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LARGE SCIENTIFIC FACILITIES

Since 2000, the government has allocated over £800m to constructing ten new large scientific facilities, with £270m earmarked for five future projects.[1] These facilities are planned and operated over long timescales, often involving international collaboration, and have a significant economic impact. This POSTnote describes the system used by the UK to plan new large scientific facilities. It gives examples of facilities both current and planned, highlighting relevant policy issues.

Background

Most scientific research is carried out by individual research groups, usually based at universities. Some advances, however, require national or international pooling of resources in a dedicated large facility beyond the resources of an individual university campus. Research councils may choose to help in their construction and operation, as well as funding the subsequent research through regular grants. Such facilities are being used increasingly, providing some of the most important recent breakthroughs (Box 1).

The UK hosts some of these facilities and is involved in many others around the world. Each facility is unique in its design, scale and purpose, making it difficult to define what constitutes a large facility. This note focuses on physical science projects with research council involvement, however it is important to note there are many other types of large facility in existence. For a project to be eligible for the Large Facilities Capital Fund (LFCF) administered by the Department for Innovation, Universities and Skills (DIUS), it must meet one or more of the following requirements:

- have capital costs greater than £25m;
- have capital costs representing more than 10% of a single research council's annual budget;
- serve the research communities of more than one research council.[2]

Box 1. Overview of some large facilities

The UK has participated in a number of large facilities that have provided major contributions to scientific knowledge. Here are some examples:

Large Electron Positron Collider (LEP), French/Swiss border
LEP (1989-2000) was the flagship facility of the European Organization for Nuclear Research (CERN). It accelerated and collided particle beams around a 27km ring, helping to develop the Standard Model of particle physics. 1,500 physicists worked on LEP, publishing 5,500 papers. Work here led to the development of the World Wide Web and the award of two Nobel Prizes. UK funds came from previous research councils that are now part of the Science and Technology Facilities Council (STFC).

Laboratory of Molecular Biology (LMB), Cambridge, UK
The LMB was founded in 1962 to study the chemical structures of large molecules. Work here has led to breakthroughs in understanding DNA, immune systems and Alzheimer's. A total of 13 Nobel Laureates have worked at the LMB, with over 6,000 papers published to date and around 400 current staff. The UK continues to fund the LMB through the Medical Research Council.

Cassini-Huygens Mission to Saturn
The Cassini-Huygens craft has been in orbit around Saturn since 2004, sending the Huygens probe to the surface of its moon Titan. So far over 70 published papers have appeared in the most prestigious scientific journals, detailing discoveries about the origins of Saturn's rings and the atmospheres around its moons. STFC funds UK involvement through the European Space Agency, with five UK research groups providing important instruments and data analysis.

A range of economic benefits often arises from the construction and operation of a large facility, while the scientific impact can be measured using widely recognised metrics. These include the number of research papers arising from use of the facility, how often they are subsequently cited, and the reputation of the journals in which they are published.

The role of the research councils

Government-funded academic research is overseen by the UK's seven research councils. A strategic partnership of the research councils known as RCUK helps them work together on their broad research priorities.

A new research council was formed in April 2007, to provide a more integrated approach to research involving large facilities. Previously the UK's national facilities, especially those at the major Science and Innovation Campuses at Harwell, Oxfordshire and Daresbury, Cheshire, had been the responsibility of the Council for the Central Laboratory of the Research Councils (CCLRC). Subscriptions to international facilities for astronomy and particle physics were administered by the Particle Physics and Astronomy Research Council (PPARC), which also awarded research grants in these areas. All of these responsibilities now belong to the Science and Technology Facilities Council (STFC).

Planning large facilities

In 2000, the government put in place new arrangements to co-ordinate the planning of large facilities. The two main components are a 'roadmap', describing projects which the UK science community would like to see built in the next 10 to 15 years, and a central capital fund. The UK has been a pioneer of the roadmap system, and other European roadmaps have since been developed which are also of interest to UK researchers.

