	3	562	24	2.7

Reasons for variance – increased forecasts of user demand and technical capability to achieve greater beam brightness. There had been no major changes to specification since the project was approved in 2001.

Procurement strategy

- Design contract for building, in-house design of machine and instruments
- Contracts for building project management, quantity surveying and planning supervision
- Main contract for building construction including mechanical and electrical services – two-stage tender with main contractor for stage one (assembly of package bids) awarded stage two contract (delivery) once work packages over 80 per cent of total value had been determined
- Separate direct procurements for supply of machine and instrument components
- In-house assembly and installation of machine and beamline components

Critical Success Factors

- focus on science
- value for money
- technical management
- recruitment, retention and development of expertise
- reputation

No metrics were associated with these critical success factors in the business case, though projections of life science demand (2200 beamline days per year) and associated beamline requirements (12) were included.

Summary of Project-Specific Strengths

- Strong commitment to project at all levels (paragraph 1.11)
- Drive and focus of dedicated delivery body - Diamond Light Source Ltd (paragraphs 2.5 and 2.20)
- Strong CCLRC, Wellcome Trust and external advisory team (paragraph 2.5)

Summary of Project-Specific Issues

- Estimation of operating costs (paragraph 2.16)
- Delays in building handover (paragraph 2.28)
- Packaging and marketing of directly procured non-specialist work (paragraph 2.27)
- Handling of design and integration (building – machine – beamlines) risk (paragraph 2.24 and Figure 10)
- Contract incentivisation (paragraph 2.28)
- Contingency provision in Phase I capital costs and incomplete capital cost estimates for Phase II (paragraph 2.13 and Figure 7)
- Weakness of critical success factors (paragraph 2.9)

Royal Research Ship James Cook

Lead Research Council

Natural Environment Research Council (NERC)

Location

Worldwide – primarily Atlantic cruise programme

Facility description

The research ship RRS James Cook is the successor to the RRS Charles Darwin, part of NERC's fleet of two such research vessels. It will be used for a programme of scientific cruises to conduct oceanographic and marine studies and is equipped to launch and recover heavy marine equipment such as submersible or towable sensing and monitoring devices. It also has on-board laboratory space and data analysis facilities.

Phasing

The ship has been designed and built under a single contract.

Status at autumn 2006

The ship was delivered to Southampton and handed over to NERC on 31 August 2006. She was undergoing commissioning trials in autumn 2006.

Capital cost and funding

Capital cost	£ million
Budget at project approval in 2002	40
Latest estimate at autumn 2006	40
Variation	none

Sources of funding	£ million
Large Facilities Capital Fund	25
NERC	15

Delivery timetable

At project approval in 2002	May 2006
At contract award in 2004	August 2006
Actual delivery	August 2006
Variation since approval in 2002	+3 months

Reasons for variation – one month extended bidding time following feedback from suppliers. Two month extension to allow two year build time following receipt of tenders.

Operating costs

Operating costs	£ million per annum
At project approval in 2002	2.8
Latest estimate at autumn 2006	3.5
Variation	+0.7 (+25.0 per cent)

Reasons for variation – increased marine diesel price, increased fuel requirement due to larger vessel and dynamic positioning, greater maintenance and spares requirement for larger vessel.

Specification

Same as business case approved in 2002: endurance (50 days), maximum speed (15 knots), dynamic positioning capability, marine complement (22 single berths), scientific complement (32 single berths), payload, stern gantry (30 tonnes – 8 metre lift), aft port and starboard knuckle cranes (40 tonnes.m). Minor changes to laboratory areas (from 285m^2 to 278m^2).

Changed from business case approved in 2002: one extra deck container, improved network capability (Cat 6 to Cat 7), addition of enhanced communications, provision of £300,000 of spares.

Critical Success Factors

Success factors were developed after the business case was submitted for Gateway review. The factors included that the vessel needed to be fit for purpose, delivered on time and within budget.

Procurement strategy

Tender for design and build based on Statement of Requirements (SoR) and Quality and Outfitting Standards (QOS). A range of acceptable suppliers for some components was specified and the contractor had to evidence the viability of any alternative suppliers he wished to use. Beyond this the design of the vessel was a matter for the contractor, subject to submission of drawings to the project team and its advisors, and on-site checking of the conformity of installations with performance requirements.

Summary of Project-Specific Strengths

- Compact but appropriately skilled project team with user representation (paragraph 2.5)
- Extensive consultation to establish stable statement of requirements (paragraph 2.25)
- Effective transfer of design risk (paragraph 2.25)
- Delivery achieved within budget and within a build period consciously extended by three months (paragraph 2.6, Figures 7 and 9)

Summary of Project-Specific Issues

- Cost of project management (paragraph 2.6)
- Estimation of operating costs (Figure 8)

ISIS Neutron Source Second Target Station – Phase 1

Lead Research Council

Council for the Central Laboratory of the Research Councils (CCLRC)

Location

Harwell Science and Innovation Campus, Oxfordshire

Facility description

ISIS is a pulsed neutron source. A heavy metal target is bombarded with pulses of highly energetic protons from a powerful accelerator, driving neutrons from the nuclei of the target atoms. Instruments allow study of the interaction of the resulting neutron beams with samples. The second target station will accommodate up to 18 instruments. Target station and instruments will be optimised for study of soft condensed matter, bio-materials, advanced materials and nanotechnology.

