N8 Research Partnership

Raising the Return - benefits and opportunities from sharing research equipment

Report for Professor Sir Ian Diamond and Universities UK – Review of efficiency and effectiveness in Higher Education

by Luke Georghiou and Sarah Jackson

The N8 is a partnership of the eight research intensive universities in the North of England: Durham, Lancaster, Leeds, Liverpool, Manchester, Newcastle, Sheffield and York.

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We were delighted to be invited by Professor Sir Ian Diamond and Universities UK to undertake this workstream as part of the Review on Efficiency and Effectiveness in Higher Education commissioned by the Department for Business, Innovation and Skills. We have received significant input and support from colleagues across the sector on this task. We would particularly like to thank those who participated in the interviews and submitted case study evidence, and the contributors to a workshop in Leeds in September to discuss reforms and recommendations. We have also benefited greatly from support and enthusiasm from the funding bodies, particularly Lesley Thompson at EPSRC on behalf of RCUK, and Steven Hill from HEFCE. We would also like to thank Ian Diamond for his detailed comments on earlier drafts, and Chris Hale, Jamie Arrowsmith and Chris Chudziak for their support throughout the project.

We have titled this report "Raising the Return". Through the course of our work it became clear that universities have made considerable progress ensure that maximum value is delivered from the investment in UK science infrastructure, both increasing productivity and retaining the UK's significant international standing in research and to support large and small businesses to develop new technologies, to innovate and grow.

The return to the UK taxpayer is already significant, and with further support the sector is ready to do much more.

Luke Georghiou, Vice President, Research and Innovation, University of Manchester
Sarah Jackson, Director of N8 Research Partnership

17th October 2014

1. Key highlights and conclusions

1. **New, cutting edge science and innovation, increased productivity and maximum value for public investment are being enabled by more efficient and effective deployment of research equipment.** This report catalogues the progress made in the past three years.
2. **Significant progress has been made in developing an infrastructure to support equipment sharing.** This includes over 25,000 items classified on regional databases developed by clusters such as the N8 research intensive universities in the North of England, the M6 universities in the Midlands, Scottish Universities and the Science and Engineering South consortium.
3. **Sharing of equipment and facilities is taking place across UK, at a range of levels, leading to increased research productivity.** There is sharing within large institutions (for example University of Manchester Chemistry Department and Oxford University); sharing of mid-tier facilities (for example the Centre for Genomic Research at the University of Liverpool); while £10m investment from EPSRC has funded five world-leading High Performance Computing facilities shared by 22 universities.
4. **These facilities are also being shared with business to drive innovation.** Using shared equipment at the National Composites Centre, part of the High Value Manufacturing Catapult, has helped Airbus UK register five patents relating to aircraft wings which have enabled cost savings of 20% and a weight saving of 15%. Further, a range of Multi-National Companies and charities have invested over £800m through the HEFCE Research Partnership Investment Fund to create new science facilities and to access university expertise.
5. **New approaches to acquisition of equipment are maximising the value delivered from the science budget.** These include pooling resources to purchase the highest specification of equipment possible, collaborative procurement of maintenance, warranties and service costs; and utilising Government Procurement Service agreements to reduce the cost of utilities.
6. **Sharing is strengthening the UK's collaboration networks.** These include the organic emergence of regional university clusters which will enable greater collaborations and long term investment planning, supporting the sharing of equipment at all universities through a national database (equipment.data.ac.uk), for example a 3D printing suite at Norwich University College of Arts, and supporting the "stickiness" of companies in the UK research ecosystem through the development of translational research facilities.
7. Despite this excellent progress, significant barriers remain. To deliver the full efficiency benefits of equipment sharing, further steps are needed;
   a) **Measurement**
   Systematic measurement of the rates and benefits of sharing will accelerate progress. We propose this should be done through a basket of metrics which include monitoring shared use of TRAC listed-facilities and business use through the Higher Education Business Community and Interaction survey. Importantly, both are existing data sets.
   b) **No-cost incentives in the current funding system:**
   Further incentives are required to accelerate culture change and development of trust between users as a basis for greater collaboration and sharing. These include sharing credit on large grants, funders ensuring flexibility for the capital and operational costs of shared facilities and where appropriate, funding bids to include mechanisms for sharing as key criteria.
   c) **Innovations in research funding policy:**
   Equipment roadmaps should be used to encourage long term capital investment planning. Sharing will be facilitated by smart specialisation at institutional and regional levels and by balancing competition and collaboration across the sector. The Research Councils have a critical role to support this and the broader sharing agenda.

2. Executive Summary

The rationale and progress of equipment sharing

1. Access to leading-edge research equipment supports increased productivity and excellence across the science base, and underpins the competitiveness of the UK economy.

2. As capital budgets have become constrained in recent years, the increased sharing of research equipment has been part of the policy response to ensure that the UK can continue to maintain a world-leading science base.

3. Sharing can yield a number of benefits[1];

- Access to leading-edge equipment: more powerful, latest state-of-the-art machines than would be affordable or fully utilised by one university alone.
- Scientific advances: Leading-edge science is dependent on accessing the most advanced equipment. This can lead to increased productivity and excellence across the research base.
- Competitive advantage for business: Providing access to state-of-the-art research infrastructure is a key to building and cementing links with large multi-national companies, influencing their location decisions, and opening links to SMEs through the value chain.

4. There has been significant progress made by the sector to develop the infrastructure to support sharing and deliver a number of benefits. These include

- Creating equipment databases (over 25,000 items of equipment have been added to databases in the UK since 2011).
- Sharing of facilities within universities (for example the University of Manchester Department of Chemistry and Oxford University).
- Mid-tier facilities providing specialist equipment beyond the reach of individual labs but necessary to perform cutting-edge research (for example the York Bioscience Technology Facility and Centre for Genomic Research at the University of Liverpool).
- New approaches to strategic planning and complementary specialisations by clusters of universities, for example in High Performance Computing and in genomics. These facilities allow larger scale projects to be undertaken that are too immense to handle in individual centres.
- Complementary provision of local facilities, for example through the EPSRC Core Capability call for Chemistry. This enables rapid turnaround on time sensitive projects, allows small scale pilot studies and experimental use of new technologies.
- Sharing of facilities with business, many in key sectors of the industrial strategy – including;
  - Investment of over £800m from companies and charities in university research facilities through the HEFCE RPIF scheme and extensive business usage of mid- tier facilities (for example High Performance Computing);
  - The development of the Catapult networks. For example, equipment at the National Composites Centre (part of High Value Manufacturing Catapult) has helped Airbus' UK register five patents relating to aircraft wings which have enabled a cost saving of 20%, and a weight saving of 15%.
- Formation of clusters of research intensive universities to enable greater sharing of regional level facilities.

