Independent review of

National Large Facilities at Harwell

Credit: Diamond Light Source

Version	Date issued	Comment	Author
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Preface

I was asked to undertake this review of the National Facilities at Harwell, not as a scientist, but as an industrial engineer, albeit one with an affinity for the science. My task was to bring a commercial perspective to the way in which these facilities are funded and operated.

I have learned a lot from the review, having chosen to conduct all interviews with senior staff and the international benchmarks on a personal basis. This process, over the last few months, has given me a very interesting perspective and has generated a number of observations that I want to share along with the detailed findings in the report.

Although not formally within the scope of the review, it has been hard for me not to draw conclusions on the overall effectiveness and international competitiveness of the Harwell facilities. In this respect, I found that the facilities bear robust and positive comparison internationally and are held in high regard amongst their benchmark facilities. I saw no signs that the UK is at significant variance with the quality or effectiveness of its scientific output.

At the outset, I saw the fundamental business model of the Harwell facilities (free at point of use to the best science) as my key area for commercial challenge. From my own perspective, anything "free vend" is likely to lead to it becoming undervalued with time or, at worst, to long-term complacency amongst users. I was therefore relentless in my interrogation of this throughout my review even including the "stress testing" of alternative models as a key feature of the independent panel review agenda.

Having anticipated that I would find the flaw in this model, I report that I found no objective evidence to support this, and that the model, which is the accepted international norm, is a robust one and supports the energetic pursuit of the best science.

Another area I wanted to challenge within the business model was industrial proprietary use as, the industrialist in me, would naturally seek to maximise the commercial exploitation. It became apparent that, as shown in the body of the report, there are indeed opportunities to do more but that it will not be transformational to the business model. With proprietary use at relatively low levels it could be judged that there is not the appetite or market for significant industrial use. However, I was encouraged to see healthy levels of industrial engagement through collaborative project work with academic institutions. This form of industrial research output is, by nature, in the public domain, although perhaps hidden from the funder's eyes. My view is that this "grey" industrial use is a cause for positive comment as it is likely to lead to economic benefit - a fact which I feel needs greater visibility amongst sponsors. It is interesting to note that this type of collaborative industrial engagement is also common amongst the benchmarks.

Having robustly challenged the key principles of the business model, I believe that if a science-rich nation like the United Kingdom wants world class facilities of this nature, then there is an implied expectation that they need to be suitably funded. The international benchmarks seem to recognise this and benefit from clear and long term government funding. If this is the accepted norm, it is incumbent on the UK's funding body to make the best possible use of the investments at the Harwell facilities.

Although the international benchmarks generally benefit from secure and long term funding there was clear evidence of normal governmental pressures being bought to bear on them to justify the investment. All faced the constant pressure to show impact, both scientific and societal.

A big difference amongst the benchmarks however, was the level of trust shown by their sponsors. Whilst all sponsors demanded the necessary key performance indicators and effective controls, there is a much greater level of individual accountability given to the comparative facilities. Five year budgets, with reviews that coincide with budget cycles, are the norm. Here in the UK, the process is one of micro management of the financing of the centres on an annual basis and this is starkly incompatible with the long-term funding needs of the facilities. The same is true for the level of governance applied to the Harwell facilities which is multi-layered and unnecessarily complicated.

This review calls for greater trust in the leadership of the Harwell facilities and to give greater accountability for expenditure over a 5-year timeframe. The expectation, quid pro quo, would be for the funder to get a stable and predictable 5-year spending profile without surprises. This would be transformational as it would allow much better long-term planning to extract the best from the investment and give government sponsors confidence and predictability.

Turning over many stones during a detailed review does lead to the identification of areas to improve, and the report includes these. None of them is individually transformational to the business model, nor indeed is it clear that they will materially contribute to the budget reduction task that the Harwell facilities has been set, but nearly all will lead to more effective operation and focus resources on extracting the maximum value. Most are easy to implement as they are within the control of the audience for this report.

There are many that I want to thank for their support in conducting this review, in particular the directors and senior staff of the facilities who afforded me such generous time and were open and cooperative. I would also to thank Dr Brian Bowsher, Professor Sir Michael Sterling, Mr Marshall Davies and the senior STFC staff as well as Ms Anna Curson and Mr Tim Livett from the Wellcome Trust.

Particular thanks must go to our international colleagues who supported me with the benchmarking input and to my very committed independent review panel comprising: Professor Andrew Randewich, Professor Ian Chapman, Dr JT Janssen, Dr Ben Brown, Dr Jean Susini, Professor Mark Johnson, Dr Thierry Stässle, Professor Richard Pattrick, Professor Paul McKenna, Dr Andrew Barrow and Dr Chris van de Walle for their robust and rigorous challenge.

Finally, I would like to thank my own team of Tamarin Adshead, Ian Collier and Kulwant Singh who provided expert independent input and Amber Vater, the very accomplished project manager seconded from NERC, without whose help this report would not have been possible.

I conclude these personal views with a belief that the National Facilities at Harwell are something for the UK to be proud of for all the right reasons.

Dick Elsy CEng, FIMechE, FIET
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April 2017

Executive summary

This review has undertaken an in-depth investigation of the fundamental and operational models employed at the STFC owned science facilities at Harwell: the Diamond Light Source, ISIS Neutron and Muon Source and the Central Laser Facility.

Evidence was gathered from two national large facility comparators and a wide group of users, both academic and industrial. Most importantly, the review also drew evidence and input from a range of international benchmark facilities from the USA, Australia, France, Japan and Switzerland. A panel review body was formed, by bringing together representatives from this cohort, to discuss opportunities for improving the current fundamental and operational models employed at the Harwell facilities.

The current 'free at the point of access' model was challenged and the following main conclusions reached:

1. Free at the point of access is the accepted and long-standing international model.
2. Charging for academic access: this would lead to a decline in the best science accessing the facilities as only those who can afford to pay for it would be able to gain access. This would also drive academic use overseas leading to underutilisation of the existing domestic facilities.
3. Increasing proprietary access: whilst this may look attractive from a commercial perspective, at the current internationally accepted rates, the facility costs are only partially recovered. It is clear that as this is an international market, there is no benefit for increasing proprietary access as an income generating tool. In contrast, access which industry enjoys through academic collaboration provides a route to impact in the wider economy and should be made more visible.

The principal findings of the panel are that to maintain the excellent science at Harwell, the current business model should be upheld and that funding levels from BEIS should be at least maintained. It is clear that world-leading science can only be achieved through sustained support and that continual squeezing of the facilities budgets will eventually drive the facilities beyond an optimal point of operation and thus compromise scientific output.

The review provides the following high-level recommendations:

- A need for a clearer commitment to funding visibility over at least a 5-year period with clear accountability from the facilities to deliver within these levels.
- The extensive and ad hoc nature of the reviews conducted of the facilities should be consolidated into a major review event every 5 years to link directly with the funding.
- Restrictions enforcing separate capital and operational budgets reduce flexibility and therefore limit efficiency in spend; this is further compounded by the inability to carry over underspend between financial years. It is therefore recommended that greater funding flexibility could increase spending efficiency and encourage more effective investments.
- Increasing operational productivity and efficiency could be achieved through a number of options including:
    - A more effective, close to source, procurement mechanism would provide efficiency improvements, shorter procurement times and reduced staff time spent on procurement - freeing up valuable scientific staff to focus on support and development of experiments.

- Opportunities to develop more streamlined operations, for example, changes to the staffing for set-up and breakdown of experiments to improve experimental up-time and scientific output.

These operational efficiencies, whilst useful for delivering more effective output are, in themselves, not enough to support the indicative budget saving task that has been proposed by BEIS. More radical reductions in up-time (i.e. closure of beamlines) would be required to meet this task, which would have a disproportional and undesirable impact on scientific output and international reputation.

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1. Introduction

The Department for Business, Energy and Industrial Strategy (BEIS) aims to address long-term challenges to the UK economy by increasing productivity and stimulating growth through research and innovation. BEIS is committed to supporting world class research which includes an investment of around £3bn via the Research Councils. This covers the full spectrum of academic disciplines from the medical and biological sciences to astronomy, physics, chemistry and engineering, social sciences, economics, environmental sciences and the arts and humanities. BEIS also fund large strategic facilities to provide national access to world-class science facilities that would otherwise be out of reach. This includes the funding of international subscriptions to enable UK scientists to access numerous international facilities that the UK alone could not build and support, such as CERN in Switzerland.

On behalf of BEIS, the Science and Technology Facilities Council (STFC); one of the seven UK Research Councils, manages a number of national facilities as well as the UK's interest in international subscriptions in the area of astronomy, particle physics and nuclear physics. STFC is responsible for key establishments at Daresbury Laboratory, Chilbolton Observatory, the UK Astronomy Technology Centre as well as the facilities at Rutherford Appleton Laboratory which includes the three Harwell facilities that form the subject of this review. The STFC supports these facilities through their annual budget allocation awarded to them by BEIS which currently stands at £609m for 2016-17 and £597m for 2017-18. Of this total STFC budget, an amount is ring-fenced for the Harwell facilities with the current allocated sum being £153.1m in 2016-17 and £147m for 2017-18. Figure 1 shows the funding flow from BEIS to the Harwell facilities.

The three facilities are described briefly below and, from here on, are referred to as the "Harwell facilities":

1. **Diamond Light Source (Diamond)** is the UK's synchrotron. It works like a giant microscope, harnessing the power of electrons to produce bright light that scientists can use to study anything from fossils to jet engines to viruses and vaccines. The machine speeds up electrons to near light speeds so that they give off a light 10 billion times brighter than the sun. These bright beams are then directed off into laboratories known as 'beamlines'. Here, scientists use the light to study a vast range of subject matter, from new medicines and treatments for disease to innovative engineering and cutting-edge technology. Over 9,000 researchers from both academia and industry use Diamond to conduct experiments.

2. **ISIS Neutron and Muon Source (ISIS)** is a centre for research in the physical and life sciences. The suite of neutron and muon instruments give unique insights into the properties of materials on the atomic scale. ISIS supports a national and international community of more than 3,000 scientists for research into subjects ranging from clean energy and the environment, pharmaceuticals and health care, through to nanotechnology and materials engineering, catalysis and polymers, and on to fundamental studies of materials.

3. **The Central Laser Facility (CLF)** offers a wide-range of laser applications including experiments in physics, chemistry and biology, novel means of accelerating subatomic particles to high energies, probing chemical reactions and studying biochemical and biophysical processes. The laser facilities range from advanced, compact tuneable lasers which can pinpoint individual particles to high power laser installations that recreate the conditions inside stars. The primary purpose of the CLF is to serve leading national and international research communities that are operating at the forefront of their respective fields and need access to the most advanced and sophisticated facilities available.

These facilities provide a wide range of techniques and experimental scope and can therefore be utilised by users from across all of the Research Councils' remit. Each produce high quality peer reviewed papers in their respective fields and offer world-leading capabilities.

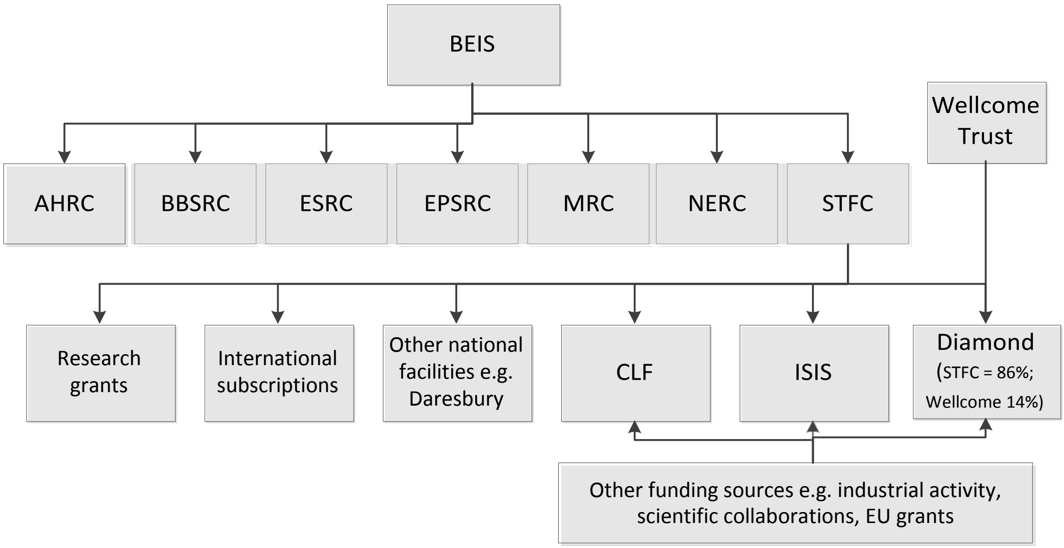


Figure 1 – Funding routes for STFC and the Harwell facilities

1.1 Drivers for change

In 2016, the Department of Business, Innovation and Skills (BIS; now BEIS) published the funding allocations for the Research Councils for 2016-21. This included firm allocations for resource and capital for the first two years for the Harwell facilities, and provisional allocations for the subsequent three years which translated into reductions in annual budgets (Table 1).

Table 1 – 2015-16 to 2020-21 funding allocations for the Harwell facilities

£m	*15-16*	16-17	17-18	18-19	19-20	20-21	5 Year Total
Resource	*107.4*	109.5	113.0	116.0	117.9	120.0	**576.4**
Resource saving task		-1.8	-4.8	-6.8	-7.8	-8.3	**-29.5**
Capital[1]	*48.5*	45.4[2]	38.8	45.2	46.1	47.0	**222.5**
Total	*155.9*	153.1	147.0	154.4	156.2	158.7	**769.4**

Source: LFIG 12-16: CSR outcomes and allocations for 2016-17

The original resource and capital allocations, prior to the resource saving, correlate to the funding required for the Harwell facilities to maintain the 2015-16 capability and capacity, with 2% inflation and with additional resource for the operation of the remainder of the Diamond Phase III beamlines as they come into operation in 2018.

