IOP Institute of Physics

Scientific infrastructure

Institute of Physics response to a call for evidence from the House of Lords Science and Technology Select Committee

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21 June 2013

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Clerk to the Science and Technology Committee
Committee Office
House of Lords
London SW1A 0PW

IOP Institute of Physics

Dear Sir/Madam,

Scientific infrastructure

The Institute of Physics (IOP) is a leading scientific society. We are a charitable organisation with a worldwide membership of more than 50,000, working together to advance physics education, research and application. We engage with policymakers and the general public to develop awareness and understanding of the value of physics and, through IOP Publishing, we are world leaders in professional scientific communications.

The IOP welcomes the opportunity to provide input to inform the House of Lords Science and Technology Select Committee's inquiry into scientific infrastructure. The attached annex details our response to the call for evidence

If you need any further information on the points raised, please do not hesitate to contact us.

Yours faithfully,

PL Knight

Peter C. Main

Professor Sir Peter Knight FRS
President

Professor Peter Main
Director, Education and Science

IOP Institute of Physics

Scientific infrastructure

Summary

1. UK researchers need access to a wide range of scientific infrastructure, ranging in scale from electron microscopes through high performance computing to international facilities such as the Large Hadron Collider at CERN. The main focus of this response is on the large-scale central facilities located at the Harwell Science and Innovation Campus, as we have serious concerns about the way in which the experimental time available to users of these facilities is disproportionately cut by constraints on operational funding.

2. These are world-class facilities used by thousands of individual researchers from academia and industry in fields that range from materials science to structural biology and address all the grand challenges identified by the UK's research councils. They are national assets representing significant capital investment, and in an ideal world would run at full capacity to maximise the return on that investment.

3. In current financial circumstances, there is no easy answer to these challenges, but they raise a number of general principles which should inform decisions on investment in, and operation of, scientific infrastructure:

- To enable UK researchers to stay at the forefront of their fields, they need access to cutting-edge facilities. But just building them is not enough – they also need adequate funding to be used and to be kept up-to-date throughout their lifetime. When a decision is taken to invest in such facilities, it is important to make provision for their long-term operation, maintenance and development.

- The current funding model has failed to resolve the tension between long-term stewardship of large facilities and the focus on short-term research priorities. When difficult decisions about the allocation of funding have to be made, it is important that user communities are fully consulted and that the decision-making process is open and transparent.

- Recent announcements of capital investment in new facilities are welcome, but in some cases appear to reflect arbitrary, perhaps political, decisions. The most efficient approach to investment for UK science as a whole is to develop and follow a well-defined national strategy, based on discussion and consensus, for continuous replacement and improvement of our scientific infrastructure.

Current availability and status of scientific infrastructure

What scientific infrastructure is currently available in the UK, do UK researchers have sufficient access to cutting edge scientific infrastructure and how does this situation compare to that of other countries?

4. Capital investment in the UK's central facilities – ISIS, the Central Laser Facility, and the Diamond Light Source, on which this response will predominantly focus – over the last 25 years, has provided the UK with a world class scientific infrastructure in large-scale facilities. A large national and international user community spanning many disciplines both in academia and industry have benefited from these facilities. The research carried out at these facilities has not only been of scientific importance, but has also produced impacts on the current grand scientific challenges – environment, energy, health, security, transport, etc.

5. ISIS is a pulsed neutron and muon source. It is the most productive facility of its kind in the world, supporting over 2000 national and international researchers in disciplines as varied as physics, chemistry, materials science, geology, engineering and biology. In 2009, the £145m second target station was completed, hosting seven neutron instruments. The second target station has attracted a further £21m from the UK government to add four more instruments to the suite by 2014.

6. The Diamond Light Source is the UK's national synchrotron science facility. By accelerating electrons to near light speed, Diamond generates light beams in the infrared part of the spectrum. The facility is a centre for excellence including fields as diverse as medicine, structural biology, physics, chemistry, materials science, and engineering. The facility is upgrading its beam-lines on an ongoing basis.

7. The Central Laser Facility (CLF) is a partnership between its staff and the large number of members of UK and European universities, who carry out research in physics, chemistry and biology. Five laser facilities are provided, including Vulcan, a petawatt laser system, used for experiments researching fusion energy, electron and ion acceleration, laboratory astrophysics and plasma physics. The system is currently being upgraded to a 10 petawatt power level.

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

9. Another example of currently available infrastructure is ALICE, a demonstrator accelerator system built at STFC's Daresbury Laboratory. ALICE is an energy-recovery accelerator which is the first of its kind in Europe and only the third in the world. At long wavelengths it is nine orders of magnitude more intense than a synchrotron and offers unique capabilities to UK scientists working in a wide variety of research fields. In April 2013, ALICE was due to close due to a lack of funding which meant that its £2m per annum operating costs had become unsustainable. It was recently saved by a research grant from EPSRC to the University of Liverpool, with collaborators, to conduct clinically led research on cervical, oesophageal and prostate cancer. Modest funding would make ALICE available to 14 other UK

research groups providing a world lead in many research fields; this is a good example of the benefits one can derive from facilities with a relatively marginal increase in funding.