1 Georghiou, L (2012), on behalf of the N8 Partnership, Sharing for Excellence and Growth, http://www.n8research.org.uk/assets/14137%20N8%20Sharing%20for%20Excellence%20and%20Growth%20Report_WEB.pdf

- Asset sharing in the social science disciplines, through the UK Data Service, and ESRC policies which ensures primary data collection is not repeated where this data is publicly available. This mirrors RCUK policies for items of research equipment.

5. There have also been significant operational efficiencies achieved including;
- Reducing the costs of equipment through collaborative procurement of maintenance contracts, warranties and service contracts at reduced cost, Government Procurement Service agreements are reducing costs of utilities and the UK Shared Business Service reducing cost of procuring research equipment.
- Ensuring greater load factors and utilisation through businesses transferring equipment for use by other partners and collaborative procurement to purchase the highest specification of facility that could not be afforded or fully utilised by a single university.

6. In addition to delivering operational and productive efficiencies through equipment sharing, there are a number of significant non-monetary benefits and changes that have emerged over the last 2-3 years. These include;
- The development of "translational research facilities" through co-investment by industry and public bodies (for example by the HEFCE RPIF scheme and in the Catapult network). This is supporting the long term development of the science base, including embedding and the "stickiness" of companies within the research ecosystem.
- Supporting universities to share equipment with partners across the research base, through the national register (equipment.data.ac.uk), for example Norwich University College of the Arts (NUA) suites of 3D printers, studios and machinery. This will support the diversity and long-term health of the UK sector, developing research collaborations and enhancing the student experience through research-led teaching across the sector.
- The rapid formation of clusters of research intensive universities will enable greater collaborations and longer term research capital investment planning. This development was organic, and hence more likely to have greater traction and enduring benefits.

7. These arrangements and ways of working have been accelerated over the last 2-3 years, and the very positive step of the planned framework for investment (BIS 2020 Vision for Science and Research[2]) will allow greater optimisation of funding, support further joint investments and greater efficiency and effectiveness of public spending.

8. Evidence collected for this report suggests that the Research Excellence Framework is not a barrier to the sharing of equipment.

Realising further benefits and overcoming barriers

9. Although there is clear evidence of the progress and benefits in equipment sharing, and the sector has developed capability to facilitate greater equipment utilisation, it is important to note that sharing is not a panacea, and significant barriers remain.

10. Sharing can involve substantial transaction costs and is best utilised for larger equipment items. Increased costs can include consumables, maintenance, travel, training and technical support and an additional VAT charge on sharing if the appropriate arrangements are not put in place.

2 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/307989/bis-14-757-consultation-on-proposals-for-long-term-capital-investment-in-science-and-research.pdf

11. These transaction costs are only in part sensitive to the scale of equipment investment under consideration – for example, access arrangements and the provision of technicians for longer hours to create availability are both largely fixed costs irrespective of the size of equipment under consideration. For that reason, formal inter institutional sharing is generally only a viable proposition for equipment of a scale around £1m.

12. In addition, it is important to recognise that sharing arrangements are complex and will take time to optimise. This is on two levels – firstly, the new administrative processes and arrangements that are being put in place (for example VAT Cost Sharing Groups, new policies to host visiting users, new booking systems), and secondly the cultural change that is taking place across the academic community. Universities work in an extremely competitive environment and increasing asset sharing requires significant cultural change. New approaches and benefits from increased co-operation, strategic planning and co-investment will take time to materialise. It is also crucial to avoid compulsory arrangements, where there is no interest or ability for sharing to work effectively.

13. Our research has identified that, despite the excellent progress, significant barriers remain and further steps are needed to deliver the full efficiency benefits of equipment sharing.

14. Firstly we recommend **systematic measurement of the rates and benefits of sharing to accelerate progress**. To drive strategies for increased sharing, and to demonstrate efficient use of assets to stakeholders, a more systematic approach is needed to evidence the impact of equipment sharing. We propose this should be done through a basket of metrics which include monitoring shared use of TRAC listed-facilities and business use through the Higher Education Business Community and Interaction survey. Importantly, both are existing data sets. Both these measures will give indications of the current scale of asset sharing activity and provide a "baseline" for evidencing future progress.

15. Secondly, greater incentives to accelerate academic buy-in and support the cultural change needed for equipment sharing should be considered as follows;

- **Allocation of credit on large grants.** There has been an increasing use of research volume as an entry mechanism for RCUK funding calls and funding allocations. This increases the importance of ensuring that collaboration and sharing are properly recognised in all award databases. This does not mean distributing funding via multiple grants. Instead the partners would agree at the outset an allocation of credit when submitting the proposal - for example the percentage of Principal Investigator and Co-Investigator time on the grant. This may also have additional benefits – it could support career progression for Early Career Researchers and greater diversity through more formal credit to female Co-Is.

- **Funders ensuring flexibility for the capital and operational costs of newly shared facilities.** Given the increased revenue costs of operating a shared facility, together with the significant contributions universities have already made towards new capital items since 2010, we recommend that there should be greater flexibility from funders to vary the institutional requirements for shared equipment items. This could apply to both the purchase costs, and the access and coordination costs. Furthermore, while it is currently the case that access and coordination costs are allowable expenses for RCUK grants this is insufficiently understood, This policy should be publicised in relevant capital calls.

- **Where appropriate, assessment of funding bids should include mechanisms for sharing as an explicit criterion**. This would incentivise long term behavioural change by linking equipment sharing to grant success. This would be less relevant in research grant applications, but could be a core part of capital funding schemes looking at specific infrastructure projects, for example the recent calls in the Great Eight Technology areas.

- **Utilise the VAT Cost Sharing Exemption.** The sector should continue to work together to overcome the complexities and costs of implementing the VAT Cost Sharing Exemption in order to mitigate additional VAT costs which may be incurred through sharing.

- **Utilise the national database and develop communities of practice.** We recommend that all new equipment purchased using public funding sources and over the OJEU threshold will be required to be registered on equipment.data.ac.uk national database. To support best practice, cross Research Council interest groups should be considered for specific equipment classes (for example e-infrastructure and bio-imaging).

- **New mechanisms to support investment planning, smart specialisation and competition and collaboration should be considered.** We recommend infrastructure roadmaps should be produced to form part of the evidence base for RCUK Capital Investment plans. This could support the development of cross-Research Council priority areas and identify long term mechanisms for the funding and administration of mid-tier facilities.