In the period since 2010 each of the facilities undertook a variety of in-house schemes to look for efficiencies in the light of a nominally flat budget. As a result, numerous schemes have been

[1] Does not include funding allocation and profile for Harwell facilities building agreed by BEIS.
[2] Original figures do not include a further £5.2m funding allocation subsequently received by CLF.

implemented to employ cost-savings within the facilities and recommendations were made for more cross-campus coordination.

1.2 Aims and scope

BEIS commissioned this independent review to seek insight into the operational, organisational and funding models of the Harwell facilities, with a view to identifying options for increasing the sustainability and financial resilience of the facilities through:

- increasing external income;
- increasing efficiency and productivity;
- other methods as identified.

It was anticipated that this review may generate ideas for future savings for 2018-19 and onwards. To achieve this, the following scope was agreed:

I. **The fundamental business model**
   a. Funding model (including capital projects)
   b. Current access model
   c. Proprietary access model

II. **Effectiveness of high cost operational elements**
   a. Availability and utilisation
   b. Staffing, recruitment and retention
   c. Procurement

A key aim of the review was to benchmark the facilities against their international counterparts in addition to comparing them to other UK facilities of similar scale in the public sector. To this end, the review selected the following benchmark facilities:

- **For Diamond:**
  - Australian synchrotron
  - European Synchrotron Radiation Facility (ESRF) - France
  - NSLSII Synchrotron Facility - USA
  - Soleil - France
  - Swiss Lightsource at The Paul Scherrer Institute (PSI)
- **For ISIS:**
  - Institut Laue-Langevin (ILL) - France
  - Japan Proton Accelerator Research Complex (J-PARC)
  - Swiss Neutron Source (SINQ) and Swiss Muon Source (SmuS) at The Paul Scherrer Institute (PSI)
- **For CLF:**
  - Laboratoire d'Utilisation des Lasers Intenses (LULI) - France
  - Orion Laser Facility at the Atomic Weapons Establishment (AWE) - UK

And National comparators included:

- UK Atomic Energy Authority (UKAEA)
- National Physical Laboratory (NPL)

The full project Terms of Reference are can be found in Annex 5.1 along with the review method in Annex 5.2.

It was acknowledged by the review team that numerous reviews had been carried out previously and these should be considered to avoid duplication of effort. A list of reporting and recent reviews is provided in Annex 5.3.

2. The fundamental business model

This section explores and analyses the fundamental business models from each of the Harwell facilities. From the information gathered and the comparisons made against international benchmark facilities and other UK national comparators conclusions have been drawn on the appropriateness of the current model.

2.1 Governance

Although a detailed analysis of the governance structures of the Harwell facilities falls outside the remit of this review it would be remiss not to briefly touch on governance as it has a direct impact on the efficiency of the facilities.

While generally STFC oversee the Harwell facilities and is responsible for providing the publicly funded portions of their budgets, there are some nuances between the three facilities and how they are governed.

Diamond was established in March 2002 as a joint venture company between STFC and the Wellcome Trust with shares of 86%[3] and 14% respectively. As a result of this limited company status Diamond are a step removed from the STFC and this allows them more flexibility than ISIS and CLF, which are wholly owned by STFC, in terms of public sector limitations such as the makeup of their Boards and procurement. The appropriateness of Diamond's governance structure has been reviewed in detail in the 2015 report 'Diamond Review Steering Group' commissioned by STFC, at the request of BEIS, when it was recommended that Diamond's existing governance model as a joint venture limited company should be maintained.

Notwithstanding the differences in the ownership of the Harwell facilities, which mean that Diamond also reports to The Wellcome Trust, all three of the facilities report to the STFC on a wide range of key performance indictors (KPI's) and metrics.

In addition to the reporting to the STFC, the facilities also report to the Large Facilities Implementation Group (LFIG) based on a different set of KPI's and metrics. The LFIG oversees the operational running and performance of the Harwell facilities and is chaired by BEIS and with representation from each of the Research Council's including STFC.

LFIG in turn reports to the Large Facilities Advisory Board (LFAB), which is also chaired by BEIS, and is composed of the Chief Executives of each of the Research Councils. LFAB has ultimate responsibility for determining the appropriate national capability of the Harwell facilities, and for approving their budgets.

Although the LFIG and LFAB advise BEIS on the capability and capacity they require from the Harwell facilities, and the appropriate levels of funding, the ultimate decision on the size of the ring-fenced budget rests with BEIS.

In addition to this reporting, each facility also reports to their own Board who oversee the delivery, performance and impact of their facilities. STFC and the facilities also report to individual audit, finance and risk committees.

[3] STFC funds 86% plus all Diamond's VAT costs.

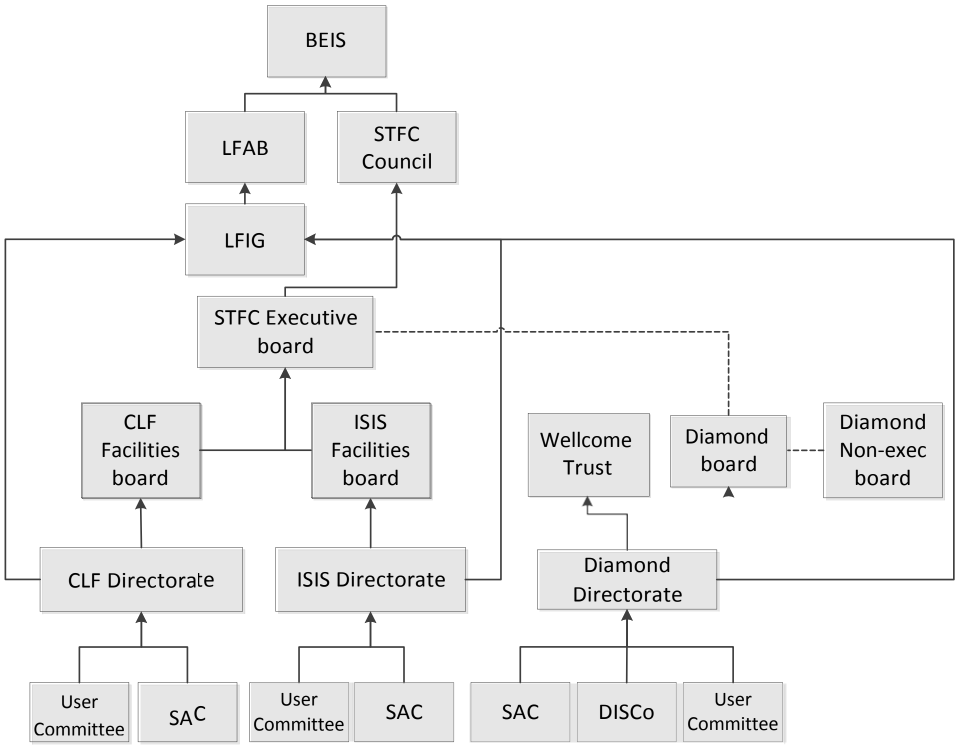
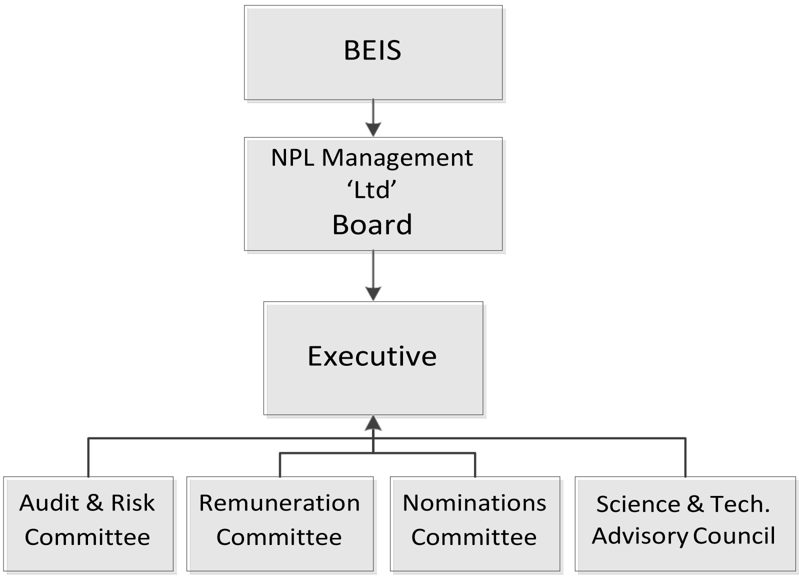


Figure 2 – Harwell facilities governance and reporting structure (dashed lines indicate non-official reporting and advisory roles)

While good governance and performance monitoring of these national assets is vital to ensure value to the public purse, the burden of reporting is vast and complicated. The multiple reporting channels, as described in Figure 2, are made more cumbersome by the variance in information required by each of these channels. In addition to internal reporting there are different sets of KPI's and metrics going to each group as well as a steady number of additional reports and reviews, such as impact evaluation exercises, bibliometric studies and benchmarking tasks, and almost all on an overlapping and sporadic basis. Some examples of this include:

- Reporting to LFIG constitutes quarterly reports on financial performance based on 14 outputs including number of weeks available to users, operational reliability, overall user satisfaction and efficiency, total visits to the facility, etc as well as general updates plus a comprehensive annual report.
- Reporting to internal boards, such as CLF's for example, includes a wide range of material to monitor the facility performance such as delivery plans and outcome, finance reports, facility scientific and technical highlights, economic impact, facility developments, safety, communications and facility risks.
- Economic Impact Reporting Framework reporting to BEIS includes a range of key metrics completed at the end of each financial year. The metrics report on 16 different outputs and financial inputs such the operating budgets, collaborative funding and external funding. In comparison the U.S. Department of Energy Office of Science evaluate the performance impact of each facility on a triennial basis.
- Annual Reports prepared for STFC's Performance & Evaluation Team (PET) with performance measured against delivery plans.

- Other types of specific reporting are: Annual Stewardship Return, multiple audits of HSE Codes, internal management audits, Project Board reporting for major projects, STFC Project Board reporting and STFC Risk Assessment.

Case Study – National Physical Laboratory (NPL)
NPL is the UK's National Measurement Institute, and is a world-leading centre of excellence in developing and applying the most accurate measurement standards, science and technology available. The NPL is a BEIS funded facility with public corporation status, limited by shares that are wholly owned by BEIS, but operating with its own board and governance. An advantage of this structure is that the facility is less bound by public sector constraints. This particular model allows upward advice from the community ensuring independent strategic advice, challenge and support to the facility. An Executive Team are then responsible for setting, prioritising, communicating and delivering the company's strategic objectives. They are also responsible for the review and reporting of company business, establishing and managing key stakeholders and managing and developing staff. 

As shown in the NPL case study, there are existing examples of BEIS funded facilities that have less complicated governance and reporting structures. International comparators are also subject to a simpler and clearer reporting system.

In order to improve efficiency, the performance of facilities should be assessed against an objective set of properly benchmarked metrics and criteria through an appropriate governance system. With the forthcoming merger of the seven Research Councils together with Innovate UK and Research England into a new body, UK Research and Innovation (UKRI), taking place in the next year this is an ideal opportunity to consider what this governance structure should be.

Recommendation 1: It is recommended that the governance structure of the facilities and the reporting lines and requirements be considered when the UKRI structure is established. Every opportunity should be taken at that point to simplify the governance of the facilities and consolidate and align the number of KPI's and metrics reported on. This should be a structure that will give the day to day confidence that the facilities are being well managed in the best interests of the UK.

As described above, the current level of oversight and reporting, coupled with the variance in information required and misaligned frequency, is extremely time consuming and places excessive demands on the facilities. This problem is compounded by the number of reviews the facilities are subject to on an ongoing basis. Responding to these reviews diverts the efforts of experienced scientific staff away from front line experiment delivery. There was a suggestion from users that the frequency of reviews, in particular, has a direct impact on them not only in that technical staff are tied up in the process and therefore unavailable but also because users are often asked to take part in these reviews themselves.

The ongoing frequency of reviews is also not commensurate with the time required to make significant changes at the facilities due to the very size of them. This coupled with that fact that the facilities are constantly undertaking internal reviews to improve efficiency means that anything more frequent than a review every 3 to5 years has more of a negative impact in terms of time spent and morale than it has real value.

Interestingly, international benchmarks, ILL and ESRF, noted that the vast majority of reviews they are subject to come from the UK share in their facilities and that other countries such as France and Germany take a far more hands-off approach. The approach by the Swiss government towards PSI follows the same vein in that they undertake a review of all federal funded facilities every 4 years and in the intervening period they allow PSI to get on with business. When this question was discussed at the panel meeting the view of the international benchmarks was very much that it was a question of trust and confidence in the leadership structure in place at the facilities. There was a suggestion that where a structure exists that gives the day to day confidence that the facilities are being properly run then the need for more frequent reviews is negated.

Recommendation 2: A process of consolidation should be undertaken in respect of the number of independent reviews of the Harwell facilities so that a comprehensive review is undertaken every 5 years, linked to major funding stages, and that ad-hoc reviews be limited.

2.2 Funding

The Harwell facilities receive their funding and income from a number of sources including a limited amount of proprietorial (paid-for) access to the facilities, partnerships agreement and other non-research grants. The majority of funding however is public money and this comes from BEIS through STFC as previously described.

Ahead of a Comprehensive Spending Review (CSR) the STFC conducts a detailed financial modelling exercise to determine the funding required for each facility and the implications on operation of a range of financial scenarios. Typically, these range from 'flat cash – 25%' to 'flat cash + 25%'. Each financial scenario is presented alongside the clear scientific implications. Factors taken into account in scenario planning include facility upgrades, the Science Requirements Document and forecast changes to operating costs among others. The Facility Directors, together with STFC's Finance & Strategy and Planning & Communications Directorates, are involved in the exercise.