Phasing

- Phase 1 - target station and seven instruments
- Phase 2 - a further eleven instruments

Status at autumn 2006 (Phase 1)

Phase 1 of the project passed Gateway 3 (contract award) in May 2006. The building housing the new target station was also completed later in 2006.

Capital cost and funding (Phase 1)

Capital cost	£ million
Budget at project approval in 2003	133.1
Latest estimate at autumn 2006	145.6
Variation	+12.5 (+9.4 per cent)

Reasons for variation – as more detailed plans for the first suite of seven instruments were worked up with user groups, cost estimates were revised up from £27.5 million to £40 million. Funding for £10 million of the cost growth will come from international sources.

Sources of funding	£ million
Large Facilities Capital Fund	127.9
CCLRC	7.7
EU Framework 6	7.0
Bilateral agreement with Spain	3.0

Delivery timetable (Phase 1)

At project approval in 2003	September 2008
Latest estimate at autumn 2006	October 2008
Variation	+1 month

Operating costs (for both Phase 1 and 2)	£ million per annum
At project approval in 2003	5.4
Latest estimate at autumn 2006	9.9
Variation	+4.5 (+83.3 per cent)

Reasons for variation – estimate available at project approval did not specify in detail what cost elements had been included. However, project affected by higher than expected energy costs. Latest estimate reflects planned savings to be achieved by discontinuing the operation of two instruments on the existing station.

Specification (Phase 1)

Original	2002 Business Case specified seven first phase instruments with five of these transferred from current target station. Initial average current 60 microamp. By project approval in 2003, it had been decided that the seven new instruments should be provided in the first phase.
Current	Seven first phase instruments but with the discontinuation of two instruments on the existing station to reduce overall running costs. Initial average current 30 microamps rising to 60 microamps after four months.

Procurement strategy

- Design contract for building, in-house design of machine and instruments
- Main contract for building construction including mechanical and electrical services
- Separate contracts for supply of steel for building and target monolith
- Separate direct procurements for supply of machine and instrument components
- In-house assembly and installation of machine and beamline components

Critical Success Factors

- Delivery of the capital facility – on time, to budget, capability met, instruments meet scientific aspiration, minimise negative impact on ISIS 1 operations
- Level of funding from overseas
- Use and impact of facility – comparison of scientific output (number of publications and impact) with other facilities, stakeholder involvement
- Major skills retained and developed

ISIS Neutron Source Second Target Station – Phase 1 *continued*

Summary of Project-Specific Strengths

- Experienced and stable project team (paragraph 2.7)
- Critical success factors able to build on performance measures that are used for the original target station (paragraph 2.10 and Figure 6)
- In response to the Gateway 1 review, the project team included a well-controlled contingency within the project's budget (paragraph 2.11)
- Strong competition for the main building contract (paragraph 2.26)

Summary of Project-Specific Issues

- Growth in capital costs as plans for instruments were worked up with users (paragraph 2.13)
- Estimation of operating costs (paragraphs 2.15 and 2.16 and Figure 8)
- Competition for direct procurement of components was mixed (Figure 10). For example, it was difficult to get companies interested in supplying steel for the relatively small amounts (approximate value £10 million) required for the monolith – a structure required to ensure the safe working operation of the neutron target.

Energy Recovery Linac Prototype (ERLP)

Lead Research Council

Council for the Central Laboratory of the Research Councils (CCLRC)

Location

Daresbury Laboratory, Cheshire

Facility description

4GLS stands for Fourth Generation Light Source. It is a proposed facility for a low energy light source to complement table-top lasers, the Diamond synchrotron light source and the proposed European X-ray free electron lasers. The full project proposal will combine superconducting energy recovery linac and free electron laser technologies to deliver a suite of synchronised state of the art sources of synchrotron and free electron laser radiation covering the terahertz (THz) to soft X-ray regimes for dynamic studies of matter.

The project being assembled at Daresbury is an Energy Recovery Linac Prototype (ERLP). It is designed to address some of the principal technical challenges that would be faced in a full 4GLS facility. At the outset it was not intended that ERLP would support a long-term programme of scientific research.

Phasing

The full 4GLS proposal had passed Gateway 1 (review of business case) when the decision to fund a prototype was taken. The ERLP is being built as a single phase project, which may yield a proposal to progress the full 4GLS scheme further.

Status at autumn 2006

The ERLP is at an advanced build stage in the former nuclear structure facility experimental hall at Daresbury. The ERLP photoinjector delivered first beam on 16 August 2006. The cryomodules are progressing through commissioning tests. Most of the sections of the beam transport system have been assembled. Shielding is in place.

Capital cost and funding (ERLP)

Capital cost	£ million
Budget at project approval in 2003	12.9
Latest estimate at autumn 2006	21.3
Variation	+8.4 (65.1 per cent)

Reasons for variation – extension of duration of project from three to five years, full costing of prototype, addition of contingency provision, addition of extra equipment including a terawatt laser, funded by North West Development Agency.