- **The Research and Funding Councils have played a significant role** to progress the sharing agenda and should be resourced to do so in order to incentivise changes in behaviour required.

3. Introduction

3.1 Why is research equipment important and why does it cost so much?

Access to leading-edge research equipment supports increased productivity and excellence across the science base. The increasing cost of maintaining the science infrastructure was originally acknowledged by Government economists in the 1960s who found real-price growth rates per scientists for major equipment of up to 20 per cent per annum in some laboratories [3]. While innovation in instrumentation and the way it is used has caused the price for a given effect or throughput to decrease dramatically, international competition to be at the leading edge of discovery and exploitation of results has tended to outweigh this. This cost of staying at the leading edge was termed the "Sophistication Factor".

3 The Sophistication Factor in Science Expenditure, HMSO 1967 quoted in Georghiou, P & Halfpenny, P (1996), Equipping Researchers for the Future, Nature, 383, October 1996,

Examples of the kind of dynamics affecting instrumentation include [4]:

- Increased performance e.g. – power, resolution, accuracy and throughput of samples
  For example the productivity of DNA sequencing technologies has increased more than 500-fold (1997-2007) [5] and continues to increase.
- New families or classes of equipment
  New equipment has emerged offering novel capabilities and enabling new science not previously possible. These new classes of equipment only partially replace facilities that are currently utilised.
- Increased equipment intensity in a wider range of disciplines
  Physics and Chemistry and associated areas of engineering were traditionally far more capital-intensive than other fields but increasingly the life-sciences have been catching up. In areas such as imaging there has been a strong convergence in equipment requirements. This is in itself a source of new interdisciplinary interactions and benefits.

The increasing cost of equipment and desire of the UK to maintain a leading edge science infrastructure has implications for public funding mechanisms. This is a well-rehearsed debate of the last twenty years: "equipment required to remain competitive in the field is becoming relatively more expensive, and unless new funding is found, existing allocation and management systems will have to change" (ibid, 1996, p. 664).

3.2 Why is sharing important?

3.2.1. Custom and practice

Sharing of equipment is a normal part of the practice of science. It is an established way of working for researchers, sharing equipment across single departments, with business, with other universities and with international partners.

It is useful to separate the main types of circumstance in which this takes place. Broadly speaking sharing can be understood as taking place at three levels:

- Casual access – where researchers are allowed occasional use of spare capacity on assets principally used by other researchers;
- Shared ownership – whereby assets are acquired jointly by or on behalf of more than one research team, possibly across institutions, with an explicit intention for joint use; and
- Central national or regional facilities which provide controlled access or research services.

It is also the case that sharing of equipment takes place with industrial partners, as companies seek to maximise return on capital. Joint investments have been made on university campuses to support translation research, including through the recent HEFCE Research Partnership Investment Fund, and through public investment in research infrastructure in the Catapult Centres to support product development.

3.2.2. Research capital reductions and policy responses

Over the years, especially in times of economic constraint, research capital funding has tended to be subject to additional restrictions, for example funding bodies imposing requirements for matched funding from industry or from institution's own resources. The current severe restrictions on capital funding (for RCUK an initial 53% reduction in capital allocation in the first year as part of the 2010 spending review settlement) have resulted in an impetus towards greater efficiency in

4 Georghiou, P & Halfpenny, P (1996), Equipping Researchers for the Future, Nature, 383, October 1996
5 Genome Synthesis and Design Futures; Implications for the US Economy, BioEconomic Research Associates, 2007

the use and deployment of equipment. The RCUK/UUK Task Group on financial sustainability and efficiency subsequently recommended:

"...greater intensity of utilisation of assets by HEIs should be encouraged, particularly the sharing of research equipment and facilities."[6]

The implementation of this recommendation was set out in March 2011 in the RCUK document "Ensuring Excellence with Impact" [7] which introduced a requirement for all applications for equipment below the Official Journal of the European Union threshold (€125,000 net of VAT) to be subject to both an evaluation of the use of existing relevant capital assets and to a contribution of percentage of the cost from non-Research Council funding. For items above that threshold a business case is required including consideration of how the investment fits with departmental, regional and national strategy, with an indication that investments will be made strategically across the research base. RCUK stated that it would work with the research community to develop methods of pooling resources in the best location.

3.2.3. What are the benefits and barriers to sharing as a policy response to changes in funding?

Although sharing equipment is part of the "custom and practice" of scientific research, greater understanding was needed on the benefits and the barriers to support greater equipment sharing as a key policy response to reduced capital funding. The EPSRC provided funding to look at how to enable long term strategic, organisational and financial changes needed [8].

Sharing for Excellence and Growth: Professor Luke Georghiou, for the N8 Universities, funded by the EPSRC (2012)

There are positive benefits of sharing equipment, of 3 main types

- Creating concentrations of research activity where collaboration between and within universities and with industry can drive excellence and impact in research
- Increased efficiency by reducing the number of items that need to be purchased and obtaining higher load factors on existing items; and
- Allowing capital items too large for a single institution to be acquired and hence solving the problem of indivisibility of asset

These benefits can only be obtained if certain pre-conditions are satisfied:

- Trust is built between the holders and users of equipment through common objectives and assurances about treatment of samples and equipment;
- Potential users need to be able to locate the equipment they need and that equipment must have available capacity in the desired period; and
- A governance and management framework needs to be in place to ensure that the additional costs associated with sharing are adequately covered and allocated, service levels clarified, and that intellectual property, health and safety, liability and training issues are organised; and
- Proximity and travel time are factored into the calculation, depending upon the likely frequency, intensity and duration of use.

6 Report of RCUK/UUK Task Group on Financial Sustainability and Efficiency in Full Economic Costing of Research in UK Higher Education Institutions, June 2010, Para 81.

7 RCUK, Efficiency 2011-2015: Ensuring Excellence with Impact, March 2011

8 Georghiou, L (2012), on behalf of the N8 Research Partnership "Sharing for Excellence and Growth" http://www.n8research.org.uk/assets/14137%20N8%20Sharing%20for%20Excellence%20and%20Growth%20Report_WEB.pdf

In view of these conditions, a pragmatic approach to the sharing agenda is critical.