These scenarios are considered by LFIG and LFAB who make recommendations to BEIS which inform BEIS's decision on the overall facility funding. As part of the preparation of the STFC Delivery Plan for the relevant spending review period, STFC proposes operating levels for the facilities, based on the agreed allocations.

STFC prepares draft budgets for each facility, taking into account the scenario input to BEIS, and any commitments agreed with BEIS in the Delivery Plan. These draft budgets are presented to LFIG for agreement prior to formal approval by the STFC Council. BEIS then award STFC an annual facilities budget for Diamond, ISIS and CLF, split into resource and capital.

Diamond's annual funding for 2015-16 was £56.8m, which included their contribution from the Wellcome Trust, and is detailed in Table 2 below.

Table 2 – Diamond resource budget 2015-16

Funding source	**Total (£'000)**
STFC	46,805
Wellcome Trust	6,960
Partnership agreements	489
Commercial use	1,228
EU funding	706
Other (including non-EU grants)	705
Total	**56,893**

Source: DLS Annual report (to LFIG) and statutory report (2016)

ISIS also receives funding and income from other sources besides STFC and its total funding for 2015-16 was £40.6m as detailed in Table 3 below. This included a number of international agreements with Sweden and Italy, with an element from the Official Development Assistance (ODA) budget which is provided through the Newton Fund (confirmed until 2018-19). The Newton Fund provides access to ISIS facilities to India and China and to a much lesser extent South Africa. Japan also pays for the operations of its Riken facility based at ISIS although this will cease in 2018.

Table 3 – ISIS resource budget 2015-16

Funding source	**Total (£'000)**
STFC	36,921
OGD/NDPB	336
Partnership agreements	162
Commercial use	195
EU funding	447
Other international	1,045
Other (including Newton)	1,506
Total	**40,612**

Source: ISIS Annual report (to LFIG) and ISIS questionnaire response

CLF's funding and income is much lower than Diamond and ISIS at £12.8m as it operates on a significantly smaller scale. Details are in Table 4.

Table 4 –CLF resource budget 2015-16

Funding source	Total (£'000)
STFC	9,179
OGD/NDPB	375
Partnership agreements	200
Commercial use	220
EU funding	85
Other	2,818
Total	**12,877**

Source: CLF Annual report (to LFIG) and CLF questionnaire response

Once an annual budget is allocated to each facility they are restricted to that budget resulting in them:

- having limited visibility and certainty of future years funding;
- having limited access to alternative capital investment funds through the public funding route;
- being unable to carry over income and funding from one financial year to the next;
- having no ability to move funding between resource and capital.

Each of these budget constraints has a direct impact on the operations and efficiency of the facilities and this was explored in detail during the review process.

Limited visibility and certainty of future years funding

Under the current model the funding horizon is short term with limited visibility given over the CSR period (2016-17 to 2019-20) but actual commitment only made on an annual basis. This restricts the ability of the facilities to develop long term strategic plans by only being able to realistically plan their budgets and operations on a yearly basis.

Although a single allocation of public funding from government that covers more than 80% of the operating costs of the facilities is highly beneficial in terms of having a secure funding stream, committing this on an annual basis is highly restrictive. This is particularly true if an infrastructure roadmap or other long term planning mechanisms do not exist. However, this need not be the case if a long-term funding stream is stable and can be committed for an extended period with a degree of autonomy conferred on the facility to manage it.

Case Study – Institut Laue-Langevin (ILL)
ILL is funded and managed by France, Germany and the UK, in partnership with 10 other countries with an annual budget of approximately €90m. The Associated Members (France, Germany and the UK) each fund 25% of the facility which covers the operational costs, with the remaining 10 countries covering the other 25% which funds the actual science. Although funding is received on an annual basis there is a 10-year commitment from the Associated Members so funding visibility and certainty is secured.

While the inclination is to not commit any funding beyond a CSR period, these facilities are unique in their offer and there is no alternative in the UK. If the UK wants to retain this key capability and ensure that the best science is produced in the UK, there needs to be a long-term commitment, like at ILL, in order to support robust operational planning. Losing this capability would have an immeasurable impact on UK science directly as well as losing the spill-over benefits that accrue from having pioneering, high technology capabilities within its shores.

Access to alternative capital investment funds

The current mechanism for access to operational capital by the facilities is through the same process as described for operational budgets. Each facility receives an annual capital budget to which they are constrained. Unlike in the early 2000's when there was a 'Large Facilities Capital Fund' against which bids were made, there is now no fixed process whereby the facilities can bid for additional capital and, more specifically, development and upgrade capital. As a result, all funding for large capital projects need to be requested through fiscal events and ad-hoc opportunities.

As a result of this approach, additional capital can materialise towards the end of the financial year due to underspends within STFC or BEIS. While this can be useful and help the capital position it cannot usually be used for strategic work due to compressed timescales and the "one off" nature of it. The facilities themselves are then constrained to spend the capital within that financial year.

Case Study – European Synchrotron Radiation Facility (ESRF)
The ESRF annual budget of approximately €90m is financed through contributions from its Members and its Scientific Associates. New investments under the Operation Programme are also mainly covered by contributions from its Members and Scientific Associates and on average; they represent about 15 to 20% of the annual expenditure. A new large scale project (e.g. Upgrade Programme) is prepared by management in the form of a strategy document and reviewed by the ESRF advisory bodies (Science Advisory Committee (SAC), Machine Advisory Committee (MAC), Administrative and Finance Committee (AFC)) that make recommendations to the ESRF Council for decision. All the member states are represented on the ESRF Council, with voting rights weighted on the basis of each Member's contributions, normalized as a percentage. As part of their mission, they liaise with their respective ministry to confirm that the proposed ESRF strategy is in line with their respective science policy and they contribute according to their membership share. Recently an agreement was undertaken to use an EU bank loan for a major capital upgrade. The loan was taken at 0% interest which allowed the Members contributions to be spread across a more manageable timeframe at no additional cost to the facility or its Members.

There are clear benefits to the ESRF model above that would benefit the Harwell facilities. Without clarity of funding allocations, effective planning for the longer term is a significant challenge given the often short-term funding horizon. This type of model would provide BEIS with better clarity of the future funding needs of the Harwell facilities to aid rational decision making in regards to strategic investments. It would also minimise the number of in-year ad-hoc capital requests to BEIS.

Recommendation 3: It is recommended that both resource and capital budgets be agreed, committed and allocated to each of the Harwell facilities to be managed on an annual basis but with a firm commitment and clarity over a rolling 5 year period.

Carry over between years

As a result of Diamond's structure and relationship with the Wellcome Trust they enjoy a greater degree of flexibility which includes the ability to transfer a limited amount of unspent capital (14%) from one year to the next. ISIS and CLF do not have this opportunity. This lack of flexibility to move funds between financial years and the resulting 'use-it-or-lose-it' approach poses difficulties when making longer term commitments, when using funds in the most cost effective way and when managing cross-year projects. This can lead to inefficient working and ineffective use of capital funds which hamper strategic decision making. At present, it takes a considerable amount of staff effort at the end of the financial year to manage procurements and budgets to ensure the full annual income is fully spent.

The ESRF have a similar but preferable situation whereby they are able to carry over committed (contracted) capital funds and are also able to do so with uncommitted capital funds under some circumstances where justification is given. They confirm that this mechanism is very useful for balancing their budget but most importantly it is indispensable when complex instruments and projects involve the risk of delays in their delivery. ILL too are permitted to carry over up to 1% of unallocated funds from one year to the next and up to 10% of allocated funds.

Allowing a degree of carry-over between years would reduce end-of-year, last-minute spend ensuring more effective use of funding that is not spent on 'quick-wins' that are potentially strategically less of a priority for the Harwell facilities.

Transfer between resource and capital budgets

Currently none of the Harwell facilities have the ability to transfer funds between their pre-defined resource and capital limits. This poses a number of challenges to the facilities which have a direct impact on their efficiency and ability for strategic decision making and are compounded by the inability to carry over funds between years as described.

It should be acknowledged that capital projects will always require resource for launch and ongoing operation; this should be considered in any capital project planning process.

The UK Atomic Energy Authority (UKAEA), a non-departmental public body, who are not subject to a distinction between resource and capital, confirmed that this allows for much greater flexibility in managing the budget and therefore better use of limited funds. International comparators have confirmed that they too have scope to switch budgets between capital and resource.

In order to adapt to changing priorities and environments it is essential to have the ability to make the best use of the available budget at a given time. If that means an unspent resource allocation can be strategically invested in improvements to facilities this would be a worthwhile justification and vice versa. If facilities are being pushed into making imperfect decisions which mean limited funds are used in a less than optimal way based on a technicality, this should not be perpetuated.

Other routes of funding

The Harwell facilities record little EU funding income (~1% per year) – see Tables 2, 3 and 4. This compares to 2% and 1% of the total budgets at the Ill and ESRF respectively. Given the low level of income from EU funding currently, this route could provide an alternative option for additional income. It is however unclear as to if EU funding routes will be available to the UK in the future.

Recommendation 4: Consideration should be given to how funding is allocated to the Harwell facilities by BEIS, through STFC, such that a degree of flexibility be introduced to allow for movement between capital and resource budgets and an element of 'End of Year Flexibility' of income from one year to the next.

2.3 Academic access model

The 'free at the point of access' model was originally developed at the Harwell reactors, the predecessor for the current ISIS facility, in the 1960's. It was utilised by other large facilities in various guises before being formally re-adopted at the Harwell facilities in 2003 after a period of trialling other models (see Table 5).

The facilities offer around 80% of maximum beamtime for 'free' access and 10% is provisioned for proprietary, collaborative, in-house and commissioning use. Demand for this free access route varies (see Section 3.1), but all facilities are 'over-subscribed' – a positive indication that only the best science is going to be awarded access. The model covers all user costs including experimental costs, travel, subsistence and consumables. This route is used by academic users and a small proportion of industrial users. In return, the outcomes of the experiments must be made publicly available.

There are two user offices at the Harwell site that manage user access; one for Diamond and a shared office for ISIS and CLF. ISIS for example, uses seven Facility Access Panels (FAPs) to peer review all beamtime proposals. Panels meet twice a year, in June and December. Proposals are ranked on a scale from 1 (unsatisfactory) to 10 (world class). Panel members, who are experts in their field (academic or industry), must declare all conflicts of interest on proposals from their own departments or proposals with which they are associated. Up to two ISIS representatives act as secretaries and give technical advice, but are not involved in the experiment review process.

As well as this standard access, Diamond offers 'Programme Access' allowing block allocations to research groups who want to make more efficient use of the beamlines and to become familiar with beamline instrumentation. The scheduling of the beamtime in groups allows greater flexibility in the choice of projects and samples. Block allocations are only operational on certain beamlines. The beamline block allocation is generally spread over a period of two years.

'Long Term Research' is also available at Diamond. This supports areas of research that require sustained and guaranteed access to beamtime for their success. The proportion of beamtime allocated to this access route is set at a maximum of 25% of the total available. Long Term Research projects are only available on certain beamlines, depending on the science that can be applied. Access periods currently last two years and two calls for proposals are run per year. Longer periods of access can be allocated but the proposals are re-reviewed on a two-year timetable.

'Rapid' or 'Express' access routes also provide an alternative route for quick and urgent (but generally restricted) access to the Harwell facilities. This route may be used where, for example, a PhD student needs a quick follow-up experiment for their research (being time limited). Access is agreed by the facility Director rather than through an access panel, which therefore reduces the amount of time required between application and experiment. This is also available for proprietary access.

Other access routes, through specific funded programmes, such as Newton are also available across the individual facilities allowing a variety of alternative routes to direct access.

Even though the system is free, the academic community is fully-aware of the need to use time effectively as competition for beamtime is high and poor beamtime usage could impact their future applications. Most UK users indicate they prefer to use the Harwell facilities over international ones where they offer the capability they require. The location and the skills of the staff at the facilities also encourages usage and helps maintain a high level of demand over international facilities.

The ‘free at the point of access’ model is generally adopted by worldwide large facilities in these science domains.

Previous access models

Between 1997 and 2003 a number of access models were employed by STFC and its predecessor, the Council for the Central Laboratory of the Research Councils (CCLRC) as outlined in Table 5.

During the period when the ‘ticket’ system was used, the UK academic community reported that researchers found it difficult to obtain enough support to exploit the excellent facilities provided through responsive mode applications to the EPSRC. The fraction of the experiments being performed at the facilities by UK academic researchers decreased. The mismatch of facility availability and funding for their use arose from the facilities being funded by the CCLRC, whilst their exploitation by universities is funded by the EPSRC.

It was even reported in the *International Perceptions of UK Research in Physics and Astronomy,* that the "mode of access to central facilities (ticket system) is not optimal". The mismatch between the funding mechanism and those of other overseas facilities to which our researchers have access meant a loss of UK science to international facilities. Whilst the intention of tickets was to provide a more realistic picture of the cost of the research being proposed, the effect was to impact significantly on demand for the facilities. This diminished demand led to the facilities being run at less than optimal efficiency and hence major national investments not being effectively exploited for the benefit of UK science.

As a result of the problems with the ticket system, the "free at the point of access" system was introduced. This enabled the alignment of access arrangements for all academic users, regardless of which Research Council sponsors their research, whilst also aligning access procedures with those in place for international facilities to which the UK subscribes.