Sources of funding	£ million
Large Facilities Capital Fund	10.1
CCLRC	8.0
North West Development Agency	2.9
EU Framework 6 Programme	0.3

Delivery timetable (ERLP) – demonstration of energy recovery

At project approval in 2003	March 2006
Latest estimate at autumn 2006	April 2007
Variation	+13 months

Reasons for variation – project extended to provide more time for designing and testing of what is a prototype for a larger potential project. Also delays in delivery of key components (especially photo-injector ceramic, booster cavities and LINAC).

Operating costs (ERLP)

At project approval in 2003	None – all capitalised as Research and Development
Latest estimate (October 2004)	£0.5 million – £0.75 million per annum for exploitation if funded
Variation	Depends on level (if any) of exploitation programme

Specification (ERLP)

- high brightness electrons from photo-gun
- beam diagnostics, test beamline and diagnostic area
- superconducting linac delivering at least 30 MeV energy increase
- bunch length control in a compressor system
- 2K cryogenics system
- electron beam dump
- energy recovery transport line
- spontaneous sources of radiation
- free electron laser with opportunities to explore seeding
- opportunities for studying source synchronisation

These core components have been retained throughout the prototype's development though the size of machine has been reduced, existing concrete and iron blocks have been reused as shielding rather than lead shielding, and maximum accessible electron energy has been reduced from 50 to 45 MeV. CCLRC have brought back into service disused experimental areas and unused infrastructure such as two radial cranes.

Procurement strategy (ERLP)

- Design by CCLRC Daresbury staff
- Direct procurement of individual components
- Assembly/installation by CCLRC Daresbury staff

Energy Recovery Linac Prototype (ERLP) *continued*

Critical Success Factors

- Build ERLP to a specification that allows key technical challenges of 4GLS to be addressed
- Demonstrate successful operation of the principal design concepts of 4GLS by addressing the key technical challenges
- Establish expertise in every 4GLS design topic
- Have active international collaborations in place for those challenges that are best addressed in this way
- Report on the results of addressing the challenges and the impact of these studies on the design of 4GLS

Summary of Project-Specific Strengths

- Extensive testing of science case with international and national scientific communities (paragraphs 1.13)
- Level and form of engagement with industry (paragraphs 1.16 and 1.17)
- Flexibility and adaptability in response to cost pressures (paragraph 2.13)
- Maximising re-use of existing equipment and contributions in kind to add value (paragraph 2.13)

Summary of Project-Specific Issues

- Limited time for initial costing of prototype (paragraph 2.13)
- No Gateway reviews of the prototype – reliance on reviews of 4GLS (paragraph 2.4)
- Subsequent capital cost increases (paragraph 2.13)
- Slippage in overall delivery date (paragraphs 2.20–2.21)
- Absence of contractual incentivisation of prompt delivery of components (paragraph 2.28)

Halley VI Antarctic Research Station

Lead Research Council

Natural Environment Research Council (NERC)

Location

Brunt Ice Shelf, Antarctic. Managed from British Antarctic Survey Headquarters, Cambridge

Facility description

The Halley Antarctic research station provides a unique location for monitoring climate, ozone and space weather. The main users of the station come from within the British Antarctic Survey (an institute of NERC). The project involves the construction of a new relocatable station - Halley VI - and the removal of the existing station, Halley V. Occupation of Halley V would become increasingly unsafe after 2010 due to the increased likelihood of the breaking and separation of the ice-shelf.

Status at autumn 2006

The project passed Gateway 3 (contract award) in August 2006 and contract was signed with the prime contractor in September 2006.

Capital cost, decommissioning cost and funding

Cost	Halley VI construction	Halley V decommissioning[1]	Total
	£ million	£ million	£ million
Budget at project approval in 2003	24.5	9.5	34
Latest estimate at autumn 2006	29.5	8.5	38
Variation			+4 (+11.8 per cent)

Note 1 – Decommissioning costs are not treated by the Natural Environment Research Council as capital expenditure.

Reason for variation - Tender price from prime contractor for building Halley VI was £16 million higher than expected. Project team reduced impact of higher tender price by reducing the size of Halley VI and combining the construction of Halley VI with the decommissioning of Halley V which will cut costs but will also curtail the science programme for a minimum of two years.

Sources of funding	£ million
Large Facilities Capital Fund	20.0
NERC (including British Antarctic Survey)	14.7
Shortfall	3.3

Note – Shortfall may be made up from industrial sponsorship or from British Antarctic Survey's own operating budget. NERC is providing a mix of capital and non-capital funding. The latter to cover decommissioning costs.

Delivery timetable

	Halley VI start operations	Halley V decommissioned
At project approval in 2003	Antarctic summer 2008-09	Antarctic summer 2009-10
Latest estimate at autumn 2006	Antarctic summer 2009-10	Antarctic summer 2009-10
Variation	+ 12 months	None

Reason for variation – the time required to undertake the procurement and let contracts was longer than had been allowed for at project approval in 2003.