10. Nuclear Magnetic Resonance (NMR) spectroscopy is a powerful analytical technique for probing the structure and dynamics of molecules with atomic resolution. There are a number of rapidly developing applications of the NMR technique to the solid state, encompassing pharmaceuticals, biomolecules and advanced materials, for example, in energy, catalysis, medicine and radioactive waste storage. The UK currently has the 850 MHz Solid-State NMR Facility, based at the University of Warwick, which has proven itself as a highly efficient facility that is run on behalf of the national community. However, for the UK to remain competitive internationally, RCUK must consider funding solid-state NMR infrastructure at 1 GHz and above, coupled with future investment to allow regional access at 700+ MHz.

11. Many areas of physics, such as particle physics, and astronomy, are by their nature multinational. Some world-class UK infrastructure is maintained for specific experiments; however, the majority of infrastructure is provided by shared multinational facilities. STFC provides UK researchers with access to large overseas facilities including CERN. Nuclear physics, another multinational area, no longer has access to a national facility since the Daresbury Nuclear Structure Facility closed in 1993. Recently, however, STFC has negotiated access to the Facility for Antiproton and Ion Research (FAIR) project in Germany, in response to the UK nuclear physics community's long-term strategy for the field.

Is sufficient provision made for operational costs and upgrades to enable best use to be made of the UK's existing scientific infrastructure? Is it used to full capacity; and, if not, what steps could be taken to address this?

12. Despite the excellence of the UK's central facilities, efficient usage has recently been greatly impeded by limits placed on the numbers of days of access allowed. This is a consequence of reduced funding, and decisions taken by the research councils in developing the RCUK Large Facilities Funding Model (LFFM), which we feel is not functioning optimally, leading to the operations of ISIS and CLF being dramatically reduced.

13. The 2010 Spending Review settlement for STFC introduced the 'Drayson partition' with ring-fenced funding for international subscriptions, grants for the STFC-funded scientific communities, and operational funding for the central facilities. According to RCUK, the LFFM was set up at the request of BIS in order to recommend the appropriate level of sustainable operational funding for the central facilities for each Spending Review period. Hence, STFC was asked to work with RCUK to agree the availability and support requirements for the central facilities, which STFC would manage independently of its budget allocation. The funding for the delivery of these requirements would be top-sliced from the Science Budget prior to allocations to each of the research councils and would be allocated separately to STFC by BIS.

14. Following the 2010 Spending Review allocations, a decision was taken by the RCUK's Large Facilities Steering Group (LFSG) that overall funding for all the central facilities should remain at the level of 5.6% of total research council expenditure. Within these boundaries, it was agreed that Diamond would operate at full capacity, ISIS would have its operation reduced to 120 days per annum at both target stations (a significant reduction compared with the historic facility operation of 180 days per

annum), and CLF operation would also be reduced. These decisions were taken despite the STFC Programmatic Review rating both ISIS and Diamond a high priority for operation.

15. The research councils made these decisions apparently unaware to what extent the facilities were supporting their current programmes; the research councils' requirements for access to the facilities for the Spending Review 2010 period had not been established. It was regrettable that they had not consulted the scientific community more widely, or adopted a more transparent approach to the allocation of funds.

16. The baseline costs for the operation of these facilities are high, typically 90% of the overall operating costs. Any savings on the variable costs, the costs that depend directly on the length of operation, are marginal and amount to only a few per cent of the operating costs, but are causing a disproportionate reduction in the scientific output and damage to many research programmes that rely on these facilities. ISIS, for instance, could deliver up to 220 days of beam time per annum to national and international scientists. Yet, over the last two years, in order to generate savings at a comparatively marginal level of £5m, a small fraction of the initial capital outlay and required amortisation, ISIS has run at only 120 days per annum. In the 2013/14 financial year, ISIS may only operate for 60 days, compared to the 180 days annual average prior to the decisions taken following the 2010 Spending Review. Such inefficient use of a national, world-class facility is extremely unfortunate.

17. The recent reduction in facility operational budgets not only directly (and disproportionately) impacts many research programmes of users of UK facilities, but also indirectly affects UK access to international research facilities. At the CLF, for example, there is reduced access available not only for the UK user community but also for the international user community, which impacts on reciprocal arrangements for UK access to international laser facilities. As a result, it also negatively impacts on the UK's involvement in EU collaborations formed in the framework of new international facilities (e.g. the Extreme Light Infrastructure project).