Setting priorities

In the UK :The RCUK Roadmap

RCUK publishes a Large Facilities Roadmap approximately every two years. Each research council proposes projects for the roadmap after a process of selection involving the following steps:

- consideration of the strategic need for the facility in the context of the research council's mission;
- input from the council's scientific and stakeholder communities;
- advice on feasibility from technical experts;
- consideration of the international context and prospects for collaboration.

Recent projects that have benefited from LFCF funding include the Diamond synchrotron at Harwell, the largest facility to be built in the UK for nearly 30 years. Diamond is a series of super-microscopes used for research in life, physical and environmental sciences. The latest edition of the roadmap is due this year[3] and examples of current projects are given in Boxes 2 and 3. Inclusion in the roadmap is a requirement for, but not a guarantee of, LFCF support.

In Europe

The RCUK Roadmap provides the UK with a basis for international discussions on new projects. Space-based and particle physics research at a European level are led respectively by the European Space Agency and the European Organization for Nuclear Research (CERN, see Box 2). The UK subscribes to both organisations, each of which produces its own roadmap.

Box 2. International collaboration

Large Hadron Collider (LHC)

The LHC, LEP's successor at CERN, will be the world's highest energy particle accelerator when it begins operating in 2008. It will test the Standard Model of particle physics, and will be used to search for the Higgs boson – a particle thought to give rise to every other particle's mass. Around LHC are four halls housing the detectors. Each detector (ATLAS, CMS, ALICE and LHCb) is purpose-designed for specific experiments.

CERN receives an annual total subscription of about £500m from 20 different nations, with STFC responsible for the UK's share of around £80m. Over a ten year period the UK has spent approximately £120m on the LHC detectors. Over 20 UK research groups are involved in crucial aspects of the project, including designing and building the detectors, data analysis and management. This involvement spans all four detector experiments.

For other research areas of European interest, a general roadmap is produced by the European Strategy Forum on Research Infrastructures.[4] By comparing with this European roadmap, as well as the strategies of other countries, the UK can reach agreements on the projects prioritised for support.

The Large Facilities Capital Fund

Administered by DIUS, the LFCF contains around £100m per year available for projects in the RCUK Roadmap. Once published, a shortlist of projects recommended for LFCF funding is drawn up by RCUK and agreed with DIUS, selected according to the following criteria:

- scientific impact;
- economic and societal impact;
- technical challenge and cost effectiveness.

While the LFCF is available for projects prioritised in the roadmap, other funding sources often contribute some (or all) of the capital costs. These include other countries, private bodies, and industry. For example, the combined capital cost of the 10 new large facilities allocated funding since 2000 is about £1bn. 67% of this has come from the LFCF, a further 18% directly from the research councils, and 15% from other sources.[5]

Issues

New types of facility

Traditionally, large facilities have been seen as 'bricks and mortar' structures such as central laboratories, research ships, particle accelerators and telescopes. New opportunities for large scale integrated research are, however, being opened up through the use of e-science and distributed centres. The broad range of facilities now entering both the European and RCUK Roadmaps reflects these opportunities, and the increasing need for costly infrastructure in all areas of research. Projects such as the UK Household Longitudinal Survey (see Box 3) will create new areas of research in the social sciences and humanities, just as important to their respective fields as the traditional facilities are to the physical sciences. This raises questions about what truly constitutes a large facility, and how funds should be allocated among them.

Box 3. A new type of large scientific facility

UK Household Longitudinal Survey

A longitudinal survey follows the behaviours and attitudes of a group of people over a long period of time. Rather than being a physical installation at a single site, this will be the largest study of its kind in the world, covering 40,000 households, led by the Institute for Social and Economic Research at the University of Essex.

The Economic and Social Research Council has committed £15.5m to the project, of which £12.5m has come from the LFCF. Other funding bodies and government departments are being approached for co-funding.

The first two waves of data collection for the survey have been funded between April 2007 and March 2012. Factors such as poverty, migration, crime, ageing, labour market dynamics and household and demographic change will be examined. As a result, there are prospects for research at the interface of social and biomedical sciences, as well as an assessment of the impacts of policy interventions on society.