- *"Even with highly efficient arrangements in place, sharing can only succeed if the circumstances are right: Sharing inevitably involves substantial transaction costs which are only in part sensitive to the scale of equipment investment under consideration – for example, access arrangements and the provision of technicians for longer hours to create availability are both largely fixed costs irrespective of the size of equipment under consideration"*
- *"Sharing is far more likely to be an economic proposition when larger items are under consideration. There is no fixed cut-off as maintenance and other requirements vary but it is unlikely that equipment below a threshold of between £200-500k will be viable for anything beyond casual opportunities"* (page 1)

The report demonstrated that although equipment sharing is not a panacea to reduced levels of capital funding, in certain circumstances it can lead to greater access to leading-edge research equipment. Importantly, the increased costs associated with sharing were also highlighted, demonstrating the need for additional recurrent funding if the benefits were to be realised. There has been a significant programme of work across the sector over the last 3-4 years to support increased equipment utilisation, which will be documented as part of this report.

3.3. Scope of this report

3.3.1. Definitions

In order to examine the efficiencies derived from increased sharing of equipment, the following definitions have been used [9]:

Productive Efficiency: achieving greater output (quality or volume) for the same, or proportionately less, input.
Operational Efficiency: Delivering the same output for reduced input

3.3.2. Analytical Framework

These definitions have been applied to create an analytical framework to demonstrate the efficiencies from equipment sharing;

Analytical Framework – Productivity and efficiency benefits from asset sharing

Productive Efficiencies resulting from equipment sharing:			
New science and technical advances	**Collaborations with industry**	**Multi-disciplinary working**	**Human Capital**
Access to equipment of a higher specification than would have otherwise been affordable	Industrial usage of equipment and any new industrial collaborations	New collaborations that have emerged across disciplines	Improved training & skills (students, researchers and technicians)
Operational Efficiencies resulting from equipment sharing:			
Cost of Equipment		**Equipment utilisation**	
Reduction in procurement costs – purchase, service or maintenance costs		Increasing load factors on existing equipment	

9 Definitions from Jackson, S (2013) "Making the Best Better – Report for the Department for Business, Innovation and Skills", http://www.n8research.org.uk/assets/files/EfficiencyReportFinal.pdf

A case study approach has been adopted to identify and evidence the benefits and efficiencies.

Many of the case studies refer to research facilities, which often encompass a number of items of major equipment. There will be other smaller items associated with this research, for example sample preparation, and computing equipment and software for analysis of the data.

3.3.3. Scope of the report

This report forms part of the Universities UK Review of Efficiency and Effectiveness in Higher Education, chaired by Professor Sir Ian Diamond. The focus is on the sharing of research equipment, although this work will draw out lessons that may be applicable for sharing other assets or services in higher education.

4. What benefits have been achieved? - Productive efficiencies

Through our research we found evidence of four types of productive efficiency – new science and technical advances; collaborations with industry; multi-disciplinary work; human capital development.

4.1. New science and technical advances

Ensuring the UK can remain at the leading-edge of research is dependent on access to the highest specification of equipment. There is significant evidence to demonstrate new science and technical advances are emerging from shared facilities at departmental, regional and national levels.

4.1.1. Departmental sharing

Departmental and intra-institutional sharing of assets can have significant benefits, particularly around maximising utilisation within large research groups and supporting cross-disciplinary research within large universities. Access to equipment at departmental level is fundamental to scientific progress;

- To enable small scale pilot studies and ensure essential and complementary data collection not requiring the highest field strength can be made cost-effectively and efficiently.
- To ensure that key scientific questions can be addressed quickly, which is a crucial concern in this fast moving field.
- To allows experimental use of new technologies, and encouraging the development of new protocols and applications of the new technologies.
- To contribute to the education of users, and training of experts, of critical importance to the UK science base.
- To maximise the efficient use of the highest specification facilities, for example the Diamond Light Source.

One such example is The University of Manchester Chemistry department which has over 60 academic staff, the vast majority of whom are research active. Much of the equipment that supports the research activity is shared. There are 4 major shared services;

1. X-Ray Crystallography - Supports activity of 30 research groups, including multiple European research council award holders and groups funded by industry.

2. NMR spectroscopy –40 research groups including research council and industry funded research
3. Mass spectrometry – 40 research groups and part of the Michael Barber Mass Spectrometry centre
4. Elemental analysis and separations – 40 research groups

This highly efficient use of shared equipment underpins all research in the Department including advances relating to a number of key economic sectors - nuclear, fine chemicals, information processing and information storage, pharmaceuticals, and in materials such as graphene and nanofabrication.

A further example is provided by **Oxford University** [10]. They have recently funded 17 initiatives, with ESPRC funding grants, matched by local cash and or in-kind support, in order to support greater utilisation of facilities. These small allocations of funding were utilised across a number of projects, for example to extend the operational capacity of an NMR spectrometer to allow multiple-sample data collection overnight, and the relocation of £300,000 worth of laser fabrication equipment to a larger laboratory providing access for several research groups. These projects, utilising relatively small funding allocations

- increased effectiveness - machines available at higher capacity; new science through collaborations across disciplines e.g. on the NMR spectrometer now has a higher sample throughput which means service time saved on the instrument can be made available to suitably trained research chemists, thus further promoting their research activities
- increased efficiency (e.g. machines operational for extended periods, remote access) – for example the estimated use time per month of the small laser facility is now up from 60% to 80%
- stimulated new approaches to sharing equipment, which will have benefits in the longer term

4.1.2. Centralised facilities in HEIs

As well as sharing equipment in universities, underpinning capability and expertise can also be shared, for example in statistics, high performance computing and data management, providing an environment for increased collaborative research across disciplines. Sharing can therefore drive greater world class excellence and impact of research across a range of areas.
There are a number of examples of institutions who have made progress in centralising specific facilities in order to achieve research outcomes. These include;

Centralised facilities and sharing within institutions

- New Centre for Genome Enabled Biology and Medicine at Aberdeen University – instead of purchasing two machines, one superior machine is being installed within a new Centre which will
- Ensure high occupancy rates of around 75% once fully operational (around the maximum for a machine of this nature)
- Reduce costs per sample by 30-40% through pooling samples in a single run
- Create new UK-led scientific advances – for example through biologists bringing in ecologists to use genomics, which researchers report is revolutionising the discipline

- University of Birmingham: Central Equipment Hubs in Mass Spectrometry, High-throughput sequencing and Microscopy – programme of work to understand and manage equipment categories across institutions

10 From: Jackson, S (2013) "Making the Best Better – Report for the Department for Business, Innovation and Skills", http://www.n8research.org.uk/assets/files/EfficiencyReportFinal.pdf

- Creating hubs of facilities – an integrated suite of facilities (for example functional genomics equipment) co-located to provide bigger and better services, increase utilisation rates and reduce duplication
- Create pathway for decision making on updating kit: when refresh is needed academics referred to most appropriate piece of equipment– reduces demand on research councils and increases utilisation of existing estate
- Pools of technicians are trained to increase skill levels, create a pool of expertise and provide better coverage for researchers across the institutions
- Programme of apprenticeships on Advanced Instrumentation training with local FE college