Operating costs

At project approval in 2003	Not provided in original business case
Latest estimate at autumn 2006	20 per cent reduction in staffing from Halley V levels
Variation	Not identifiable – relative to business case

Specification

Original	2003 Business Case specified that Halley VI was to accommodate a minimum of 16 personnel in the winter and a maximum of 52 personnel in the summer. Structures to be either relocatable and be able to be moved to a new site up to 20 kilometres away every 10 years, or to be located at a site 25 kilometres from the edge of the ice shelf.
Current	Minimum accommodation specification has been maintained and structures will be relocatable. Initial design in 2004 envisaged that Halley VI would comprise 11 modules, as part of reducing costs this has now been reduced to eight modules.

Procurement strategy

- Initially envisaged that three short-listed design companies would work with one of the same number of short-listed construction companies to deliver a tender for design and build.
- Only one compliant contractor expressed interest in the construction element. The procurement strategy was thus revised with each of the three designers working with the same construction company to firm up their proposals.
- Once a preferred design was selected the construction company approached the market to cost the project, and the resulting estimate was not affordable.
- Project was re-scoped and a contract was let for the construction of Halley VI and the demolition of Halley V. Design risk for Halley VI transferred to the contractor. Within the "target cost" construction contract, the main contractor will be paid actual costs plus a percentage fee. The contract includes pain/gain provisions to encourage the contractor to minimise actual costs.

Halley VI Antarctic Research Station *continued*

Critical Success Factors

Twelve critical success factors were identified in April 2004. They covered project timescale, minimum specification (e.g. accommodation), fitness of facilities for research and science and environmental impact. Examples of the success factors include:

- Halley VI facilities fit for Physical Science Division's (of the British Antarctic Survey) long-term monitoring and core science research.
- Halley VI facilities are suitable to accommodate a Physical Science Division's "well found" laboratory.
- Halley VI facilities fit for gateway access to the interior for all the science divisions of the British Antarctic Survey.
- The construction and through life operation of Halley VI complies with the requirements of the Antarctic Environmental Protocol.
- The through life operating costs are significantly reduced, bench marked against Halley V.
- There should be minimal disruption to the science activity on the Brunt Ice Shelf during the project i.e. the long-term monitoring datasets.

In addition, a further thirteen "significant success factors that are not specifically measurable but that would enhance the value of this project" were identified in April 2004. These included:

- A reduction in the requirement for manual and mechanical snow management.
- A reduction in the multiple handling and manual handling of stores.

Summary of Project-Specific Strengths

- Recruitment of external project manger in 2003 has boosted project management skills and aided stability in project team (paragraphs 2.6 and 2.7)
- Project team have contained the level of cost growth by identifying and costing a wider range of options for delivering the science objectives and by combining construction with demolition of the existing Halley V station (paragraph 2.13)
- Pain/gain share provisions in main contract (paragraph 2.28)

Summary of Project-Specific Issues

- Prior to Gateway 3, reviews had lacked independence as they have been conducted by the project board (paragraph 2.4)
- Expressions of interest were received from only one compliant contractor (paragraph 2.25)
- Original tender to build Halley VI much higher than budget (paragraph 2.13)
- Operating costs not specified in original business case (paragraph 2.15)
- Some science will be suspended whilst Halley VI is built (paragraph 2.13)
- Slippage in delivery date of Halley VI (paragraphs 2.20 and 2.21 and Figure 9). Further delay would increase the risk that the project would not be completed before any breaking and separation of the ice-shelf where the current Halley station is located (paragraph 2.23)

HECToR High End Computing Service

Lead Research Council

Engineering and Physical Sciences Research Council (EPSRC)

Location

Dependant on tendered proposals

Facility description

HECToR is the next generation of high performance computer service. It will replace the CSAR service at Manchester University which ended in June 2006, and the HPCx service operating at Daresbury in Cheshire, which is due to close at the end of 2008. It will provide a high capability computing resource for the UK scientific community, with the ability to perform complex and inter-related calculations on a single machine. This meets a different requirement to the high capacity computing offered by Grid-based solutions.

Phasing

HECToR will be implemented in three phases, with each phase lasting two years and representing a doubling of the initial sustained capability.

Status at autumn 2006

At November 2006, the preferred hardware provider, the computational science and engineering support provider, and tenders for the facilities management provider had been selected.

Capital cost and funding

Capital cost	£ million
Budget at project approval in 2004	65.0
Latest estimate at autumn 2006	59.4
Variation	–5.6 (8.6 per cent lower)

Reasons for variation – Cost reduction mainly due to project procuring hardware at a lower cost than expected.

Sources of funding	£ million
Large Facilities Capital Fund	52.0
EPSRC	9.0
NERC	3.3
BBSRC	0.7

Delivery timetable

At project approval in 2004	December 2006
Latest estimate at autumn 2006	September 2007
Variation	+ 9 months
Reasons for variation	Project delayed to accommodate availability of Large Facilities Capital Fund support.