Table 5 – Previous funding and access models applied to the Harwell facilities

System	Strengths and weaknesses
Ticket system (1997-2003); EPSRC awarded 'tickets' to researchers for facility access via research grants. EPSRC transferred funding to CCLRC based on number of tickets awarded. EPSRC were allocated a budget from BIS within their annual baseline.	• Tensioning facility requests against other proposals helped demonstrate the quality of facility based research and avoided duplication of peer review through Research Council grant applications and peer review for facility access • Access via grants demonstrated future demand for facilities but access had to be planned further in advance • Placing ownership of ticketed days with users and setting facility service standards improved the service delivered to users • Users chose to use international facilities if they were easier to access or offered a better quality facility or environment • The mechanism led to a narrowing of the community using facilities as not all previous users applied via this mechanism • There was a view that research grants using facilities appeared very expensive when peer–reviewed and ranked with proposals that did not require facility access
Core plus model (variation on tickets 2001-2002); EPSRC provided core 'top-sliced' funding to CCLRC. EPSRC awarded 'tickets' for facility time as part of research grant applications but the ticket cost was cheaper than in the previous model as funds were made up from the top-slice.	• Tensioning by conventional peer review helped demonstrate quality of research and avoided duplication of peer review through Research Council grant applications and peer review for facility access • Making a longer-term commitment to the operating costs allowed more strategic planning • Periodic review of the 'core' element allowed comparison of investment in large facilities • Allowed some response to variations in demand • The mechanism still led to a narrowing of the community using facilities • There was a view that research grants using facilities still appeared expensive when peer–reviewed and ranked with proposals that did not require facility access
Direct funding (2003+): Operating costs funded from CCLRC/STFC baseline. Changes managed as part of the CSR process.	• One organisation managing the funding allocation process makes decision making relatively simple as they must seek to maximise value to the UK • Funding provision can be planned over a CSR period with clear knowledge of the impact on operations for each facility • It is important that users without grant funding are still able to gain access to the facilities (subject to peer review) • It is simple to integrate beamtime funded from non-Research council sources such as EU, international or commercial using this model • The absence of a direct connection between the strategies/grant portfolios of the user Councils and priorities of STFC may result in non-optimum facility provision • Risks lie with STFC only

Source: Extract from a paper that was considered by the UK Research Council's Executive Group in 2009 when reviewing the mechanisms by which to support users of large national facilities

Alternative access models - Norwegian model

An alternative model has been implemented by the Research Council of Norway for university owned research infrastructures – see case study below. The Research Infrastructure Resource Model[4] (RIR-model) provides a method to declare costs for use of research infrastructure based on the full costs generated by the activity. The model was developed by the university sector, and is now fully supported by the Research Council of Norway.

Case Study – Research Infrastructure Resource (RIR) Model
The RIR-model requires institutions to divide their research infrastructures into a number of clearly defined entities (RIRs). The RIR model derives a price which equals cost per hour/day/ week. The price is determined by the *full costs* of the RIR divided by the RIR's capacity. Full costs include: • Space – rental and building related costs for research space such as laboratories and workshops • Scientific equipment – depreciation costs • Common operating consumables and service/maintenance contracts, i.e. shared costs for all users • Technical support – personnel costs for the technical support staff needed to sustain the operational infrastructure The capacity of a RIR determines the denominator in the price fraction. A RIR's capacity equals the total number of user hours a RIR is designated for in a normal operating phase. The definition of capacity takes into account limiting factors such as service and maintenance time and the RIR's opening hours. The actual use of a RIR may deviate from the planned use, but subpar exploitation of a RIR due to low efficiency may not be used as a basis in the denominator of the price fraction allowing for a higher RIR price. Only externally funded projects and external users will be charged for use of the RIR as a starting point.

The RIR model attempts to calculate the costs of using the research infrastructure based on the costs of each activity. The general concept is that users pay a fixed entry point charge and some users pay an additional price for special equipment/services. As an example, the Norwegian nanotechnology facility charges €100 an hour. This could clearly be amended for facilities where the experiments require weeks rather than hours.

This provides a transparent model for costing which is communicated and justified more clearly. Awareness of the costs/prices of research infrastructures provides a basis for discussions on strategy, prioritisation and funding. This is increasingly important for new capital, where the need to justify operational costs that support capital investments should be made.

The RIR model is flexible and may be adapted to various types of research infrastructures but is yet to be applied to large national or international facilities but there is optimism in Norway that the model can be used on any scale. The Norwegian Research Council provides basic funding for some high cost Research Infrastructures (covering the cost of unused capacity, 4 years minimum). In

[4] http://www.uhr.no/documents/A_Norwegian_Research_Infrastructure_Resource_Model_270214.pdf

addition, the Norwegian Research Council provides funding for operational costs (user fees based on a full cost methodology) as part of the *research grant*.

On discussion, the panel agreed that, although successful for small, institutional based facilities, the model may not be applicable for large facilities. This discussion is outlined in Section 2.5

2.4 Proprietary access model

The Harwell facilities offer unique capabilities that are not only attractive to UK and international academics but also to UK and international industries. Industrial use is often sought and delivered either through direct access, as previously described, whereby the results are published and the cost of usage is free; or through proprietary (paid-for) access, where the user choses to keep the results private. For the latter, the user must pay for access. Each of the facilities have a different model for calculating the charge rate for this usage as explained in the sections below. As a policy, these facilities will allow up to 10% of total beamtime to be made available to industry for proprietary access.

At Diamond, for 2015-16, £1.2m was generated through industrial (proprietary) income, representing 2.1% of operating costs. However, the number of proposals awarded beamtime for proprietary access was 6.7% of the total number of proposals, both proprietary and non-proprietary, awarded beamtime implying proprietary access is subsidised. The contract pricing for this access is agreed in consultation with the client on a case by case basis.

Unlike the CLF and Diamond, ISIS has an 'Industrial Collaborative R&D scheme' (ICRD) established to provide a third access route for industrial partners. The scheme involves a contract between STFC and the industrial partner. The industrial partner can decide after the experiment if the results are to be published in open literature or kept confidential. In the latter case the beam time has to be paid for at the proprietary rate. Industrial income for ISIS is however still low - £0.3m representing 0.1% of total costs, against 4% of total usage. It costs approximately £170,000 per working day to run ISIS but charge out rates can vary between £10,000 and £20,000 per day depending on the type and format of the experiment and level of consumables required. This is a comparable rate to the Japanese neutron source hosted at the Japan Proton Accelerator Research Complex (J-PARC).

For CLF, industry income for 2015-16 was £220,000 being 1.7% of operating costs. Of the total time delivered for 2015-16, 3% was utilised by industry. There is again no standard charge out rate with a price calculation taking place for each piece of work depending on the client and circumstances. CLF does not have a specific group or scheme to facilitate access from industry unlike Diamond and ISIS.

Access to the facilities by industry can also be undertaken through academic institutions, rather than directly through the access system or proprietary access, and this is known as '**Grey Access'**. This accounts for approximately 25% of all usage for Diamond and 15% for ISIS[5]. This is not just a UK phenomenon but is reflected by similar rates at international comparators; PSI report 10-15%; ILL 15% and ESRF between 25-30%. While there is evidence that grey access is viewed negatively, as industry is getting free access to beamtime, the opposite perception should in fact be drawn. Through having industry involvement in experiments, it opens up the scope for an economic impact you would not otherwise have with a purely academic experiment. Industry is also not always equipped to make the best use of the facilities in terms of know-how to operate the equipment and analyse the resulting data, something that academia is well placed to do. Grey access is therefore not something to be viewed negatively but rather something to be encouraged. ISIS has already

[5] Figures for CLF unavailable at the time of reporting

recognised this access by including names of companies in its annual 'business report'. The panel agreed that greater visibility of grey access should be promoted to ensure both academics and industry are getting credit for promoting research and development and impacting the UK's economic development. Industrial partners are frequently noted on initial grant applications but are not always encouraged to form part of the beamline time application for facility access.

Feedback from industrial users suggests that the current charge rate for proprietary access was at the right level and their continued usage of the facilities would be influenced if costs should rise. There was some concern that the costs for ISIS were however higher than their comparators. In one user's experience ISIS cost them approximately £24,000 for 24 hours for proprietary use which they suggest is between 1.6 and 6 times more expensive than other comparable facilities that have been accessed. Although the user confirmed the experiments still represent value for money, it was noted that 'the amount we will perform in UK is tempered by the requirement to justify the high cost of beamtime.' The cost will however be dependent on the complexity of the requirements.

Although there is global competition for the small amount of income that industrial users can bring, feedback from UK industrial users suggests the facilities at Harwell have high standards and provide an excellent service.

"The main reason for using ISIS and Diamond is the excellent technical support. It is genuinely the best of any of the facilities we visit. The staff (particularly at ISIS) are world experts in their fields/instruments. They are extremely helpful and patient with users and have a genuine interest in getting experiments successfully performed." - Industrial user

Case Study – Charging commercial rate for access – ESRF

The ESRF facilities are available for commercial access and proprietary research. The rates applied for commercial access are based upon costs recovery for the instrument, and include an element of market demand.

Staff time for scientific assistance is set at a fixed rate of €175 per hour. Clients with headquarters or a research laboratory in the Member States of the ESRF benefit from a 20% discount on commercial access charges. Clients in France outsourcing R&D to the ESRF may benefit from the research tax credit for which the ESRF is accredited. All clients are treated equally, and negotiation on a case-by-case basis is not permitted.

ESRF also provides for manufacture-and-sale of unique instrumentation where the financial framework provides for overheads and a margin on the costs. The hourly rates for staff costs are provided annually by the Administration Division and include an overhead. These figures are approved by the Board of Directors, and then by the ESRF Council.

Other international facilities also receive relatively few industrial proprietary users, but are looking at increasing usage primarily for political reasons as well as knowledge transfer rather than as a means of enhancing their income. For example, a 5% increase in proprietary use to generate approximately £2m a year of income for one facility was being targeted. A more aggressive approach to increased industrial usage is therefore unlikely to yield a significant outcome for the facilities in terms of generating income (and at best may be a zero-sum game) and is unlikely to have an impact on the cost reduction task the facilities have been given. There may however be other reasons to want to increase industrial usage as mentioned above and this may indeed be healthy. Making grey access more visible might go some way to support those goals.

"There are many areas where alternative facilities are available and [an increase in cost for experimental time] above a cost threshold would drive the use of facilities outside the UK."
- Industrial user

Other facilities, such as PSI, encourage industrial use in return for capital investments. A company will pay for new equipment which entitles them to usage at the facilities, on the agreement that the equipment remains in the facility at the end of the agreement. The company gets a dedicated beamline and support for its experiments in return. For example, PX II beamline was funded by the Max Planck Society (MPG) and two pharmaceutical companies. The yearly costs to operate the beamline are split by the three industrial partners.

Recognising 'Grey' access would help funders recognise the longer-term socio-economic benefits and highlight the already close working relationships between academia and industry. This will be an important link to make, in light of the UK Government's Industrial Strategy.

Recommendation 5: Efforts should be made to make 'Grey' industrial access more visible, for example through annual reporting as exemplified by ISIS.

In summary,

- Demand for industrial proprietary access is not oversubscribed - the current allocated 10% is not fully utilised.
- Full economic cost recovery is not applied as this would be cost prohibitive to industry and therefore the existing level of industry usage is actually being subsidised. This is common with the international benchmarks and this has consequently led to a level of accepted international rate for facility access.
- There are few other benefits for the facilities themselves to these partnerships. Occasional gifting of equipment does occur but generally there are few spin-outs or gains from the industrial benefits achieved e.g. increased profits from new products or money saved by amending current products.
- The Harwell facilities each have a different approach to industrial engagement and lessons could be learnt across the facilities and a more aligned approach could be an effective route to industrial engagement.
- In the light of the Industrial Strategy, the need to engage more with industry is likely to be a big driver for STFC and the other Research Councils.

To reduce the burden on STFC funding it would be appropriate to increase the industrial income. However, the following issues are likely to occur if there was a move from the current position:

There are 2 ways to increase industrial revenues:

1. <u>Increase charge out rates to try and recover actual cost.</u> This carries the very real risk of losing UK industry to overseas facilities who also subsidise industrial usage.
2. <u>Increase industrial proprietary usage of facilities by better promotion to industry and increased visibility</u>. In this case, the free at point of use model is likely to suffer by a reduction in, already oversubscribed, beamlines. This would be detrimental to the main purpose for which the facilities were set up, which is to deliver the best science. Given that proprietary industrial usage at the current charge out rate is actually being subsidised by the facilities, this would not make economic sense.

As a consequence of the above:

a) As data and outcomes from proprietary usage does not have to be made publicly available, the discoveries from this research would not be published which would not be in the interests of STFC or the UK.
b) If industry is charged actual cost there is a concern they would become focused on cost and not the best science.
c) There are likely to be increased costs of promoting and administering industry proprietary users.

There is also an argument, that if industry users choose to go elsewhere, academic usage could increase and fill the remaining 10% of beamtime allocated to industry. However, this could have a detrimental impact on benefits gained from UK industry using UK facilities whereby other labour markets are impacted if industry move away and the societal benefits of innovation are lost to the UK.

The balance of activity between international partnerships, training, running commercial services, conducting in-house research and developing new technologies therefore all needs to be tensioned against the academic share of facility access and the political consideration of what a nationally funded facility should prioritise. Increasing industrial usage will not provide a much-improved income, but will lead to social and economic benefits that the UK government aims to support by funding.

Recommendation 6: A stronger and more joined-up, cross-facility, approach should be taken to industrial engagement. Industrial income is not likely to provide a solution to the funding gaps currently faced by the facilities; but it will provide significant economic and social benefit to the UK.