From: Jackson, S (2013) "Making the Best Better – Report for the Department for Business, Innovation and Skills", http://www.n8research.org.uk/assets/files/EfficiencyReportFinal.pdf

4.1.3. Mid- Scale facilities - High Performance Computing facilities

In 2012 the EPSRC funded five new high performance computing (HPC) clusters, investing £8m of capital and £2m revenue funding to support HPC provision at 26 universities. These facilities are all shared, ensuring maximum efficiency for provision of HPC within the research base. Some examples of the new science that is being taken forward through the availability of leading edge computing capability are;

Emerald - shared by Bristol, Oxford, Southampton and UCL universities
- Researchers at UCL are working with GPU specialists at Oxford to optimise the performance of a tsunami simulation code.
- Scientists at Bristol are investigating how mutations of a key enzyme in H1N1 (the 'Swine influenza' virus) lead to the development of resistance to current antiviral flu treatments
- Scientists at Imperial College London have been able to achieve unprecedented levels of accuracy in computational fluid dynamics, specifically relating to Unmanned Aerial Vehicles, allowing engineers to understand complex flow patterns and thus perform aerodynamic design, without flying an aircraft or even starting up a wind tunnel.

N8 HPC – shared by Durham, Lancaster, Leeds, Liverpool, Manchester, Newcastle, Sheffield, York
- Enabling for the first time the realistic simulation of the new generation of fast switching high efficiency power modules for the power electronics industry.
- Supporting more accurate simulations to improve the design of wind turbines and increase their efficiency and operating performance.
- 3-D modelling of materials performance in fusion energy, where analysis (which would have taken eight months to achieve with commercial software on a high-spec workstation) was solved with open source code on the N8 HPC facility in one day.

4.1.4. Mid- Scale Facilities – Life Sciences

Universities across the UK are host to medium scale facilities of national and regional importance to the science base. These provide a route to cost-effective access to equipment which is too expensive to be provided through single investigator grants. This is an area where a significant amount of sharing takes place, maximising utilisation of these specialist facilities. The following examples demonstrate the leading edge science being undertaken;

Centre for Genomic Research, University of Liverpool – providing access to multiplatform sequencing and array technologies – these are priced beyond the reach of individual labs but necessary to perform cutting-edge genomic research, for example

- New and improved bioinformatic pipelines
- Novel published genomic data sets including *de novo* sequencing of non-model organisms
- Improved methodologies for metagenomic analysis.

This facility also underpins a number of key strategic research priorities at the University and supported "the development of in-house expertise that has led to advances in biological and bioinformatics research", as one respondent explained.

University of York Bioscience Technology Facility – providing state of the art equipment, training and services in biosciences research. On average, 30 different external academic groups and 20 commercial organisations use this facility each year. The Facility has supported a range of new science and technical advances including

- Method Development- work on label-free mass spectrometry, protein solubility screen, flow cytometer sorting of pollen grains, and algal cells – range of different areas
- Applying emerging technologies- method development work with Brukker (global equipment manufacturer) and Phase Focus (SME in Sheffield). Breadth of biology and department means significant range of applications for new methodology

Scottish Universities Life Sciences Alliance (SULSA) –22 leading edge life sciences facilities that are open to all researchers at SULSA universities. The research tools that have been created at these facilities since 2012 are also now available to the community, for example

- panel of monoclonal antibodies of medical importance, new controller software for bio-imaging applications, novel metabolomics analysis tools,
- new methodologies in identifying and analysing protein binding kinetics.

UCL Genomics Centre and Barts Genomics Centre – the two centres signed a memorandum of understanding in 2008 committing to share equipment access to establish mutually complementary resources and avoid inefficient duplication. This enables larger scale projects that are too immense to handle as individual centres, and a greater volume of work is possible as projects can be completed at an accelerated rate. This includes

- International study on links between genomic signatures & autoimmune disease;
- European study to identify genomic variants associated with celiac disease.

4.1.5. National facilities

The Diamond Light Source on the Harwell Science and Innovation Campus in Oxford is the UK's national synchrotron facility and is a medium energy source. It is the largest UK-funded scientific facility to be built for over 40 years. The applications of synchrotrons cover virtually all sciences – for example fundamental physics, engineering, environmental, medicine, biology, chemistry and cultural heritage. There are a range of projects operating at the forefront of ground-breaking research, for example;

- pioneering research into developing new cancer therapies that can be tailored to the individual patient
- working with metal munching earthworms to establish new ways to clean up polluted soil and improve the environment
- solving the molecular structure of the foot and mouth disease virus, leading to the development of an effective vaccine
- helping to preserve the centuries old timbers of King Henry VIII's favourite warship, the Mary Rose, for future generations.

The facility is operated by the Science and Technology Facilities Council for the academic community – in 2012/13 there were 2,500 unique users who made 6,300 user visits to the facility.

4.2. Collaborations with industry

The second type of productive efficiency supported by asset sharing is collaborations with industry. This is significant as joint provision of infrastructure is key to cementing links with large multi-national companies, influencing their location decisions, and opening links to SMEs through *the value chain. As Haskell et al highlight "There is general evidence that multi-national enterprise (MNE) location is affected by the quality of a nation's science base. The most compelling evidence specific to the UK is the pharmaceutical MNEs locate their labs near to highly-rated university Chemistry departments"*[11] .

4.2.1. Strategic Partnerships - UKRPIF

The infrastructure of the UK science base provides competitive advantage for industry partners. This is evidenced by the significant sums companies are willing to invest to facilitate this access. The UK Research Partnership Innovation Fund (UKRPIF), managed by Higher Education Funding Council for England (HEFCE) has unlocked private investment in capital facilities of over £800m, stimulated by public funding of £300m.

UK Research Partnership Innovation Fund (UKRPIF)

The UK Research Partnership Innovation Fund (UKRPIF) is a fund launched in March 2012 for UK universities seeking investment in long-term capital projects that secure and accelerate significant private sector or charity co-investment in strategic research partnerships. The fund is managed by Higher Education Funding Council for England (HEFCE), and to date

- A total of £301m UKRPIF project funding has been invested in 22 projects in the first two Rounds of the UKRPIF scheme.
- This has leveraged £816m co-investment from research partners- £321m is from companies, whilst £515m is from charities and other not-for-profit sources

The partners cover a range of sectors, including aerospace, automotive, petrochemicals, fast moving consumer goods, healthcare, telecoms, IT, research, marine and energy generation. Some examples of the joint facilities and research equipment benefiting from RPIF investment;

King's College London – Research and Innovation Hub in Cancer This project aims to create a unique Research and Innovation Hub at the Cancer Centre at Guy's Hospital, London in collaboration with Guy's Hospital. The project includes an investment of £34,700,000 between 2013/14 and 2014/16 in equipment to enhance an integrated approach to clinical and research work. This includes using key new technologies, such as technology to facilitate better molecular and clinical data collection, and making use of emerging imaging and 'omics technologies to follow tumour regression, progression and underlying molecular context.