Operating costs

At project approval in 2004	£5.4 million per annum over six years
Latest estimate at autumn 2006	£8.2 million per annum over six years subject to finalisation of contract for service provision. Estimate is based on predicted rather than final prices as at autumn 2006 contracts for service provision had not been finalised.
Variation	+£2.8 million per annum (+51.9 per cent)
Reasons for variation	Increased electricity prices. Increased estimated cost per staff member on computational support and engineering.

Specification

When it was approved in 2004, the project was specified in terms of an initial *peak* capability of 50–100 teraflops, doubling at each upgrade. The specification was changed in 2005 to a requirement that initial sustained capability should be at least 2.5 times that of the HPCx service, rising by a multiple of 2.5 at each upgrade. This has resulted in a nominal initial peak performance within the range initially specified for Phase 1 and significantly above that initially specified for Phase II. The change from peak to sustained capability was driven by an understanding that the latter was a more meaningful requirement for the applications of the user community.

Procurement strategy

- Three contracts – supply of hardware, computational support and engineering (CSE) and facilities management including accommodation
- Responsibilities for the hardware contract will pass to the facilities provider – CSE contract stays with EPSRC

Critical Success Factors

Developed following Gateway 1 and in preparation for Gateway 2

- world-class scientific output as measured by bibliometrics and international reviews
- greater scientific productivity as measured by code performance, slowdown, utilisation and availability
- training support for graduates and post-docs as measured by numbers of such users and annual survey
- increase in UK computational science and engineering skills base as measured by number of staff in CSE contract
- increased collaboration with industry as measured by number of research grants with industrial collaboration
- strengthen UK's position for world-class science as measured by position in TOP500 list of supercomputers

HECToR High End Computing Service *continued*

Summary of Project-Specific Strengths

- Strong governance structures developed during the project's evolution (paragraph 2.5)
- Critical success factors relatively well developed (paragraph 2.10 and Figure 6)
- Extensive market engagement yielding strong interest from hardware suppliers (paragraph 2.26)

Summary of Project-Specific Issues

- Increases in estimates of operating costs (Figure 8 and paragraph 2.17)
- Handling of depreciation charges (paragraphs 2.3 and 2.14)
- Limited engagement with industry to realise exploitation potential (paragraphs 1.16 and 1.17)
- Few tenderers for computational support, engineering and facilities management contracts (paragraph 2.26 and Figure 10)

Muon Ionisation Cooling Experiment (MICE) – Phase 1

Lead Research Council

Particle Physics and Astronomy Research Council (PPARC) holds the funding from the Large Facilities Capital Fund. The experiment is hosted by the Council for the Central Laboratory of the Research Councils (CCLRC)

Location

Harwell Science and Innovation Campus, Oxfordshire

Facility description

The Muon Ionisation Cooling Experiment (MICE) is a step towards the possible creation of a factory capable of producing a very intense and focused beam of neutrinos. Such a factory would aid the understanding of the properties of neutrinos which are one of the fundamental particles[12] which make up the universe. MICE seeks to demonstrate that "muon cooling" – making a tightly focused muon beam – is possible through a process of ionisation. It is thought that such a breakthrough could improve the performance of a future neutrino factory between four and ten times. The project is being taken forward through an international collaboration including input from continental Europe, North America and Japan.

Phasing

- Phase 1 – Build a characterised muon beam on the ISIS neutron scattering facility at Rutherford Appleton Laboratory, Harwell.
- Phase 2 – Implement the full MICE experiment.

Status at autumn 2006

Phase 1 has been approved. The project passed through a combined Gateway 2 and 3 (procurement strategy and contract award) in December 2004. By autumn 2006 funding for Phase 2 had not been confirmed.

Capital cost and funding (Phase 1 only)

Capital cost	UK only	Total for UK and international project
	£ million	£ million
Budget at project approval in 2004	9.7	22.7
Latest estimate at autumn 2006	9.7	22.7
Variation	None	None

Sources of funding	£ million
Large Facilities Capital Fund	7.5
CCLRC	1.3
Particle Physics and Astronomy Research Council	0.9
International partners	13.0

Delivery timetable (Phase 1)

At project approval in 2004	By end of 2006-07
Latest estimate at autumn 2006	November 2007
Variation	+8 months

Reasons for variation – Much of the work on MICE can only be undertaken when the host ISIS facility is shutdown. A major planned shutdown of ISIS has been put back which will delay completion of MICE. Within the MICE project progress has been slower than planned due to problems in getting staff needed for the project. However, the delay resulting from staffing problems has been less than that caused by the delay to the ISIS shutdown.

Operating costs (Phase 1 and 2 – UK only)

Total lifetime UK costs of exploiting MICE are expected to be in the region of £5 million.