Measuring impacts

As well as bringing scientific benefits, research councils are increasingly looking to measure and maximise their economic benefits to the UK. While it is agreed that construction and operation of large facilities have significant economic impacts, they are difficult to quantify. Opportunities arising from knowledge transfer and spinout companies are inherently unforeseeable.

Case studies have been carried out on a range of research council facilities. One such study measured the impacts of a part of Daresbury's Synchrotron Radiation Source (SRS) across its operational lifetime (see Box 4). An economic impact study of the whole SRS is currently being carried out. This will be used to develop, for the first time, a universal system of impact metrics applicable across the range of STFC's facilities.

Box 4. Measuring economic impacts

Synchrotron Radiation Source (SRS)

A predecessor to Diamond, SRS was used for research in life, physical and environmental sciences and engineering. An RCUK study looked at the protein crystallography capability of SRS. During 1995-2004, £12.6m of funds were provided by the Research Councils, 698 scientific papers were published, and work led directly to a share of the 1997 Nobel Prize for Chemistry. The following other impacts were recorded:

- The facility employed around 250 staff. Each year more than 700 visiting researchers and PhD students received training and used the facility. Skills and expertise have been passed on to other synchrotron facilities, including Diamond.
- Direct economic impacts include a specialised software tool which is generating around £800,000 per year. Private companies made use of the facility, including one which now has external collaborations exceeding £500m in value.
- Greater, indirect, impact comes through use of measured protein structures by the pharmaceutical industry. Although it is almost impossible to evaluate this contribution, even a 0.5% share of revenues in major drugs markets would translate to an economic impact in the tens of millions of pounds.
- A number of open days, schools science visits and other events were hosted in which thousands of people visited the laboratory. These were designed to raise the facility's profile and inspire local young people.[6]

Report by the National Audit Office

In January 2007, the National Audit Office (NAO) published a report examining the current system for planning, prioritising and delivering new large facilities.[5] Included in the NAO report is a survey of 62 senior scientists. These respondents were satisfied with the level of clarity and fairness used to select projects for the RCUK Roadmap.

The report states that a facility's value for money ultimately rests on its scientific outcomes. Although these are uncertain, the current system "should deliver a significant contribution" to the UK's science infrastructure. It recognised the RCUK Roadmap as a positive initiative, encouraging scientists across disciplines to develop new facilities over a sensible planning horizon. Three major recommendations were also made:

- On production of the draft roadmap, there should be a consultation period to ensure greater transparency. This should be open to interested stakeholders such as learned societies and other funding bodies.
- Operating costs for proposed facilities should be better estimated and scrutinised. Estimates of Diamond's costs, for instance, have increased significantly since approval of the initial business case. These include not only direct costs such as electricity and staff, but also increased research grant funding due to the greater demand and capacity brought about by the facility.
- Once LFCF funds have been earmarked, there should be opportunities to revise priorities in case of any significant reassessments of costs and benefits.

Report outcomes

Following on from this report, a handbook has been published together with DIUS and RCUK, intended to help strengthen proposals for LFCF funds in the areas above.[7] This also outlines how the subsequent steps of prioritising facilities and allocating LFCF funds are made, since these were considered to be unclear to some scientists.

The 2008 draft of the RCUK Roadmap has seen some changes to previous editions:

- Current facilities, for which UK funds have already been committed, are included. This increases its scope from simply a list of possible LFCF candidates to a comprehensive overview of UK large facilities. Over 60 projects are listed on the latest draft roadmap.
- The 23 projects overlapping with the European roadmap are specifically highlighted, reflecting the increasing alignment of the two roadmaps.
- As recommended, an open consultation period has been included to allow interested external parties to comment before publication.