2.5 Stress testing the current access model

To test the current funding model the panel discussed the strengths and weaknesses of the previous 'ticket' system, the current model and the Norwegian model presented in Section 2.3. Options to amend the current model are outlined below:

a) Introduce a usage charge - A modified access model where all users are charged the experimental usage fee, for example, set hourly/daily/weekly costs

The current 'free at the point of access' model encourages the best science to access the facilities through the peer-review process. It ensures costs on Research Council grants are managed and comparable with grants that do not require large facility access. If facility access was included on research grants; the total cost of the grant would far exceed the cost of non-facility using grants. It is essential to judge value for money during the peer review process and, as such, a level playing field should be ensured by excluding large facility costs.

With such a strong international landscape in all comparable areas of science offered at Harwell, and equally competitive processes to provide access along the same free of the point of access model, there is a risk that UK academics would seek overseas facility usage over UK facilities. UK demand would therefore decline as a result if the current model was changed. This would however make sure the best science is seeking the best facilities and provide an overview of true demand that may currently be masked by the free at point of access model. Such a phenomenon has been seen by the implementation of the RIR model in Norway, as applied to small, institutional-sized infrastructures, but there is yet no evidence that this could apply to national large scale facilities such as those at Harwell. Implementation of a similar model may therefore risk a decline in UK science, home-grown training and industrial access that nurtures innovation in the UK.

Sourcing costs from other routes was generally considered to have little benefit to the overall funding landscape; university funding is mostly allocated from the UK Government, so although some costs could be sourced directly from these institutions, this is the same route that supports the Harwell facilities. Such a system would also need to involve a similar management process to the previous 'ticket' system which was noted as resource intensive; therefore creating an additional administration burden for the Harwell facilities.

Although the current access model creates a strong UK base for science and access for UK scientists and the process is highly comparable to that at international equivalents, the one drawback of peer-review is that, when it is done well to ensure scientific excellence, it is time-consuming and (therefore) rather inflexible and in some cases, leading to long delays (>6 months) between proposal and beamtime. There are opportunities however to explore more flexible (so-called) 'mail-in access' for short, simple, characterisation measurements and further technology developments could help manage demand better.

Consideration was also given to research carried out at low Technology Readiness Levels (TRL) that is often carried out by industry in partnership with academics (grey access). The panel agreed that industry would be unlikely to want to pay for low TRL research as the risks are generally high. This would risk losing the economically valuable grey access that is currently created through the free access model.

b) Travel and subsistence (T&S) costs - A modified model where users contribute to their own travel and subsistence costs when using the Harwell facilities

It was noted that even asking users to cover travel and subsistence costs could be problematic in many cases and those most likely to suffer as a result would be the PHD's and students. In the review panel AWE offered an example based on their own experience running a £185m facility costing £10m per year. It was considered that by enforcing users to cover their own T&S, there was a risk of deterring facility use in favour of other facilities that cover such costs. This would have a detrimental consequence on the scientific outputs and the best science would be driven elsewhere. Reflecting therefore, on the rationale to save a relatively small portion of a T&S bill of no more than £0.2m per year would not be pragmatic. Options for charging rates would also require a significant time and effort to calculate, regularly test if the rates were still valid, and negotiate with users causing additional administrative workload on the facilities to manage the payments and review the costs.

"The funding for consumables, travel and accommodation at ISIS are also an enormous benefit to working in the UK at a UK facility. These relatively small amounts of funding help to ensure that researchers can make most efficient use of their beamtime. This is particularly important in PhD student projects, training the next generation of scientists, where funding for the training is typically extremely limited. A typical PhD student at the University of X will have £3,000 to cover all of their consumables, travel and training for an entire PhD project." – Academic user

Recommendation 7: It is recommended that no change to the fundamental business model should be implemented. The peer review process employs the same high degree of rigour to those in place at other equivalent international facilities.

3. Operations

3.1 Availability and Utilisation

Diamond, ISIS and CLF are national assets of substantial scale and complexity which represent an initial and on-going public investment to support the UK's premier position in international research. The potential for delivering excellent science outcomes is directly related to the operational time that can be made available for conducting experiments.

The established access model (set out in Section 2.3) creates a prioritised workload for each facility via academic peer review submissions. When it comes to peer review access all three of the Harwell facilities are oversubscribed as is evidenced in Table 6.

Table 6 – Application success rates (2015-16)

Facility	Proposals received	% of proposals awarded time	Beamtime requested	Beamtime awarded	% of beamtime requests awarded	Comments
Diamond	1,473	65.0%	16,021 shifts	8,920 shifts	55.7%	Includes new Block Allocation Group and Long-Term Proposal applications access for 2015-16. Beamtime awarded figure does not include BAG/LTP awarded in previous years.
ESRF - Diamond benchmark	2,384	40.4%	34,009 shifts	14,162 shifts	41.6%	Figures for public peer-reviewed applications. 1 shift = 8 hours.
ISIS	1,232	72.0%	5,234 days	3,421 days	65.4%	Includes all types of access.
ILL - ISIS benchmark	1,188	65.0%	7412 days	4,184 days	56.4%	Includes all types of access.
CLF	145	59.0%	496 weeks	261 weeks	52.6%	Includes all types of access.
LULI[6] - CLF benchmark	22	73.0%	70 weeks	50 weeks	71.4%	Includes all types of access.

Allocation of beamtime also needs to allow for a level of industrial engagement, internal research and development, training and facility maintenance/enhancements. As each unfulfilled application represents a lost opportunity for a potentially significant scientific contribution there is an explicit need to ensure the operating regime maximises the potential for experimental time while minimising unutilised capacity.

[6] LULI data includes two comparative lasers: LULI2000 & ELFIE

From discussions and reports seen it is very clear that all the facilities are actively seeking to manage this balance and there are many good examples of proactive actions to address facility weakness and initiatives to improve output from the experiments through equipment modifications and capital investments.

The facilities have actively engaged with external organisations to realise opportunities such as through the Diamond Beamline reviews conducted with international participants and ISIS use of an independent consultancy (Red Scientific[7]) to improve their operating model.

In addition to maximising the available operating time there is also a need to minimise unplanned downtime during operations. Given the often significant delay between an application and actual beam time access, users expect a very high degree of certainty from the facility that their experiment will run to plan. While a loss of small amounts of beamtime is not normally detrimental to the user programme, this is more significant when these failures occur more frequently or for longer periods of time as this directly impacts on already tightly scheduled experiments.

While, as previously noted, it is not strictly appropriate to compare the three facilities like for like, it is interesting to note their performance over time recognising that major facility maintenance projects take place over some years. Nonetheless the performance would at best be described as static. Given the importance of reliability to capacity a target not less than 95% would seem appropriate.

Table 7 – Reliability of facility beamtime

Facility	**2015-16**	**Target**
Diamond	97.6%	98.0%
ESRF (Diamond benchmark)	99.1%	
PSI (synchrotron- (Diamond benchmark)	99-99.5%	
Australian Synchrotron (Diamond benchmark)	97.0%	
ISIS	91.4%	90.0%
PSI (Proton accelerator - ISIS benchmark)	90.7%	
J-PARC (MLF[8] ISIS benchmark)	96.4%	
CLF	92.2%	85.0%
LULI (CLF benchmark)	93.5%	

Source: Review communications

The nature of the Harwell facilities means that a substantial proportion of the operating costs are identified as fixed costs which include staff. For Diamond this is reported as 79% and for ISIS and CLF this is reported as approximately 80%.

The lower the variable cost of operating a facility the higher the return for an increase in capacity. Increasing the availability of the facility is therefore the most cost effective way of providing

[7]http://www.red-scientific.co.uk/about-red/

[8] Materials and Life Science Experimental Facility (MLF)

additional capacity. As such, determined pursuit of increased availability which can be utilised should be a primary activity of the operation.

The same desire that exists to be the best at developing new science needs to carry through into the operational ethos of the facilities themselves. The objective being not just to 'compare well' with other benchmark facilities but to be the facility that others benchmark themselves against.

3.2 Downtime Reduction

The time available for conducting experiments is a product of the time available when the beams are operating (the primary driver of output) and the time when experiments are able to make use of the available beam, hence the established measures of 'Beam Time' and 'Experiment Days'.

Minimising beam line non-operating time is key to performance, both in terms of capacity and in terms of on-time completion of the programme of experiments. Facilities undergo significant planning to ensure experiments will run on-track and work closely with the users to ensure their preparation is also planned to a tight schedule. Feedback from the user community reveals that the academic users are extremely conscious that the work they undertake in preparation for beamtime access is significant to ensure success of the experiment. Failure of an experiment is generally recorded and will be considered by a panel on future applications.

Figure 3 is an example of how the CLF plans its workload after a call for proposals to minimalize risk of academic experimental failure at the early stages of the experiment planning process. Staff work closely with academics to reduce risks and ensure the samples are prepared to the highest quality before the experiment is attempted. Significant time is also spent internally planning experiments to provide the most effective timetable for beamtime usage.

Downtime arises from both planned events such as maintenance or facility projects/changes and unplanned failures and it is important that equal rigour is applied to minimising downtime arising from both planned and unplanned events.

There is clear evidence across the facilities that unplanned downtime is tracked and scrutinised for root cause and corrective actions implemented. It is less clear that planned downtime is subject to the same rigorous drive for elimination although there is evidence of actions being taken that reduces some of these losses.

While the ideal outcome would include opportunities for the elimination of the need for the downtime completely, the most likely focus will be on how to modify the facility to make the task easier to achieve or redesigning the way the task is undertaken.

The same needs to apply to downtime associated with experiments. Aggressive pursuit of unplanned downtime from all causes is important to raising availability at the experiment level however the efforts to move from 98% reliability to 99% for example are exponential. On the other hand, the reduction in downtime that results from set-up, configuration and tear-down are areas where a real improvement could be made, as appropriate to each facility.

The evidence of action taken to increase efficiency can also be seen in the reduction of experiment duration at CLF where the 'slot' allocated has reduced from 6 weeks to 5 weeks on their Vulcan and Gemini facilities. Set-up time was reduced from 2 to 1 week whilst maintaining a 4 week shot programme. The change had little detrimental impact on the user experience and has enabled ~23% increase in the number of experiments annually.

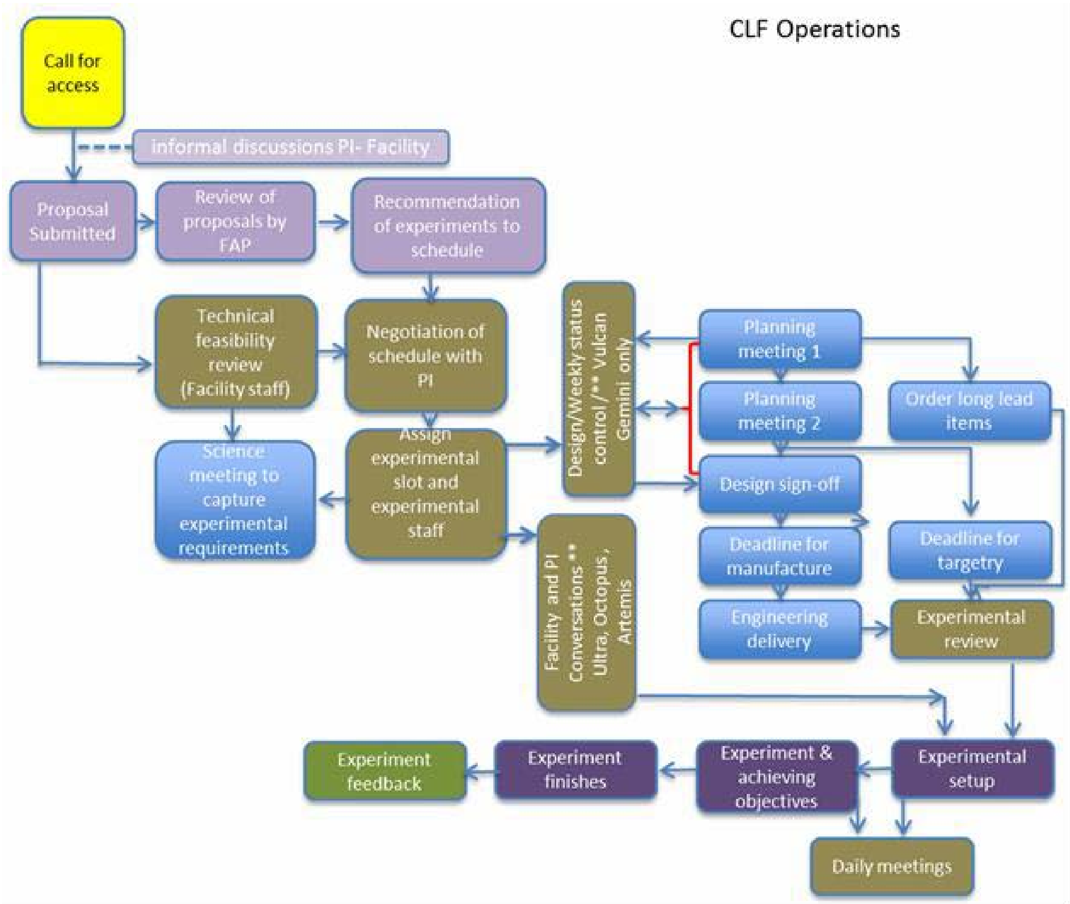


Figure 3 – CLF work planning process

Case study – Impact of automation at Diamond
Four of Diamond's beamlines have been upgraded to allow for a higher degree of automation and sample throughput. 2009: 6 samples/hr= 144 samples/day 2011: 20 samples/hr=288 samples/day; 2014: 20 samples/hr=288 samples/day (unattended) or 488 samples/day (attended) 2015: 35 samples/hr=840 samples/day fully attended. On one particular beamline in 2009 a staff of 3 could support 1,000 samples per month which equated to 330/person/month. In 2015 a staff of 4 could support >12,000 samples per month which equated to 3,000/person/month. Consequently 75% of the usage by 2015 would previously not have been possible.