At project approval in 2004	£1.6 million per annum for three years
Latest estimate at autumn 2006	£1.8 million per annum for three years
Variation	+£0.2 million per annum for three years (+12 per cent)

Specification (Phase 1)

Original	At project approval in 2004, the UK's planned contributions to the building of a characterised muon beam facility were to include: installation and commissioning of the MICE Muon Beam on ISIS; execution of a programme of essential research and development; construction, installation and commissioning of the tracker system required to meet the first measurement phase of MICE
Current	No major change from above

Procurement strategy

- Experiment will be located in an existing hall at the ISIS facility
- Direct procurement of components, such as magnets and solenoid cryogenic. For the latter there was limited competition
- Use of some refurbished components and materials
- Contributions in kind from international collaborators in terms of equipment and staff time
- Installation and assembly by staff from CCLRC and UK universities

Muon Ionisation Cooling Experiment (MICE) - Phase 1 *continued*

Critical Success Factors

The 2003 Business Case identified "three broad key criteria for success" for the MICE project reflecting the different groups involved:

- For the international collaboration taking forward the MICE experiment, to demonstrate that an ionisation cooling channel can be designed and built, and its performance understood. The key deliverable is publication of the results of the cooling demonstration.
- For the UK MICE (i.e. CCLRC, PPARC and universities) collaboration, to demonstrate that it can lead and host advanced accelerator research and development. The key deliverables are the provision of the muon beam as specified and the UK contribution to MICE, and the participation and the leadership of the analysis of the results.
- For the CCLRC, to demonstrate that it can host and manage an international collaborative project in advanced accelerator research and development. The key deliverables are the performance and reliability of muon beam and technical support to MICE, and the successful delivery of the project within the agreed cost, time and quality envelope.

Summary of Project-Specific Strengths

- Extensive engagement and involvement of international and national scientific communities (paragraphs 1.12 and 1.20)
- Project team active in overseeing and supporting contribution of overseas partners (paragraph 2.24)
- Re-use of existing equipment and materials from the UK and overseas (paragraph 2.13)
- Stability in project team (paragraph 2.7)
- In response to the Gateway 1 review, the project team identified in detail and costed the various tasks necessary to complete the project (paragraph 2.11)

Summary of Project-Specific Issues

- Delay in shutdown of the host ISIS facility has pushed back the completion date of Phase 1 (Figure 9)
- Phase 2 was not funded by autumn 2006 and thus there remained a risk that project may not be completed (Figure 7)
- If Phases 1 and 2 are not completed until 2010 it could significantly compromise the prime objective of MICE of informing the design of a neutrino factory (paragraph 2.23)

Laboratory of Molecular Biology

Lead Research Council

Medical Research Council (MRC)

Location

Cambridge – Addenbrooke's Hospital Campus

Facility description

The Laboratory of Molecular Biology is an institute of the Medical Research Council which opened in 1962 on the Addenbrooke's Hospital site in Cambridge. It is widely acknowledged as one of the world's leading biochemical laboratories with strengths in structural biology, cell biology and neurobiology, and strong groups in immunology, cancer biology and biotechnology. The building was extended in 1968 and a new block was added in 1970. The project is to provide new premises for the institute to tackle overcrowding and replace buildings nearing the end of their planned lifetime.

Phasing

The project is planned as a single phase construction project.

Status at autumn 2006

An outline brief had been converted into a concept design and the project team submitted its procurement strategy for Gateway 2 review in November 2006.

Capital cost and funding

Capital cost	£ million
Budget at project approval in 2005	155
Latest estimate at autumn 2006	164
Variation	+9 (+5.8 per cent)

Reasons for variation – inflationary pressures as project delivery has slipped since approval

Sources of funding	£ million
Large Facilities Capital Fund	67.0
Medical Research Council	88.0

Delivery timetable

At project approval in 2005	June 2009
Latest estimate at autumn 2006	May 2011
Variation	+23 months

Reasons for variation – the developer of the wider site (where the Laboratory is to be located) has not secured planning permission as quickly as expected. Also extended operational commissioning period

Operating costs

At project approval in 2005	Extra running costs of £1.2 million per year relative to current building. It is also expected that the new building would be cheaper to maintain (by an unspecified amount) for the first ten years
Latest estimate at autumn 2006	No later estimate available
Variation	Not applicable

Specification

Original proposal was for 24,000m² building. By the time of business case approval in 2005 the design was for 27,000m² building. By autumn 2006 the design had developed and the building had increased to 30,438m² to allow for more plant space. Dedicated areas for industrial collaboration and School of Clinical Studies occupation have been omitted but with some flexibility to incorporate the former into the "Director's wing" and the latter to be incorporated if university funding is forthcoming.

Procurement strategy

- In-house preparation of outline brief
- External consultants employed to develop concept design
- Different external team used to develop detailed design
- Tendering of contract to build to detailed design
- Consideration being given to the construction contractor taking over responsibility for the design team

Critical Success Factors

No critical success factors were set out in the business case submitted to MRC council.