18. Science carried out at the central facilities is spread across several research councils' area of activities. There is a perverse incentive to reduce costs from each council's perspective despite the valuable multi- and cross-disciplinary advantages. In fact, a relatively modest increase in the operating budget would increase the scientific output dramatically. A more coherent and stable funding model for the facilities is needed rather than the current model whereby each individual interest group attempts to minimise its own contribution.

Long-term needs, setting priorities and funding

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

19. The key long-term requirement is for a coherent and well-argued large facility strategy or roadmap. Priorities must be set on the basis of evidence of scientific outputs and taking proper account of the societal impact of large facility research. The logical approach is to develop a funding model that appropriately reflects this strategy, because otherwise inevitable funding pressures may lead to decisions that cause significant long-term harm.

20. The strategy should include elements of resource planning and a timeline and should not be simply a catch-all ‘wish list’, which is what the RCUK’s published strategic framework for capital investment, ‘Investing for Growth’, is to a certain extent.

21. Not all facilities need to be based in the UK; those where it is scientifically optimal and/or more cost effective should be overseas. The strategy for use and to influence the construction of overseas facilities should be fully consistent with the need for, and development of, appropriate UK-based facilities. The numbers of UK users and overall resource scale are relevant factors. Where technologically possible and most cost-effective, such facilities could be delivered in partnership with commercial organisations. Upgrades of existing and planning for future facilities must be considered as part of the national strategy if the UK is to remain at the forefront of scientific and technological advances. Additionally, full consideration should be given to host future international facilities in the UK, not just for scientific reasons, but due to the benefits they will accrue for the economy.

22. Facilities can only be delivered from platforms of strong and vibrant skills and technology, which the UK currently has; maintenance and enhancement of these platforms should be considered coherently with the facilities strategy. Relevant skills reside in the university, national laboratory and industrial sectors, and dedicated programmes may be required to enhance areas of future need.

Since the last Comprehensive Spending Review, a series of additional announcements have been made on investment in scientific infrastructure. What have been the impacts of this approach to funding scientific infrastructure? What impact has removing capital spend from the ring-fenced budget had on investment in scientific infrastructure and should the ring-fenced science budget be redefined to include an element of capital spend?

23. The reduction in capital funding announced by the 2010 Spending Review applied not only to expenditure in relation to the construction of large facilities and upgrades to existing facilities, but also included maintenance costs associated with existing facilities, and the funding available for university-based laboratory equipment.

24. Even though significant amounts of capital funding have been released for scientific infrastructure in recent times, and have been welcomed, they still do not equate to the total amount that was cut from the 2010 Spending Review. Additionally, the impact of this funding has been limited because the funds have been allocated on the basis of political rather than scientific considerations resulting in an unplanned, non-strategic, opportunistic approach that leaves little room for proper planning and prioritisation. This has been a hindrance to allocating capital funds to where they are most needed (e.g. upgrades to existing national facilities, and provision for operational costs for the full exploitation of these facilities) and makes it difficult to plan for the long term for both the research councils and the community. Future capital investment should be made on a transparent, competitive basis and on scientific merit, including provision for the efficient exploitation of the investment. For this reason, capital funding for research needs to be re-established as an annual component of the Science Budget and increased to its historic level of funding.

25. Nonetheless, some good has resulted: the opportunities for efficiency gains in co-working, equipment sharing and regional planning of distributed assets have been

seized, notably by the N8 Research Partnership, with other groups following suit. However, the method of distributing capital funds by the research councils is not optimal. The appearance of funds with very short deadlines has meant that university groups have to continually draft potential capital bids in anticipation of funds becoming available. This is insufficiently strategic. Hence, there is a need for a national timetable and strategy for continuous replacement and improvement of scientific infrastructure that incentivises the new efficiency measures and allows for optimum deployment within world-class research groups.

If the current funding level is maintained or reduced, what would be the long term impacts on scientific infrastructure in the UK?

26. The long-term implications will be that we will not be able to operate our national facilities at an optimal level, which will lead to a reduction the scientific output having repercussions for the UK's science base and the economy.

Governance structures

Does the UK have effective governance structures covering investment in scientific infrastructure, how do they compare to those of other countries, and are there alternatives which would better enable long-term planning and decision-making?

27. There is a perception that the governance of UK facilities has been sub-optimal with shorter-term influences and interests taking precedence. These short-term changes in strategic direction reflect tensions between operating and development pressures and the absence of a coherent strategy. Clearer lines should be drawn between UK facilities governance, including a longer-term strategic view to ensure the sustainable operation of the UK's facilities, and their 'day-to-day' management.