The use of standard allocations of time between experiments would suggest the presence of an 'allowance' rather than time developed from a determination to minimise lost time. While such allowances may be required for effective planning they often take on a life of their own and become the norm, 'the way it is', enabling them to pass with little or no challenge or review. Effective leadership is essential here, there should be an on-going action plan detailing planned improvements with timing. Evidence of action over time should be visible through continuously reducing allocations.

3.3 Disruptive Improvement

While this continuous improvement is an essential aspect of any organisation's drive for efficiency and effectiveness, there is also a need to encourage and promote the potential for disruptive change to create new thinking and new operating models. Sometimes such changes can emerge within the organisation but often inspiration comes from approaches taken in different sectors, industries or research environments.

Driving such improvements internally normally starts with an 'unreasonable challenge'. A good example was shared by one of the interviewees – they had been asked what it would take to reduce the time allocated to experiments from 5 weeks to 3 weeks. It was not clear whether there had been a serious attempt to answer the question but there should be encouragement to do so.

Set-up, commissioning and tear-down of experiments consumes a significant time allocation.

While it is recognised that there are constraints in terms of personnel and funding for modifications it is an aspect of operations that is ripe with opportunity. Some examples could be:

- the design of the experimental stations to support rapid change over;
- simultaneous set up of the next experiment while current experiment running;
- standardised location for tools, connections and equipment;
- duplication of frequently used equipment to allow off-station build-up of experiments;
- skilled and trained set-up/tear-down personnel;
- set up teams working on alternative shift patterns.

A good example of how an unreasonable challenge can trigger a revolution of approach can be seen by looking at the adoption of SMED by the automotive industry particularly in their metal pressing operations.

Case study – SMED in the automotive industry
SMED or Single Minute Exchange of Dies was developed by Shigeo Shingo, a Japanese industrial engineer. His pioneering work led to documented reductions in changeover times averaging 94% (e.g. from 90 minutes to less than 5 minutes) across a wide range of companies. The essence of the SMED system is to convert as many changeover steps as possible to "external" (performed while the equipment is running), and to simplify and streamline the remaining steps. A successful SMED program delivers the following benefits: • Faster changeovers and therefore less equipment down time. • Improved responsiveness to customer demand through more flexible scheduling. • Improved consistency and quality as a result of standardising processes.

A further example of a paradigm shift which challenges preconception would be the approach to pit stops in Formula 1 racing. Using conventional thinking, changing a full set of tyres on a car in 1.92 seconds is beyond comprehension. This was achieved by the Williams team in 2016 and is the product of continuous optimisation and thinking differently.

Recommendation 8: Seek advice from experts in optimising performance of complex systems that include change overs of product and process – practitioners not consultants - and invite them to participate in internal performance review activities to challenge existing thinking.

It is also recommended that a mechanism is established to incentivise this pursuit of improvement in availability through healthy competition and recognition. 'Disruptive improvement' is likely to provide the greatest opportunity for 'invest to save' projects and, while not initially saving money, it will lead to more science.

3.4 Retention and recruitment

The current operational headcount for each of the facilities and the relationship between this and the operating costs are shown in Table 8. Again, care should be taken in drawing comparisons between the facilities.

Considerable frustration was evident from all of the Harwell facilities, particularly from the technical and science staffs, that being a public body and being required to operate under the public sector pay constraints for a number of years was now causing significant difficulties with retaining staff and recruiting new/replacement personnel.

Table 8 – Headcount and operating costs for 2015-16

Measure	Diamond	ISIS	CLF
Average Headcount FTE (direct)	557	454	127
Average Headcount FTE recharged from STFC (No. of contractors)	0	33 (14)	10 (8)
Total (excluding contractors)	557	487	137
Operating Costs £m	56.5	43.1	12.6
£000's/Direct Head	101.4	88.5	92.0

Source: Diamond statutory accounts and questionnaire responses

The view was that while the pay restraint had kept people broadly in step with equivalent roles in other public sector organisations they were not able to compete with other organisations employing people in similar fields and this was resulting in long delays in recruitment and posts remaining unfilled for extended periods. The location of the facilities in the Oxfordshire area exacerbates the problem as it is a relatively expensive area to live, particularly for technicians and support staff. This is a problem confirmed by UKAEA who are also based in the area and face the same difficulties.

There was also concern about discrepancies of salaries between the facilities themselves. For a sample of 21 staff, our findings indicate basic salaries at ISIS may be approximatively 9% lower than Diamond, however, the sample was based on grade comparisons and not actual roles and responsibilities. Further work is therefore needed, with a larger sample and more reliable comparator data to be able to make a clear conclusion.

Notwithstanding the above, there was no evidence of any *chronic* problem with retention of personnel, headcount being reported as largely stable at 6.8% turnover in the past year for Diamond and 7.5% for ISIS[9]. With absence at around 3%, this doesn't indicate a major issue with morale and

[9] Figures for CLF unavailable at the time of reporting

is in keeping with national levels. However, this is averaged across all staff and it has been suggested that this is not actually a true picture for all personnel. Science staff, for example, are less likely to move away, as they are working at world-leading science facilities. It remains a challenge to recruit engineering staff in a location where engineering staff are in high demand.

It is widely recognised that there is a national shortage of skilled labour and that all three facilities are competing in a small pond for good people. Some of the problems with recruitment also stems from the fact that the facilities needs are for a particular skill set that is in even shorter supply than the generally constrained skilled labour market. At ESRF, few science staff are offered permanent contacts as it is believed that there is an advantage to encouraging staff to circulate across international facilities and take/bring a diverse range of skills with them. ESRF did not record any ongoing issues with staff recruitment and retention.

Recognising the direct impact of labour availability on experiment days it is unwelcome to see, as reported by ISIS in their 2015-16 annual review, that instruments could not be run due to the shortage of people. Presuming that the allowed 1% salary discretion for shortages in key roles had already been offered then the Executive Team should have a formal review process to identify alternative ways, such as the supplemental admin support described below, to respond to the shortage without impacting on experiments. The formal review process should also include reviewing vacancies that have remained open for long periods.

3.5 Liberating Human Resource

Availability alone does not deliver scientific output, there needs to be adequate support from technicians and scientists to ensure effective planning, set-up, execution and subsequent analysis of the data captured. However, with staff largely an element of fixed cost, the principal opportunity is in ensuring that they spend their time making full use of their knowledge and skills where they can maximise their contribution.

Effective use of resources applies to people as well as equipment. Significant resources can be freed up by improving the operation of internal processes such as in procurement which is covered separately in Section 3.6 below. Similar comments were also made about the inadequacies of the HR systems supporting ISIS and CLF leading to extra non-added value activity.

Throughout the review process it was frequently commented that people felt they were engaged in some administrative tasks that should either not exist or should be being done by someone else. While all roles entail some administration, the overall impression was that the right balance had not been achieved in a number of skilled areas. Judicious application of some additional administrative support has the potential to free up time from skilled people in resource challenged activities. The current approach is for administrative budgets to be pre-defined, denying pragmatic management responsibility.

Given the similarities that exist in the Diamond and ISIS offering, great potential exists for shared learning and sharing of some back-office functions such as HR and finance. Closer working relationships should be fostered and mechanisms for routine exchange of ideas put in place. This will support useful plagiarism and reduce the need to learn things twice.

Although not a formal recommendation of this review there may well be a strong case for a level of integration in the technical areas for Diamond and ISIS. The case for integration of CLF is less clear. As a minimum, every opportunity should be taken to exploit the benefits of, for example, common services requirements, shared spares stock holding, supplier held consignment stocks for common use items and aggregation of purchases to maximise discounts.

Increasing the capability for and capacity to undertake data analysis is another area of potentially significant productivity gain and a candidate for invest to save opportunities.

Recommendation 9: Roles critical to the support of experiments, starting with those where recruitment is proving difficult, should be reviewed to ensure that administrative tasks are eliminated where possible or, if essential, being done by administrative staff to reduce the inappropriate burden of non-science activities on scientific staff – even if this requires the recruitment of a limited number of appropriate additional staff. The facility management team need to be free to make their own decisions on balancing administrative and technical headcount within their own budgets.

3.6 Procurement

All facilities owned and managed by STFC, including CLF and ISIS, are compelled to use UK Shared Business Services (UKSBS). UKSBS is a limited Company, funded by government, which delivers shared services to BEIS and its partner organisations, including the Research Councils, and their centres and facilities. UKSBS provide finance, human resources, and procurement services.

Due to Diamond's ownership model, they do not have to follow UKSBS for procurement and other services and have full autonomy in this respect. ISIS and CLF on the other hand are required to use the BEIS UKSBS and have no in-house procurement staff based at the facilities, so all liaisons with UKSBS is through STFC and the facility project teams and technical staff.

Procurement is critical to the delivery of operations and continued development at each of the facilities. However, a recurring theme in discussions with ISIS and CLF staff was the failure of the existing procurement process to meet operational needs, something reinforced in discussions with Diamond personnel who were clear that they would not want to be operating in the current UKSBS environment.

Diamond's procurement system is supported by 4.3 full time employees (FTEs). On average around 9,000 orders are processed electronically per year with a total value of about £40m. This enables direct contact with science and technical divisions to enhance understanding of what is being purchased.

In comparison, in 2015-16 ISIS spent £33m on 8,406 orders procured through UKSBS and a further 2,541 orders using a Government Procurement Card (GPC) totalling around £0.5m.

There is a strongly held view that, while the UKSBS processes are in many cases appropriate and effective for category management of widely available items, they do not work effectively for infrequent and technically complex 'major project' purchases.

Effective and productive purchasing of complex technology requires strong engagement of the scientists and technical staff with the purchasing team facilitated by short and responsive communication channels. It is important that a shared understanding is developed between the technical and purchasing staff to ensure that there is ongoing awareness of the 'big picture' in which the purchase decisions are being made, thereby allowing for the development of the best approach and not simply discrete purchases. There is much evidence that ISIS and CLF staff are spending substantial non-added value time in progress chasing and evaluating bids, including from organisation that they know are not capable of meeting the quality and delivery requirements.

Case study - Government Procurement Card (GPC) procurement options
A GPC is issued to staff within the BEIS family for small scale purchases that cannot be made through existing procurement routes. Each card carries two limits for control purposes, these are: • 'Single transaction limit', this is the maximum value that can be purchased for each individual transaction. • 'Monthly credit limit', this is the total amount that can be purchased within each monthly cycle. All new cards are set as standard with a £1,000 (inclusive of VAT) single transaction limit and a £5,000 (inclusive of VAT) monthly limit; Card Administrators have no authority to amend this.

ISIS have evaluated the impact of the current UKSBS process on their technical staff and believe that it is consuming between 7 and 10 full time equivalent heads who would otherwise be supporting technical work but are currently dealing with administration relating to procurement, which should only be a minor part of their roles. This is clearly not an acceptable position and needs prompt resolution.

It is fully accepted that sound procurement processes must underpin the purchasing function to avoid inappropriate behaviour and ensure transparency in the tendering process. The UKSBS's processes provide these but, in operation, would seem to act primarily to ensure that the risk of a sub optimal purchasing outcome is prioritised above other potential risks to the programmes such as delay or danger of poor supplier performance.

It is important that organisations balance the emphasis on rule compliance with empowering their staff to act appropriately in an environment founded on trust. It is not possible to eliminate all risks in procurement but clear statements of policy supported by an appropriate level of oversight and auditing can be used to ensure staff act with integrity. In such an environment, the use of facilities such as Government Procurement Cards for purchasing and payment of low value goods or services can significantly reduce the purchasing burden and speed up the response times.

The relationship between the facilities and UKSBS is further complicated as, although they are customers of the service, they do not own the relationship with the service provider as UKSBS is contracted to BEIS. Hence the normal tools available to a customer such as withholding payment or re-sourcing cannot be brought into play to effect change. It also means that access to potential useful data is limited under data protection.

Although BEIS may be willing to change the contracting relationship it is far from clear that this would give the facilities the leverage they need to deliver an acceptable service.

Case Study – ISIS procurement using UKSBS
Item: Specialist cryogenic sample environment equipment (ISIS) Value: £612,920 ex VAT Duration: initial plans started in May 2015; Tender published in May 2016 – no payment was made in 2016-17 as planned – ongoing. ISIS teams began to draw up technical requirements for the suite of equipment in May 2015 with the expectation that a significant staged payment would be made before their 2016-17 year end. These teams have gained an extensive knowledge of the market and are aware of the state-of-the-art through technical relationships with both suppliers and other scientific facilities around the world over many years. Once an outline requirements specification had been developed, UKSBS was contacted and a buyer assigned to the project. The buyer worked with the STFC team to finalise a set of tender documentation. Two companies submitted tender responses. Both were known to STFC; one has a successful reputation for providing this type of equipment; the other was known for providing equipment that was below specification standard. The assessment and scoring process proved to be challenging and very time-consuming in avoiding STFC being contracted to purchase unsuitable equipment. After a number of issues during the process UKSBS informed STFC, after the tenders closed, that STFC was not allowed to self-reference and that tenderer-supplied references could not be scored. After a lengthy technical review, detailed clarification questions were developed which enabled STFC to demonstrate that some of the technical claims were unachievable, which allowed the returns to be rescored. This process took an additional two months. The contract was placed, however, the winning company subsequently refused to accept UKSBS standard terms and conditions and 4 months of negotiations followed. These lengthy delays resulted in the project missing its financial year deadline.