Summary of Project-Specific Strengths

- Wide agreement on the scientific strength of the institute and the need for a new building (paragraph 1.12)
- Detailed consideration of some lifetime costs e.g. interstitial floors and chilling options (paragraph 2.20)
- Value engineering to contain costs (paragraph 2.13)

Summary of Project-Specific Issues

- Initial cost estimate at prioritisation was £55 million below the budget approved in 2005 (paragraph 1.18)
- Since project approval, forecast capital cost has increased by a further £9 million. This has been driven by inflationary pressures caused by a delay in the project. The developer of the wider site (where the Laboratory will be located) has taken longer than expected to secure planning permission (paragraph 2.13 and Figure 9).
- Loss of specific space for industrial collaborations (paragraph 1.17)
- Gateway 1 missed (paragraph 2.4)
- No critical success factors (paragraph 2.9)

Institute for Animal Health

Lead Research Council

Biotechnology and Biological Sciences Research Council (BBSRC)

Location

Pirbright Laboratory – Pirbright, Surrey

Facility description

Pirbright, is one of three locations where the Institute for Animal Health has laboratories. The Pirbright laboratory has a remit to carry out research, diagnostics and surveillance on epizootic (fast spreading) viral diseases of farm animals, including foot and mouth disease. The new facility will provide modern, combined laboratory buildings for staff from the Institute and the Virology Department of the Veterinary Laboratories Agency currently located at Weybridge, Surrey. The Virology Department is responsible for research into endemic and epizootic viral diseases in farm animals, poultry and horses, and some work into diseases of importance to public health.

Phasing

- Advance works – preparation of the site and some initial works for the main building
- Main building programme – includes a new main laboratory research complex; an avian isolation unit; refurbishment of some existing buildings and some supporting infrastructure works

Status at autumn 2006 (main building programme)

The project went through Gateway 2 (Procurement Strategy) in February 2006 and was rated as 'Green'. The principal contractor for the main building programme was appointed in September 2006 and the contract was signed in November 2006.

Capital cost and funding (for both Phases)

Capital cost	£ million
Budget at project approval in February 2006	121
Latest estimate at autumn 2006	121
Variation	None

Sources of funding	£ million
Large Facilities Capital Fund	31
BBSRC	23
Department for Environment, Food and Rural Affairs	67

Delivery timetable (completion of main laboratory building – part of main building programme)

At project approval in February 2006	November 2009
Latest estimate at autumn 2006	December 2009
Variation	+1 month

Reasons for variation – additional time needed to implement procurement strategy

Operating costs

At project approval in February 2006	Operating costs not specified in original business case prepared in January 2004. Whole life costs for the programme (including capital and operating costs, based on a 60-year life) were calculated at around £5,900 million in January 2006
Latest estimate at autumn 2006	Being reviewed, due to be delivered end November 2006
Variation	Not applicable

Specification

Original	The original business case in January 2004 proposed a new laboratory to accommodate up to 280 staff with a gross internal area of 28,500m^2, including a science area of 14,800m^2. By project approval in February 2006 the Laboratory was designed for 223 staff with the gross internal area reduced to 13,900m^2 and the science area to 6,200m^2.
Current	No change from February 2006.

Procurement strategy

- The construction contract for the building within the advanced works phase is controlled through a traditional contract in which the Institute retains much of the design risk.
- A two-stage design and construction procurement route was selected for the main building programme.
- During Stage 1 the selected contractor will work with the client's design team to review and develop the design and arrive at a contract price. If the contract price is accepted, then the design responsibility is then transferred to the contractor.
- The client's design team will maintain their contract with the Institute for Animal Health rather than being subcontracted to the successful contractor.

Critical Success Factors

- Meet government and statutory requirements. Transfer of current operations at the Institute for Animal Health and the Veterinary Laboratories Agency to the new facility with minimal disruption
- Retention of reference laboratory status
- Provision of service and contingency capacity during redevelopment project
- Enhanced physical security and biosecurity. No actual or potential breaches of disease security or health and safety requirements as a result of the new procedures
- Improved quality assurance of operations
- Deliver the programme on time, within budget and to a sustainable business plan.

Institute for Animal Health *continued*

Summary of Project-Specific Strengths

- New enhanced project team and management structure put in place to prepare and deliver procurement strategy (paragraph 2.7)
- Benchmark data used to inform recosting of project post business case (paragraph 2.11)

Summary of Project-Specific Issues

- Initial project team had insufficient experience of managing large complex projects (paragraph 2.7)
- Fast track approach was adopted to preparing the project's business case. Project was not ready when it went through Gateway 1 in January 2004 and the period to move from business case to procurement strategy for the Pirbright redevelopment was extended. It took two years to prepare the procurement strategy, leading to a delay in the planned completion date of the new laboratory by a year (paragraph 1.18)
- Since being prioritised for support from the Large Facilities Capital Fund in 2004 the project has been rescoped. The new laboratory will now house 25 per cent less staff than originally envisaged when £121 million was first earmarked to the project in 2004. The project's principal sponsors have confirmed the new laboratory will meet their needs (paragraph 1.18)
- Operating costs were not included in original business case at Gateway 1 (paragraph 2.15)

Research Complex and Essential Infrastructure

Lead Research Council

Medical Research Council (MRC) on behalf of other councils. MRC hold the funding from the Large Facilities Capital Fund and will operate and manage the Complex.

Location

Harwell Science and Innovation Campus, Oxfordshire

Facility description and phasing

The Research Complex will comprise laboratory and office space for visiting users of Diamond, ISIS and other facilities at Harwell. The Complex is intended to be multi-disciplinary in order to encourage collaborative working between physical scientists and life scientists.

The essential infrastructure is a programme of works designed to improve the facilities at Harwell to meet the increased demand that Diamond and ISIS 2 will place on existing services.