Total UKRPIF funding awarded: **£15,000,000**
Total co-investment committed: **£32,600,000 (from Guy's and St Thomas' Charity)**

University of Liverpool: The Materials Innovation Factory Liverpool is establishing is a new type of 'factory' that aims to push manufacturing to a more advanced level and support world leading research in Advanced Materials. The project includes a commitment of £6,042,000 to

11 Haskel, J; Hughes, A; Bascavusoglu-Moreau, E (2014) "The Economic Significance of the UK Science Base", A report for the Campaign of Science and Engineering. http://sciencecampaign.org.uk/UKScienceBase.pdf

equipment for the improving and streamlining analysis of advanced materials, including the programmed synthesis of organic materials and the analysis of microbial populations by direct DNA sequencing. Shared space for academics & industry, plus "analyst hotel" which provides 2/3 month incubation space. Approximately 150 Unilever staff will be co-located with university researchers as part of this facility.

Total UKRPIF funding awarded: **£11,000,000**
Total co-investment committed: **£22,000,000 (from Unilever)**

University of Sheffield: The AMRC Factor 2050 Sheffield are developing an engineering 'Factory of the Future' capable of producing client-specific products, and able to accommodate rapid changes in product design, to support industrial growth in the UK and to improve the UK's exploitation of world-class research in this area. £18.8million investment (£7.8million of which is in kind) is being made in equipment capable of producing exactly the volume and type of products desired by clients, and accommodating rapid changes in product design, for items from aircraft to mobile devices.

Total UKRPIF funding awarded: **£10,000,000**
Total co-investment committed: **£33,100,000 (from the AMRC Industrial Board)**

4.2.2. Industry collaborations & usage of mid- scale facilities

The evidence collated for this report found significant levels of industry collaboration through mid-scale facilities. A range of engagements were cited, which can be broadly classified as follows; Collaborative Research: this was the most common arrangement, where companies were undertaking joint projects with university researchers, benefiting from both the access to leading-edge equipment and academic expertise. For example at the Centre for Genomic Research, University of Liverpool collaborative projects are undertaken with AstraZeneca, Unilever and Shell. At the N8 HPC currently 20% of projects have an industrial component, whilst the Emerald HPC has directly engaged with SMEs including NAG Ltd., Zenotech and Cresset Biomolecular Discovery Ltd. When allocating computing resource, priority is given to collaborative work, especially between academic partners and industry

Training and Conferences: Companies using the N8 HPC include EDF, National Grid, AXA, Caterpillar, AstraZeneca, Johnson & Johnson and Tokamak Solutions are using the facility collaborating with academics and developing the capability to use HPC in their businesses. The UCL Genomics Centre and Barts Genomics Centre offer services to industry users and also work closely with equipment and reagent suppliers, hosting technology conferences, training, and negotiating academic discounts on behalf of the UK community.

Flexible Options (attractive for SMEs) The University of York Bioscience Technology Facility has 20 different commercial users per year, and 67 in the last 6 years. The Facility provides very flexible arrangements to support that engagement, including Contract Research, Knowledge Transfer Partnerships, CASE studentships and research collaborations. This is particularly attractive to SMEs who like the flexibility and the range of options available. Large companies also use the facility, for example AstraZeneca, and also Government labs, for example the Food and Environment Research Agency.

4.2.3. High cost of staying at the leading edge

Often larger scale collaborations and strategic partnerships can be stimulated by short engagement for a specific service using university equipment. For example, an initial interaction with GlaxoSmithKline, using the Electron Paramagnetic Resonance (EPR) national facility at the University of Manchester for contract research has grown to a funded Research Fellow within the Chemistry department. As one respondent commentated *"universities provide equipment that industry partners do not realise they need or cannot afford to maintain on their own"*.

A hybrid approach is taken by PZ Cussons, a global fast moving consumer goods company, with the corporate headquarters based in Manchester. For their personal wash category (brands like Imperial Leather and Original Source) they have a purpose built innovation and manufacturing facility, based in Agecroft, Manchester. The work undertaken is mainly wet chemistry and benchwork, where the individual capital items are worth approximately 20k each. Given the high capital cost of state of the art research equipment, PZ Cussons have a strategy of working with universities where capital items are not available in house- for example high-end analytical techniques.

PZ Cussons – capital facilities and approach to sharing

Background

PZ Cussons is a multinational consumer good business in 5 core categories - personal care, home care, beauty, food and nutrition and electricals. The global headquarters is based in Manchester, including the personal wash and personal care businesses. There are approximately 250 people working in the UK on brands like Imperial Leather, Charles Worthington, Original Source and Carex.

All the commercial functions of the business, including Sales and Marketing, are undertaken in Manchester alongside the fragrance business (Seven Scent). There is also a large innovation and manufacturing facility based in Agecroft, Manchester employing around 200 staff. This facility drives the R&D pipeline for the personal wash category.

Human Capital and Research Equipment

The innovation and manufacturing facility was purpose-built approximately 5 years ago. The major considerations for siting this facility in the UK were;

- Human Capital: over 200 years of collective experience in the R&D team
- Innovation eco-system: established network of academic partners and collaborators for R&D activities.

The human capital and position within an innovation ecosystem are linked to a broader global network. These intangible assets are extremely hard to replicate in another market, and would take a number of years to do so.

R&D interests and high value research equipment needed to support R&D strategy

The work undertaken at Agecroft is mainly wet chemistry and bench work, and the core facilities are

- evaluation sensory booths,
- humidity controlled, evaluation laboratory – shine and light testing,
- analytical and formulation laboratories.

The individual capital items (for example microscopes) are worth approximately £20k each. Given the high capital cost of state of the art research equipment, PZ Cussons have a strategy of

working with universities where capital items are not available in house (e.g. freeze fracture of formulations or high end analytical techniques).
Partnerships with universities include

- University of Liverpool and high throughput formulation capabilities
- Flight simulator at University of Liverpool– measuring alertness and how it can be affected by using different fragrances.