Case Study - Diamond procurement process
Single Tender example: Four sets of processing hardware electronics Value: $80,617 Duration: 4 days A single tender justification was supplied for this purchase as Diamond was involved in collaboration with another synchrotron to adapt one of their Radio Frequency systems. This purchase was for the hardware platform that was defined by the other synchrotron as part of the collaboration so there was no choice with regards to the choice of supplier. The requisition was raised (with a single tender case) and authorised on 15th December. As it was a new supplier Diamond had to do supplier checks and add them to the system which was done on 16th December and the Purchase Order was issued to the supplier on 19th December. **OJEU Tender example: Compute nodes** Value: £300,000 Duration: 10 weeks The project and procurement teams discussed the requirement and agreed the documentation before the formal process started. The OJEU notice published was published on the 13th December with a tender return date of 19th January. The requisition was raised on 6th February and fully authorised the following day. Following the standstill period the contract was issued on 20th February with delivery at the end of March.

It is telling that Diamond staff expresses confidence and satisfaction in respect of their purchasing process. They maintain a close proximity between technical staff and the purchasing team which, when combined with their system for electronic approval of requisitions, enables timely response when needs arise.

Relevant international comparison would also suggest that purchasing is best delivered by teams closely linked to the operations and staffed by experienced personnel able to contribute to the procurement outcome beyond the simple buying transaction.

Similar to the model adopted by Diamond is the ILL facility in Grenoble, France who operates their own small in-house procurement resource consisting of 1 specialist buyer and 1 general buyer as part of a procurement team of 7 FTEs who deliver €50m of purchases a year.

Wider shared services across large facilities are undertaken at the Swiss PSI. PSI is governed in a similar way to the Harwell facilities, whereby the federal budget (76%) is allocated on a 4 year basis via the Board of the Swiss Federal Institutes of Technology (ETH). The ETH allocation to PSI is then distribution to the three facilities that mirror two of those at Harwell:

1. Swiss Lightsource (SLS)
2. Swiss Neutron Source (SINQ)
3. Swiss Muon Source (SmuS)

These facilities are operated at one site and are strongly organized in a matrix structure (specifically for all central services and those which all facilities benefit from) which enforces no internal cost allocation as these are managed under one central PSI budget.

Other organisations such as NPL have 3 FTEs in their procurement team who procure around £10m of capital a year. Similarly, at the Cullham facility run by UKAEA, an in-house procurement team of approximately 12 FTEs are employed to carry out procurement to the value of around £30m a year.

In summary, the current procurement system used by ISIS and CLF does not offer a transparent system and creates a significant distance between the customer and the supplier making it difficult to manage complex procurements. This generally creates long lead up times for purchases and often inappropriate tender processes are used. Changing this approach could significantly free up ISIS and CLF staff who spend time working on procurement issues. Bringing the suppliers closer to the customers at the facilities (rather than at STFC or UKSBS) will ensure specialist equipment knowledge is utilised, preventing inappropriate processes being applied to specialist orders.

Bringing together other back-office services such as recruitment and finance may also benefit all three facilities by reducing duplication of teams across the site and encouraging shared expertise in areas where skills shortages are apparent.

Recommendation 10: A better procurement model should be established for ISIS and CLF in place of the current UKSBS arrangement. In order to do so in the most cost effective way it should be considered whether the Diamond model could be applied to ISIS and CLF or as a combined procurement office. This could be aligned to other shared services such as collaborative development in the area of e-science, human resources and other back office or regular functions that cross-cut each of the facilities that are currently being duplicated.

Such an arrangement would give ISIS and CLF a geographically co-located service provider and ownership of the contractual relationship. While the Harwell facilities have different capabilities, some of the work they undertake gives rise to similar requirements for equipment, materials and services.

It is acknowledged that, even within the current arrangement, steps have been taken to seek opportunities to capitalise on common requirements and develop joint proposals such as those that led to the Diamond and ISIS shared Helium recovery and liquefaction facilities.

Having a single purchase group with visibility of the purchase requirements of all three facilities will enhance the opportunity for further identification and leverage of shared purchase requirements while continuing to benefit from Government Collective Agreements as well as reducing the overhead of the activity. It would also allow the three facilities the scope, where appropriate, to work with other similar facilities with some commonality in technology on the procurement of major items of technology, in the UK and across Europe.

3.7 Capital investments

The level of capital investment made in the facilities was reviewed, over the 4 years ending 31 March 2016 relative to the depreciation provision being made over the same period.

Table 9 – Capital expenditure and depreciation 2012-13 to 2015-16

	Total fixed asset additions (£'m)	Total depreciation charge (£'m)	Difference (£'m)
Diamond	124	128	-4
ISIS*	96	85	+11
CLF*	10	21	-11

Source: STF finance and Diamond 2016 statutory accounts. *Data excludes buildings.

This summary suggests there is a risk of under investment as the depreciation provision is not being replaced by capital investment at CLF. If our aim is to improve the science, then as technology advances BEIS should be looking to increase its investment in capital assets at these facilities as just maintaining them could lead to a decline in productivity and a loss of world leading status. This should be reviewed in further detail.

4. Recommendations

4.1 Fundamental business model recommendations

Recommendation 1

It is recommended that the governance structure of the facilities and the reporting lines and requirements be considered when the UKRI structure is established. Every opportunity should be taken at that point to simplify the governance of the facilities and consolidate and align the number of KPI's and metrics reported on. This should be a structure that will give the day to day confidence that the facilities are being well managed in the best interests of the UK.

Recommendation 2

A process of consolidation should be undertaken in respect of the number of independent reviews of the Harwell facilities so that a comprehensive review is undertaken every 5 years, linked to major funding stages, and that ad-hoc reviews be limited.

Recommendation 3

It is recommended that both resource and capital budgets be agreed, committed and allocated to each of the Harwell facilities to be managed on an annual basis but with a firm commitment and clarity over a rolling 5 year period.

Recommendation 4

Consideration should be given to how funding is allocated to the Harwell facilities by BEIS, through STFC, such that a degree of flexibility be introduced to allow for movement between capital and resource budgets and an element of 'End of Year Flexibility' of income from one year to the next.

Recommendation 5

Efforts should be made to make 'Grey' industrial access more visible, for example through annual reporting as exemplified by ISIS.

Recommendation 6

A stronger and more joined-up, cross-facility, approach should be taken to industrial engagement. Industrial income is not likely to provide a solution to the funding gaps currently faced by the facilities; but it will provide significant economic and social benefit to the UK.

Recommendation 7

It is recommended that no change to the fundamental business model should be implemented. The peer review process employs the same high degree of rigour to those in place at other equivalent international facilities.

4.2 Operational recommendations

Recommendation 8

Seek advice from experts in optimising performance of complex systems that include change overs of product and process – practitioners not consultants - and invite them to participate in internal performance review activities to challenge existing thinking.

Recommendation 9

Roles critical to the support of experiments, starting with those where recruitment is proving difficult, should be reviewed to ensure that administrative tasks are eliminated where possible or, if essential, being done by administrative staff to reduce the inappropriate burden of non-science activities on scientific staff – even if this requires the recruitment of a limited number of appropriate additional staff. The facility management team need to be free to make their own decisions on balancing administrative and technical headcount within their own budgets.

Recommendation 10

A better procurement model should be established for ISIS and CLF in place of the current UKSBS arrangement. In order to do so in the most cost effective way it should be considered whether the Diamond model could be applied to ISIS and CLF or as a combined procurement office. This could be aligned to other shared services such as collaborative development in the area of e-science, human resources and other back office or regular functions that cross-cut each of the facilities that are currently being duplicated.

Minor recommendations

Minor recommendations can be found in Annex 5.12. These have been suggested to the individual facilities for their consideration.

4.3 Out of Scope Considerations

There are a number of considerations that are likely to affect the Harwell facilities but which have not been dealt with as part of this review:

- **Political** – Changes in governmental priorities could redirect funding away from the general science budget. The current 'Industrial Strategy' however, focuses on key technologies to which the facilities provide the basic research needs e.g. manufacturing processes and materials of the future, biotechnology and leading-edge healthcare. Research and development investment is expected to increase by £4.7bn in total, an extra £2bn per year by 2020-21. The Research Councils will be challenged to distribute any additional income that they receive through this fund and the Harwell facilities will be in competition with other science priorities.
- **UK Research and Innovation** – The seven Research Councils, Innovate UK and Research England are combining to create UK Research and Innovation (UKRI) by 2018. The Research Councils will maintain their science identities but it is not yet known how this will impact on the delivery of the Harwell facilities.
- **Leaving the EU –** There is still a lot of uncertainty as to the impact of the UK leaving the EU. This may impact the UK's ability to interact with EU funding, infrastructure initiatives, recruiting scientists from abroad and the exchange of data. There may also be impacts on

the demand for UK facility usage if UK users are prevented from using other European facilities.

- **Governance structure –** While this review has considered governance from a reporting perspective, it has not addressed the opportunities that might exist from restructuring the facilities into a single consolidated entity.

5. Annexes

5.1 Terms of Reference

Aims and objectives:

To review the operational, organisational and funding models of the three large facilities based at Harwell science campus (ISIS, Diamond and the CLF) with a view to:

- Identifying options for increasing the sustainability and financial resilience of the facilities through: increasing external income; increasing efficiency and productivity; or any other method to be determined by the panel.

The review should look at international comparators in the public and private sectors as well as comparable facilities in other industries (if appropriate).

The aim is to maintain the quality, volume and breadth of science done at the facilities while improving efficiency. Nevertheless, operational changes to increase efficiency may involve some compromises, or gains in one area at the expense of others. The report should highlight the likely scientific impacts of any changes recommended.

The review should give a view as to the current efficiency, usage and performance of the facilities but also suggest innovative and potentially radical models that could be beneficial as well as identifying the potential gains and risks of such options. "Invest to save" proposals should also be considered.

Governance: The review will be overseen by the Large Facilities Advisory Board (LFAB) and will report to BEIS Director General for Business and Science. LFAB can adapt the terms of reference with agreement of the BEIS DG Business and Science.

The review should be led by an independent expert with no current ties to STFC or the large facilities under review. The lead reviewer should be supported by a panel of experts including, but not limited to:

- Industry and/or commercial experts with experience of delivering efficiency, return on investment and maximising income.
- Scientists with experience of delivering or working with large facilities (in UK and internationally).

The review should be transparent, fair and independent at all times. Reviewers should have access to all relevant documentation, information and data required to make fully informed decisions including financial and commercial information (shared on a confidential basis if necessary).

Outputs: The review panel should deliver a written report with associated background material and relevant evidence to BEIS.

5.2 Method

This independent review has been conducted through a number of evidence gathering stages as outlined below. A BEIS Steering Group (Annex 5.4) and Project Team (Annex 5.5) were established to manage the process.

Stage 1 – Information gathering

A desk based literature review was carried out along with information gathering to collate background information and key contacts. This enabled the Project Team to identify and confirm the scope of the project. It was noted that a number of previous reviews had been conducted.

Stage 1 included information requests and introductory meetings with internal facility staff (Annex 5.6). A request for contacts was also issued to each facility to enable the Project Team to recruit expert groups to provide information for the review. Three expert groups were used to provide evidence for this review:

a. Facility Senior Staff (e.g. Heads of Finance, Science Directors, Directors/Heads of Operations)
b. International Benchmarks and National Comparators
c. Expert Users (academic and industry)

Stage 2 – Evidence gathering

The second phase saw requests for information sent to the experts identified in Stage 1. Experts were asked to provide written input into the review in the form of a questionnaire (Annex 5.7 and 5.8). This request provided the evidence for expert analysis (Stage 3) and the review panel (Stage 4).

In parallel to this process, in-depth interviews were carried out with the facility staff, international benchmarks and national comparators to gauge the operational and fundamental business models employed at each facility. A list of interviewees is provided in Annex 5.9 and 5.10.

Stage 3 – Expert analysis

The Project Team included independent experts in finance and commercial operations who analysed evidence collected from across the Harwell facilities and the benchmarks, and conducted in-depth interviews in order to provide the panel with a summary of the fundamental and operational models. The evidence was then presented, along with that from the international benchmarks, to an expert panel that were charged with making recommendations in line with the scope of the review.

Stage 4 – Panel review

The expert panel reviewed the evidence and made recommendations on the fundamental and operational models of the Harwell facilities. The panel was made up of a selection of experts from the international benchmarks, national comparators and both academic and industry users (Annex 5.11).

Stage 5 – Reporting

The review report and recommendations of the panel were presented to BEIS at the end of April 2017.

5.3 List of recent, relevant reviews

Ad hoc reporting

- Big Science: Public investment in large scientific facilities (2007) National Audit Office
- ISIS international review (2013) ISIS international review committee
- Large Facilities Project: Science Requirements Report (2014) BEIS
- ISIS Resourcing report (2014) STFC
- Review of the governance and operation of the Diamond Light Source Synchrotron (2016) Diamond Review Steering Group
- UK Neutron Strategy (2016)
- Red Scientific - ISIS Operational Review Phase 1 Report (Internal review - ongoing)

Regular reporting

- Facility board reporting (individual facility reporting)
- LFIG quarterly reporting (individual facility reporting)
- Annual reviews (individual facility reporting)
- STFC Annual report (all facilities input)
- STFC Impact Report (all facilities input)
- Bibliometric Citation Analysis

5.4 BEIS Steering Group Members

- Dr Stephen Axford (BEIS, Deputy Director, Science & Research Directorate)
- Dr Adam Baker (BEIS, STFC Sponsor Team)
- Mr Gareth Davies (BEIS, Director General, Business and Science)
- Mr Robert Hunter (BEIS, STFC Sponsorship Team)
- Dr Janet Seed (STFC, Associate Director Research and Innovation Strategy)
- Mr David Snell (BEIS, NERC & STFC Sponsorship Team)

5.5 Project Team

- Mr Dick Elsy (CEO, HVM Catapult) – Project Lead
- Dr Amber Vater (NERC) – Project Manager
- Mrs Tamarin Adshead (HVM Catapult) – Project Support
- Mr Ian Collier (HVM Catapult) – Operations Expert
- Mr Kulwant Singh (HVM Catapult) – Finance Expert
- Ms Anna Kalinina (STFC) – Analysist
- Dr Emily Swaine (STFC) – Analysist

5.6 List of informal discussions

General discussions regarding the review were conducted with the following key individuals to gain thoughts on the review scope and areas of potential investigation such as current foreseen barriers and opportunities.