Funding issues

Operational costs

The LFCF provides capital funds for new projects but, once built, operational costs must be met by research councils. It is anticipated that operation of STFC's new facilities will cost £75m more (at 2006-2007 prices) than initially expected over the next three years.[5] While the NAO guidelines should improve estimates of these costs at the planning stage, unforeseen factors such as increases in electricity and fuel prices have also proved significant.

Other fluctuations in costs come from subscriptions to international projects, which are affected by changes in exchange rates and GDP. Previously the government has protected the research councils from these fluctuations, but, as of March 2008, this protection has been removed. STFC will be liable for increases up to £6m as a result.[8]

STFC shortfall

In October 2007, the UK's latest science budget was announced.[9] Following its budget allocation, STFC announced it was to reduce or stop some research programmes, including some international collaborations in astronomy and particle physics, leading to widespread concern in the scientific community.

The merging of CCLRC and PPARC into STFC means that one set of funds now covers long-term costs (international subscriptions, construction and operation of new facilities) as well as supporting university research grants. Some scientists have argued that this risks a situation where the research grants, which fuel the demand for large facilities, are used as a reserve to cover fluctuations in long term commitments.

Some projects in the RCUK Roadmap are affected by the STFC announcements. Current projects include the recently built ALICE detector at LHC (see Box 2) which is likely to receive reduced future support. Funding has been withdrawn for research and development of the proposed future International Linear Collider, planned as the next major particle physics project after LHC.

A House of Commons Select Committee for Innovation, Universities, Science and Skills report, published in April 2008, states that the proposed project cuts stem from insufficient funds being allocated to STFC.[8] Concerns are also expressed at the way that these cuts have been reviewed and communicated by STFC. The government has responded by stating that STFC has received funding in line with its budget allocation, and that this represents an overall budget increase.[10]

Scientists believe the STFC announcements will not only result in job losses, but will also have an adverse impact on the UK's reputation, possibly undermining future collaborations. Some scientists see the cuts as a result of former PPARC funds being used to shoulder the costs of new large facilities for other research areas that would have been borne previously by CCLRC.

Site selection

Because of the economic impacts associated with hosting a large facility, choice of location can become an important issue. LFCF proposals are encouraged to consider a range of national and international sites.

One key debate was over the location of Diamond, which was due to replace the Synchrotron Radiation Source at Daresbury, but after lengthy deliberation was built at Harwell.[11] Recent setbacks to other proposed large facilities at Daresbury have led to concerns about the erosion of its science base, which are reflected in the Select Committee report. DIUS, however, states the government is committed to maintaining both Harwell and Daresbury Science and Innovation Campuses as world class research centres.

Overview

- Large scientific facilities are increasingly required to address some of the most important areas of research. They can also lead to a diverse range of economic and social benefits.
- The UK uses a roadmap system to plan future large facilities. The government contributes to the costs of construction via a dedicated large facilities capital fund.
- New opportunities for large scale research are encouraging the development of new types of large facility, such as distributed and virtual centres.
- A key challenge for UK science budgets is to balance the large, long term operational costs of these facilities against funding of regular research grants.

Endnotes

1 *Big Science: Public investment in large scientific facilities*, House of Commons Committee of Public Accounts, 2007.
2 *Large Facilities Roadmap*, Research Councils UK, 2007.
3 www.rcuk.ac.uk/research/resinfra/lfroadmap.htm
4 *European Roadmap for Research Infrastructures Report 2006*, European Strategy Forum on Research Infrastructures, 2006.
5 *Big Science: public investment in large scientific facilities*, National Audit Office, 2007.
6 *Excellence with impact*, Research Councils UK, 2007.
7 *Strengthening the preparation of project proposals*, National Audit Office, 2007.
8 *Science Budget Allocations*, House of Commons Innovation, Universities, Science and Skills Committee, 2008.
9 *2007 Pre-Budget Report and Comprehensive Spending Review*, HM Treasury, 2007
10 *Science Budget Allocations: Government Response to the Committee's Fourth Report of Session 2007-8*. House of Commons Innovation, Universities, Science and Skills Committee, 2007.
11 *A new UK synchrotron*, POSTnote 132, December 1999.

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