4.2.4. Catapults: High Value Manufacturing Catapult & Transport Systems Catapult

The Catapult network are a series of physical technology and innovation centres where UK businesses, scientists and engineers work side by side on late-stage research and development. There are seven catapult centres, many of which provide access to state of the art research facilities, some pre-existing, for example the high value manufacturing and offshore renewable energy catapults, whilst others are newly created. Some examples of the equipment available at the Catapult networks, and level of industrial partnerships include;

High Value Manufacturing Catapult – National Composites Centre

- The National Composites Centre supports the development of 4 of the Great 8 Technologies: Advanced Materials, Robotics, Nanotechnology, Energy / Energy storage
- All equipment in the facility is shared and available for use by industry as part of membership arrangements or on a pay-as-you-go basis.
- Global companies like Airbus, Rolls Royce provide long term contracts and funding security, with over 100 SMEs using the facilities
- Working with the NCC has helped Airbus' UK operation to increase the number of engineers trained in composites, increase productivity by 10%-15% and register five patents relating to aircraft wings which have enabled a cost saving of 20%, and a weight saving of 15%.

High Value Manufacturing Catapult - Centre for Process Innovation

- National centre with £90m of innovation infrastructure and assets located on four sites to support process manufacturing industries
- Prototyping facilities at the National Printable Electronics Centre including in materials, ink formulation and optoelectronics were utilised in a programme involving Leeds, Liverpool, and Manchester universities and companies such as bio-photonics light therapy specialist PolyPhotonix, global packaging supplier Chesapeake and security print manufacturer Tullis Russell.
- SMEs including start-up company PolyPhotonix and Plaxica, a spin out company from Imperial College, have accessed the facilities to test, develop and scale-up new processes and products in an infrastructure unaffordable to new enterprises.

Transport Systems Catapult

- Created in 2013, the Transport Systems Catapult aims to exploit business opportunities for intelligent mobility. In contrast to the High Value Manufacturing Catapult which operate their own facilities, the Transport Systems Catapult works with partners across the science base to utilise existing infrastructure, including
  - State-of-the-art 'MK Data Hub' which will support the acquisition and management of vast amounts of data relevant to city systems from a variety of data sources, including data about energy and water consumption and data acquired through satellite technology, social and economic datasets, and crowd sourced data from social media
  - High Performance Computing capability from the Science and Technology Facilities Council
  - Strategic partnerships with 14 universities selected based on their relevant expertise, infrastructure and coverage across the range of transport systems.

4.3. Multi-disciplinary work

The third productive efficiency benefit from equipment sharing is new collaborations and increased possibilities for multi-disciplinary research across subject disciplines. This occurs both across the natural sciences and through data sharing within the social sciences.

4.3.1. Equipment sharing in science and technology

The case studies collected for this report demonstrate the breadth of shared equipment usage across disciplines, for example

- NMR and Mass Spectrometry equipment shared in the University of Manchester supports work that crosses the chemistry-life sciences interface, while X-Ray Crystallographer machine has supported work published in Science journals (Nature), and Physics, Chemistry and Materials journals
- The relocation of £300,000 worth of laser fabrication equipment to a larger laboratory at Oxford University has provided access for several research groups and increased the capacity of this system so that it can now support several lines of research. Projects have involved researchers from four departments (Chemistry; Materials; Atomic Laser Physics, Astrophysics) alongside Engineering.
- University of York Bioscience Technology facility has a user base from physics, chemistry and archaeology, in addition to biology, and the breadth of facility allows a "one stop shop" approach, meeting the needs of a range of disciplines. Forty three research publications in last 3 years have facility staff as co-authors, of these around one quarter include other departments or other universities
- N8 High Performance Computing facility has over 100 projects registered over a wide range of research areas, including chemistry, engineering, earth sciences, electronics and computing, maths, life sciences and physical sciences.

Centre for Genomic Research, University of Liverpool – supporting multi-disciplinary projects

The CGR is involved in numerous collaborative, multidisciplinary projects with academic groups, industry and government departments. These projects span biomedical and clinical projects (addressing cancer genomics, transcriptomics, human genetics, outbreak analysis); genomics, population structures and evolution of pathogens and their hosts; nutrigenomics, health and 'wellness'; pathogen detection; biotechnology; environmental and evolutionary biology; mechanisms and biomarker discovery in pharmaco and eco-toxicology and disease resistance; biofuel species and sustainable energy production; agri-tech, including food security, processing and husbandry; archaeology, anthropology and zoology, including sequencing and profiling of ancient DNA.

4.3.2. Asset Sharing across Social Sciences disciplines

The Economic and Social Research Council have supported data sharing across UK social science over a number of decades through "the data archive". This service is now enhanced, providing a much richer offering: http://ukdataservice.ac.uk/. The UK Data Service is a comprehensive resource funded by the ESRC to support researchers, teachers and policymakers who depend on high-quality social and economic data.

This provides a single point of access to a wide range of data including large-scale government surveys, international macrodata, business microdata, data made available for secondary analysis from primary research, qualitative studies and census data from 1971 to 2011. All are backed with extensive meta data, support, training and guidance to meet the needs of data users, owners and creators.

It has been a consistent rule that any ESRC applicant whose research proposal involves funds for primary data collection must establish that the required data are not already publicly available [12]. This mirrors the equipment policy recently introduced by RCUK. Secondly ESRC also requires data collected on an ESRC grant must be made available for secondary analysis across the research base. This has a number of gains:
– maintaining the high quality of research output through the possibilities of replication
– creating a culture of data sharing (not data hoarding)
– supporting high quality teaching through using data from cutting edge research
– ensuring efficiency through no duplication where data already exists

The UK Data Service is now providing a basis of expertise for the UK's national Big Data strategy. In 2013 it received funding to establish the Administrative Data Service, (as part of the broader Administrative Data Research Network) facilitating research access to routinely collected data from businesses and local governments in a way that maximises research outputs while protecting personal information. It will also play a coordinating role in two further phases of the Big Data Network.

UK Data Service – Sharing assets across the Social Sciences

The UK Data Service provides an easy-to-use web portal to an expanding range of high-quality digital data including UK census data (1971 to 2011), government surveys, international macrodata, business microdata, longitudinal studies, qualitative resources, and data from individual research projects. All are available to search and download from a public website, and come packaged with detailed metadata, related documentation and clear citation information. They are backed with expert guidance, training and helpdesk support to meet the needs of researchers, teachers, data owners and other stakeholders. The Service and its predecessors, along with the ESRC Research Data Policy, has ensured that the social sciences remain at the forefront of a data sharing culture, while fully protecting the privacy of data subjects.