- Dr Brian Bowsher (STFC, CEO)
- Dr Andrew Dent (Diamond, Physical Science Co-coordinator)

- Dr Andrew Kaye (CLF and ISIS, User Programme Manager)
- Dr Andrew Taylor (STFC, Director National Laboratories)
- Dr Neil Pratt (STFC, Head of Light Sources, Neutrons & International Facility Business Operations)
- Mr Marshall Davies (STFC, Council Member and Audit Committee Chair)
- Mr Neil Phimister (STFC, Director of Finance)
- Ms Alison Roblin (Diamond, Head of Procurement)
- Ms Anna Curson (The Wellcome Trust, Head of Operations)
- Mr Tim Livett (The Wellcome Trust, Chief Financial Officer)
- Professor Andrew Harrison (Diamond, Director)
- Professor John Collier (CLF, Director)
- Professor Robert McGreevy (ISIS, Director)
- Professor Sir Michael Sterling (STFC, Council Chair)

5.7 List of questionnaire respondents

- Australian synchrotron
- Atomic Weapons Establishment (AWE)
- Diamond Light Source (Diamond)
- European Synchrotron Radiation Facility (ESRF)
- Evotec
- GlaxoSmithKline plc. (GSK)
- Infineum
- Institut Laue-Langevin (ILL)
- ISIS Neutron and Muon Source (ISIS)
- Japan Proton Accelerator Research Complex (J-PARC)
- Johnson Matthey PLC
- Laboratory for Laser Energetics (LLE)
- Loughborough University
- MedImmune
- National Physical Laboratory (NPL)
- Physical Sciences and Engineering Advisory Panel
- Rolls-Royce
- Royal Holloway, University of London
- Soleil
- St Andrews
- STFC Life Sciences and Soft Materials Advisory Panel
- STFC Physical Sciences and Engineering Advisory Panel
- The Central Laser Facility (CLF)
- The Hamburg Centre for Ultrafast Imaging
- The Paul Scherrer Institute (PSI)
- TWI
- UKAEA
- Unilever
- University of Bath
- University of Bristol
- University of Leeds
- University of Manchester

- US Department of Energy (on behalf of NSLSII Synchrotron Facility and Spallation Neutron Source (SNS)
- University of Strathclyde

5.8 Questionnaires

Background

The UK Government Department for Business, Energy and Industrial Strategy (BEIS) wish to evaluate, through an independent review, the national facilities at Harwell: Diamond Light Source, Central Laser Facility and the ISIS Neutron and Muon Source. The review will not focus on the scientific outputs or impacts of the science undertaken at the facilities, but will investigate the operational effectiveness and fundamental business model implemented by the STFC to provide potential options for increasing the sustainability and financial resilience of the facilities over the long term. The review will therefore have a *commercial focus* rather than a scientific one.

The review aims to collate evidence of how successful the current operational and fundamental business models are and so, along with information requests to the facilities for comparison, we are requesting evidence from comparator facilities. International benchmarks will be used to compare and contrast other operating models to see what can be learnt from them, including consideration of more radical operating models. We are also asking a range of experts from the community of users, other national facilities and international scientific comparators to input into the review.

Process

The information requested in the questionnaires (from facilities, national and international comparators and users) will be presented to a panel of experts who will be tasked to evaluate the evidence and make recommendations to address the following project scope:

A. **The fundamental business model – provision of a national capability**
    a. Overall funding model and financial performance
    b. Academic access model
    c. Non-academic/commercial access model
B. **Effectiveness of high cost operational elements**
    a. Headcount
    b. Capital projects
    c. Procurement processes
    d. Operational “up-time”

The questionnaire below provides the list of questions and therefore topics that we are keen to gain an insight into to address the above scope. These will be sent to the facilities, international and national comparators.

Section I – Fundamental business model

1. How is the facility funded? Provide a breakdown of the capital and resource funding streams (operational and investment)? Max. 1 side A4
2. How is the ongoing capital requirement covered? e.g. upgrades and 'operational' capital. Max. 1 side A4
3. How is forward 'new' capital investment funded? Include a description of the decision criteria for forward planning experiments and major facility upgrades? e.g. Government science policy. Max. 1 side A4
4. What other sources of income support the facility? a. What is the structure of the income? b. Provide a breakdown of sources (e.g. industry, EU, etc.). Max. 1 side A4
5. How is the overall scientific value of the facility assessed against overall and ongoing costs? Max. 1 side A4
6. What are the perceived benefits and barriers to the current business model? Max. 2 sides A4

Section II – Operating model - General operations

1. Describe the decision-making process for workload planning, including: a. How are the overall levels of operation (e.g. scientific support /maintenance/ development) prioritised? b. How are experiments for academics and industry prioritised? c. What approvals are required for an experiment to be authorised? Max. 2 sides A4
2. What are the key operating elements of the facility and their approximate utilisation (as days and as percentage of possible days)? a. Provide brief examples of issues that cause the facility to be out of service. Max. 1 side A4
3. What is the operating pattern of the facility e.g. Single day shift or 24x7 etc.? Max. 1 side A4
4. Who is responsible for the risk of experimental overrun/problems? Max. 1 side A4
5. What percentage of the experiments are routine (requiring little or no customisation of the equipment) and bespoke (requiring significant (£>10k) capital/resource to customise standard equipment that is unlikely to be re-used in a 5 year period)? Max. 1 side A4
6. What percentage of experiments start and finish as per their agreed plan when approved? Max. 1 side A4
7. What are the key performance measures? e.g. beam time availability, efficiency, economic impact. Max. 1 side A4
8. How are current efficiency and effectiveness rates measured at the facility? Max. 1 side A4

9. Outline the current procurement process. Provide a brief example of a recent procurement. Explain how this was approached, the length of time required to procure the item and the final outcome. Max. 2 sides A4

Section III – Operating model – Finances

1. What are the ongoing operating costs (day to day running costs)? Max. 2 sides A4
2 How are the experiments paid for? Max. 1 sides A4
3. How are the commercial charge rates agreed? Max. 1 side A4
4. How are direct, indirect and estate/overhead cost accounted for? Max. 2 sides A4

Section IV – Operating model – Staffing

1. Headcount: please provide details of; a. The total costs for staff within the facility (including number and type of facility staff by grade/band, department and contract length). b. The breakdown between full time heads and full time equivalent contracted resources. c. Contributions made to shared activities (for example, across the campus where the facility is based, the organisation owning the facility, between international facilities). Max. 3 sides A4

Section V – Operating model – Effectiveness

1. Describe any activities, processes or partnerships that could be undertaken in alignment with international comparators that could make better use of the facilities? a. What would the benefits and barriers to these activities be? Max. 2 sides A4
2. What would you identify as the biggest causes of inefficiency and why do they happen? Max. 2 sides A4
3. What are the perceived benefits and barriers to the current operating model? Max. 2 sides A4

User Questionnaire

Section 1 – Personal details

Please specify if you would prefer your response to be anonymised.

Name & position	
Institution	
Summary of your expertise	(max. 200 words)

Section 2 – User questionnaire

1. Describe your reasons for choosing the facility for your experiment. a. Did you have alternative options for conducting your research? A*nd/or* what option would you have if this facility wasn't available? b. Were you provided with the budget cost for using the facility when you sought funding for you research? Max. 1 side A4
2. How was the funding model structured? Include comments on: a. What was the total cost of facility usage (include any breakdown if known)? b. Who covered the costs of your experiment/use of the facility? c. Who is responsible for the risk of the experiment e.g. cost of experimental overrun/problems? d. Was the experiment successful i.e. was the experiment delivered and did the users gain valuable data/results from the experiment? If not, why not? e. Did your usage represent value for money? Max. 2 sides A4
3. Was the agreed physical capability provided? Include comments on: a. Was the quality and capability of support staff as expected? Max. 1 side A4
4. Was the agreed volume (i.e. amount of beamtime) of service delivered? Max. 1 side A4
5. Could the facility be accessed when needed? Max. 1 side A4
6. Can you quantify the impact of your experiment? Max. 1 side A4
7. What are the benefits of working at the facility? Max. 1 side A4
8. What areas of the facility/access could be improved? Max. 1 side A4
9. Have you maintained an ongoing relationship or usage of the facility? Max. 1 side A4
10. Would you use the facility more frequently if there was more time available for usage? Max. 1 side A4
11. What are your views of the funding model for your experiments? Max. 2 sides A4
12. Would your institution consider providing some level of funding support for your experiments in the future? Max. 2 sides A4
13. Would an increase in cost for experimental time have an impact on your estimated future usage? Max. 2 sides A4

5.9 List of 'deep-dive' interviews

Financial and operational experts from the HVM Catapult carried out interviews with key staff at the Harwell facilities and STFC.

- Dr Cristina Hernandez-Gomez (CLF, Division Head - High Power Lasers)
- Dr David Clarke (CLF, Division Head – Lasers for Science)
- Dr Elizabeth Shotton (Diamond, Head of Industrial Liaison)
- Dr Philip King (ISIS, Science Director)
- Dr Ric Allott (CLF, Business Development Manager)
- Dr Rob Clarke (CLF, Group Leader Experimental Science)
- Mr Brian Wyborn (CLF, Head of Operations)
- Mr Gary Robbins (STFC, Head of Operations)
- Ms Jane Tirard (Diamond, Director of Finance & Corporate services)
- Ms Philippa Foster (STFC, Deputy Director of Finance)
- Professor David Stuart (Diamond, Directors of Life Sciences)
- Professor John Collier (CLF, Director – discussions in relation to financial aspects)
- Professor Laurent Chapon (Diamond, Physical Sciences Director)
- Professor Richard Walker (Diamond, Technical Director)
- Professor Sean Langridge (ISIS, Science Director)
- Miss Zoë Bowden (ISIS, Head of Operations)

5.10 List of user and benchmark phone interviews and visits

- Atomic Weapons Establishment (AWE)
- European Synchrotron Radiation Facility (ESRF) – including a facility visit in Grenoble
- Institut Laue-Langevin (ILL) – including a facility visit in Grenoble
- Johnson Matthey PLC
- Laboratoire d'Utilisation des Lasers Intenses (LULI)
- National Physical Laboratory (NPL)
- US Department of Energy (on behalf of NSLSII synchrotron facility and Spallation Neutron Source (SNS)

5.11 Panel membership

Name	Role/Organisation	Organisations relationship to facilities	Potential Conflict of Interest (beyond relationship in previous column)
Mr Dick Elsy (Chair)	CEO, HVM Catapult	Review Project team; Project Lead	Independent
Dr Ben Brown	Office of Science, US Department of Energy	International Benchmark, Diamond and ISIS	Independent
Professor Ian Chapman	CEO, UKAEA	National Comparator	Independent
Dr JT Janssen	Research Director, NPL,	National Comparator	Independent
Professor Paul McKenna	Professor of Physics, University of Strathclyde	Academic user, CLF	Independent
Professor Richard Pattrick	Professor of Earth & Environmental Sciences, University of Manchester	Academic user, Diamond	Chair of Diamond Science Advisory Committee
Professor Andrew Randewich	Chief Scientist, AWE	Industrial user, CLF and Diamond	Independent
Dr Andrew Barrow	Engineering Manager, Rolls-Royce	Industrial user, Diamond and ISIS	Independent
Professor Mark Johnson	Associate Director, Institut Laue-Langevin	International benchmark, ISIS	Independent
Dr Thierry Strässle	Head of staff, The Paul Scherrer Institute (PSI)	International benchmark, ISIS and Diamond	Independent
Dr Jean Susini	Director, ESRF	International benchmark, Diamond	Independent
Dr Chris van der Walle	Research Fellow, MedImmune	Industrial user, ISIS	Independent
Dr Amber Vater	NERC, Senior Programme Manager (Capital)	Review Project team; Project Manager	Independent

5.12 Minor recommendations

General recommendations for the Harwell facilities

a. Investigation into tactical pricing to try and better reflect the value that the facilities offer should be undertaken for industrial proprietary access. This could also include agreements for royalties or share of profits from discoveries made by industry that are subsequently generating positive cash flows to feedback financial successes into the facilities; or from technologies that are developed as a consequence of research and development at the facilities.
b. Explore the opportunity cost of providing increased accommodation on site as limited on-site accommodation currently results in increased costs for transport, administration, and other related expenditure.
c. Dual shift work could be applied during set up/break down of experiments to reduce the amount of time taken and therefore create more up-time in the year.

Specific to ISIS

d. Capital investment on ISIS to upgrade old elements would mean less failures and reduce the downtime – this would ensure more up days and more experimental time and hence less of a lag between application for beamtime and experimental time being undertaken.
e. ISIS data software upgrade – to enable real time observations would allow sample preparation to be done quicker and waste less time between experiments. In addition, there are opportunities for collaboration across the Harwell facilities to benefit from use of the existing supercomputer.

Specific to CLF

f. There seems to be opportunities and interest from industry to engage further with CLF and CLF should explore this.
g. Apply a similar project as the ISIS Red Scientific review of operations looking for on-the-floor bottlenecks to save time and effort.
h. An additional target station on Gemini would significantly enhance the beam time available. This would enable experiments to be assembled and disassembled in one target station, whilst running an experiment at the same time in the other. This would provide significant additional capacity on the most over-subscribed high power laser.

International recommendations

i. User communities noted that there could be improvements in the coordination of 'dark' shutdown periods across international facilities.

Other

j. Industrial representation should be encouraged on all peer-review access panels to strengthen engagement and alignment to the new Industrial Strategy.