National Audit Office

Big Science: Public investment in large scientific facilities

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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.

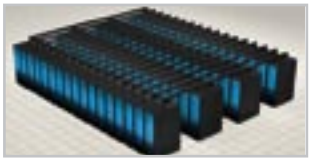
Delivery: Delivery of Halley VI and decommissioning of Halley V by end of 2009-10 Antarctic summer.

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.