28. The governance of specific initiatives directed towards the provision of new facilities, including associated R&D programmes and design studies, needs to be clarified. STFC is charged with effective delivery of such activities but has no ring-fenced budget allocation. Furthermore, the last major new UK facility feasibility study (i.e. for the New Light Source project) a few years ago revealed that no standard oversight and decision-making procedures are in place, either within RCUK or the government. Such mechanisms need to be established to manage the process of UK decision-making and investment in any future large-scale facility.

29. Indeed, RCUK has shown that its planning horizon is too focused on short-term scientific priorities, which places difficulty on STFC in terms of managing the central facilities. STFC's challenging role is the responsibility for the stewardship and the development of the UK's long-term strategy for the large facilities in dialogue with the other research councils; as part of this, it is equally important that the user communities of each of the central facilities are consulted in order to get a full picture of the likely demands for beam-time access and to maximise the scientific output of each facility.

Are effective structures in place for funding of medium-sized scientific infrastructure and enabling sharing among Higher Education Institutes and Research Institutes?

30. The decision by the research councils to alter the way in which equipment purchases are funded has placed a growing need on the scientific community to use the equipment and laser loans pools run by ESPRC, for example, to drive a number of research projects. These loan pools are turning into vital avenues of research infrastructure sourcing, providing, as they do, access to expensive (>£100k) items of equipment over long loan periods (6-8 months). The numbers of sets of equipment within the pools is limited. The loan pools need long-term, secure funding, and more investment is required to secure more sets of equipment and to ensure those items bought are cutting edge.

Partnerships (i.e. EU collaborations)

To what extent do funding structures in the UK help or hinder involvement in EU and international projects, and should the level of UK involvement be improved?

31. The expertise developed as a result of the infrastructure investment provides the UK with a strong asset in negotiating involvement in EU and other international projects. Lately, however, the UK has acquired a poor reputation among European facilities as a result of sending mixed messages with regards to funding commitments, mainly due to a lack of sufficient resource. There are cases where the UK has missed opportunities by entering a collaboration at too late a stage to influence effectively a facility's design to our advantage. The European Spallation Source (ESS) and Euro-XFEL are two examples. The FAIR project is another, where the UK has joined only at associate partner level, a special category that had to be created to cover the low contribution made by the UK that did not meet the membership level achieved by all other major EU countries.

32. Participation in international facilities should be encouraged, as partnerships at a European or in some cases global level are vital for delivering large infrastructures that are beyond the financial capability of most single countries. Successful examples are CERN and the European Space Agency. However, in many cases European-scale facilities are based on national infrastructures and capabilities, so are not necessarily a direct substitute for national support of domestic infrastructures that drive R&D, innovation and technology.

33. Integrated over many programmes and years, large sums of EU funds have been provided to support science via, for example, FP6 and FP7. However, the sums involved, even for 'large' projects, are typically small (€1–10m) on the scales needed to support European infrastructures at a world-class level.

34. Other large infrastructures, for example, ESS and Euro-XFEL, are still being funded primarily at the host-nation level, albeit with additional contribution secured essentially via *ad hoc* agreements with other countries. Large-scale projects such as ESS and Euro-XFEL have the potential to give UK researchers access to world-class instruments. On the other hand, access to UK world-class facilities, such as Diamond and ISIS, can be offered to European researchers in return for co-investment contributions. Where relevant, commercial organisations should be better engaged in partnerships to deliver both UK and European-scale facilities.

What impact does publicly funded scientific infrastructure have in terms of supporting innovation and stimulating the UK's economy?

35. Many areas of our world-leading science and engineering research rely on the central facilities. These include research that supports development programmes in major companies such as Rolls-Royce and Airbus, as well as research to underpin safety cases for the UK's operating nuclear plant.

36. For example, synchrotron facilities, such as the former Synchrotron Radiation Source (SRS) and the current Diamond Light Source, have had a positive and significant impact on many areas. The structure of the foot-and-mouth-disease virus was determined first at the SRS, leading to potential new vaccines that could save the UK £80m if another outbreak were to occur. Synchrotron light is considered essential in modern pharmaceutical research, illustrated by the investment in Diamond by the Wellcome Trust.

37. Throughout its lifetime, 300 local businesses benefited from the SRS, with £300m being awarded in contracts – the financial impact on the local economy throughout its lifetime is estimated to be almost £1bn. At the time the SRS closed in 2008, many of the UK's leading companies had used the facility. Similarly, more than 1000 companies have benefited from construction or technology contracts for Diamond.

How accessible is publicly funded scientific infrastructure in the UK to industry and small and medium sized enterprises? Is there room for improvement?

38. Some companies also access the central facilities via the funding of academic research, by partnering research groups in projects. Additionally, the central facilities make great efforts in working together with industry. For example, the ISIS 'Collaborative R&D with Industry' scheme introduced two years ago has proven very attractive. It enables industry to explore the power of the technique before committing to a full programme of exploitation. There is scope for expanding the scheme but this is severely limited due to the reduced operation of the facility.

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