Status at autumn 2006 (the Research Complex)

The project passed through Gateway 1 in March 2006. Funding from the Large Facilities Capital Fund was formally announced in August 2006.

Capital cost and funding

Capital cost	Research Complex	Essential Infrastructure
	£ million	£ million
Budget at project approval in March 2006	26.4	7.1
Latest estimate at autumn 2006	26.4	8.3
Variation	0	+ 1.2 (+16.9 per cent)

Reasons for variation – cost of upgrading power has increased by £0.4 million and the costs of improvements to the restaurant and to the kitchen are likely to be in the region of £0.8 million higher than budget

Sources of funding	Research Complex	Essential Infrastructure
	£ million	£ million
Large Facilities Capital Fund	26.4	6.0
CCLRC (at March 2006)		1.1

Delivery timetable (Research Complex)

At project approval in March 2006	March 2009
Latest estimate at autumn 2006	June 2009
Variation	+3 months

Reasons for variation – The Programme Board decided that additional time was required to engage users whilst the facility was being designed. As a result, the date for Gateway 2 was moved from June 2006 to November 2006 and the completion date was also put back.

Operating costs (Research Complex)

At project approval in March 2006	£1.64 million per annum
Latest estimate at autumn 2006	Not yet reviewed
Variation	Not applicable

Specification (Research Complex)

Original	The business case approved in 2006 specified that the area required for the research complex is 4,756m^2 net internal area and 5,658m^2 gross. Facilities must be able to cope with diverse research requirements.
Current	No change from above

Procurement strategy (Research Complex)

Subject to Gateway 2 review in January 2007.

Critical Success Factors (Research Complex)

- Creation of an exciting place to work.
- The provision of facilities that will create world-class research and world-class personnel/scientists.
- Integration and interaction (synergy) between scientific disciplines.
- Rutherford Appleton Laboratory (i.e. Harwell) operations continue unaffected by the works.
- Diamond achieves its scientific potential in delivering science by the in-house and user communities.
- The project is completed on time, within budget, to the required quality and done safely.

Summary of Project-Specific Strengths

- Specification of critical success factors and performance measures in the project's business case (paragraph 2.10 and Figure 6)
- In preparing the project's science and business case, the project team identified and costed a range of options for varying the size and equipment within the building. Benchmarking data was used to inform costings (paragraph 2.11)
- Business case identified options for funding operating costs which will fall to a number of Research Councils (paragraph 2.14)
- Stability in project team (paragraph 2.7)

Summary of Project-Specific Issues

- The funding allocation from the Large Facilities Capital Fund has driven the timing of the project with the Complex planned to be completed in 2009 some two years after the Diamond Synchrotron is likely to open (Figure 9)

ENDNOTES

1 *The Green Book: Appraisal and Evaluation in Central Government*, HM Treasury Guidance.

2 The Office of Government Commerce expects a PRINCE2 project to have the following characteristics: a finite and defined life cycle; defined and measurable business products (or objectives); a corresponding set of activities to achieve the business products; a defined amount of resources; an organisation structure, with defined responsibilities, to manage the project. http://www.ogc.gov.uk/methods_prince_2_overview.asp

3 The new Council will not be responsible for all large facilities. For example, the Biotechnology and Biological Sciences Research Council and its partners will remain responsible for the redevelopment and running of the laboratory located at the Institute for Animal Health.

4 *Setting Priorities for Large Research Facility Projects supported by the National Science Foundation*, Committee on Setting Priorities for National Science Foundation-Sponsored, Large Research Facility Projects, National Academies Press, Washington, D.C. 2004.
A Framework for the Evaluation, Funding and Oversight of Canadian Major Science Investment: Draft Discussion Paper Office of the National Science Advisor, Ottawa, 2005.
Final Report of the National Research Infrastructure Task Force, Australian Government Department of Education, Science and Training, Canberra 2004.

5 *European Road Map for Research Infrastructures, Report 2006*, European Strategy Forum on Research Infrastructure (www.cordis.europa.eu/esfri/).

6 *Delivery Plan 2005-2008 CCLRC*, May 2005.

7 *Future Access to Neutron Sources: A Strategy for the UK*, CCLRC, March 2006.

8 *Science and Innovation Investment Framework 2004-2014: Next Steps*, HM Treasury, Department for Education and Skills, Department of Trade and Industry, Department of Health, March 2006.

9 As part of an on-going programme of work to better understand what drives the performance of major defence projects, the NAO have developed a gold standard of project control. A summary of the standard is at www.naodefencevfm.org/downloads/pdf/gold_standard_poster.pdf.

10 The new performance management system was set out in *Science Budget Allocations 2005-06 to 2007-08* Department of Trade and Industry, May 2005 (www.dti.gov.uk/files/file14994.pdf).

11 None of the projects prioritised from the 2005 road map had been approved by autumn 2006.

12 In particle physics, an elementary particle or fundamental particle are those subatomic particles not known to be compositional – i.e. made up of smaller particles. Current particle theories claim that such indivisible particles are the "fundamental particles" from which all larger particles in the universe are made. Both neutrinos and muons are fundamental particles.

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