These investments have returned numerous benefits to those who use data:
- Over 24,000 users – from all sectors and across the globe – are registered with the UK Data Service
- Data are being downloaded a rate of 61,000 datasets a year.
- Users can look in the data catalogue for a list of academic publications that have used each data series (for example, the Quarterly Labour Force Survey).
- There are over 100 research case studies demonstrating how data are used in specific projects, for example research into alcohol pricing policies, business labour practices during the recession, and buy-to-let landlords.
- An additional 32 teaching case studies showcase how teachers are integrating real-world data into their studies to strengthen both research skills as well as provide an evidence base for economics and social science courses.
- A 2012 independent report of ESDS (the precursor to UK Data Service) found that for every pound invested in data and infrastructure, the Service returns at least £5.40 in net economic value to users and other stakeholders.
- A 2014 report commissioned by Jisc found that the Service generates a healthy return on investment, as it *"facilitates additional use which realises additional returns that could be worth some £58 million to £230 million over 30 years (net present value) from one year's investment expenditure – effectively, a 2.5- to 10-fold return on investment."*

12 http://www.esrc.ac.uk/_images/Research-Funding-Guide_tcm8-2323.pdf

There are currently more than 24,000 users – from all sectors and across the globe –registered with the UK Data Service. Data are being downloaded a rate of 61,000 datasets a year.

4.4. Human Capital: skills development and benefits for teaching

The final productive efficiency and benefit from equipment sharing is around the development of human capital and high level skills for the economy. Our findings demonstrated the development of scientific skills and expertise as critical, both to facilitate the sharing of equipment and as a benefit arising from that sharing.

. The case studies highlighted 3 main types of skills development;

- **Undergraduate skills development:** For example, the Diamond Light Source Facility hosts an outreach programme for 30 undergraduate interns per year, who are given one-two month project and training opportunities. Undergraduate teaching is also supporting by the Bioscience Technology Facility at University of York, where final year undergraduate projects are completed using equipment in the Facility.
- **Postgraduate skills development:** There was significant evidence of use of facilities by PhD researchers. For example PhD students regularly use the facilities at UCL Genomics and Barts Genome Centres, either in collaboration with staff, or as trained and independent users of the equipment. Furthermore, several hundred students utilise the facilities at the Diamond Light Source for PhD studies and are trained by beam-line scientists. The highly-trained technical staff and engineers who develop their skills at Diamond in some cases move to companies who require such expertise. Approximately 15% of Scottish Universities Life Sciences Alliance PhD students have accessed a SULSA facility out with their university every year.

There were also a number of examples of skills development at Masters level. For example, The University of York have established an MSc course in Bioscience Technology to develop skills base for the technology of the future, while MSc students at UCL Genomics and Barts Genome Centres benefit from tours of the facilities and receive lectures from experienced staff based at both sites. Finally, the Centre for Process Industries and the National Industrial Biotechnology Facility, part of the High Value Manufacturing Catapult, has supported courses at the University College London using laboratory findings to discuss how students would upscale their process to ensure that it is robust and cost-effective at a larger scale, attractive for potential investors.

- **Skills development for researchers** Staff at the Emerald HPC have identified that researchers are increasingly learning to code and are collaborating with internal and external software development teams to create and optimise algorithms that emulate real-life behaviours in a virtual world. Developing code that operates efficiently on multi-core systems is a challenge, and researchers frequently request Emerald resource to 'pressure test' their code at scale.
- **Continuing Professional Development (CPD):** The University of York provide standard and bespoke CPD courses at the Biosciences Technology Facility which supported training for over 200 people on 16 courses during the previous year.

4.4.1. Importance of skilled technicians

The case studies also highlight the critical role of skilled technicians in supporting equipment sharing. One respondent identified scientific technicians as "the real assets for equipment sharing". The availability of local experts and training can greatly reduce the inertia barriers for Principal Investigators to engage with technologies that are new to them. In addition, skilled technicians can also support academics in opportunities to gain initial "pump priming" or proof of concept data.

Recent data has highlighted a potential shortage in this area - on average UK Higher Education institutions will lose between 25-35% of its highly skilled professional technicians in the next three to five years as many reach retirement age [13].

To support further skills development and training for technicians **The University of Sheffield is leading work, funded by HEFCE, to modernise and develop career pathways for University technicians**, including new professional accreditation schemes and a national framework for competencies. Within Sheffield they have looked at ways to develop flexibility to accommodate peaks in teaching and research activity and "new blood" training courses to address the gap in technical staff at graduate and apprentice level.

Equipment sharing opens new avenues for the training and development of technical staff and researchers, with associated benefits for teaching. The operators have skills that enable the researchers to gain significantly from their use of the equipment, increasing skills and productivity and reducing errors. Given the future skills shortages that have been identified, it is critical that the sector looks to address this, and the HEFCE funded project being developed by Sheffield is a welcome step.

4.5. Operational efficiencies

In addition to increasing productive efficiencies and the delivery of increased outputs through equipment sharing, there may be some circumstances where operational efficiencies are also achieved. This is delivering the same output for reduced input.

In respect of equipment sharing, there are two main types of operational efficiencies: firstly reducing the cost and secondly reducing the overall amount of equipment that is purchased.

4.5.1. Procurement

We have found a number of examples where collaborative working and activity through research consortia has enabled savings on the cost of research equipment. These savings are manifest in a number of ways; supplier discounts on cost of equipment purchased, warranties and service contracts provided at no cost, collaborative procurement of maintenance contracts, reductions in costs of utilities. Some examples that we found were as follows;

- **Reduction in cost of equipment purchased:** Supplier discounts between 5 to 30% are regularly achieved through the London Next Generation Sequencing User Group. Colleagues from UCL, Barts and other HEIs exchange information on current pricing via this group in order to obtain best deals from suppliers.
- **Warranties and service contracts at no cost**: University of York Biosciences Technology has developed relationships and goodwill through regular collaboration with equipment manufacturers. This has led to discounts on equipment due to the Facility acting as a full demonstration site, and lifetime warranties have been provided for no charge. When suppliers are involved in training, they will often provide servicing of equipment free of charge. This is all possible due to high levels of human capital and the world-leading technologists based at the Facility.
- **Collaborative procurement of maintenance contracts:** Scottish universities have a strong track record of delivering collaborative procurement savings through the Advanced Procurement for Universities and Colleges (APUC). APUC have led the Equipment Database and Maintenance project for Scottish Universities (EDAM), which has a specific objective to achieve supplier discounts on maintenance contracts. The first wave of tenders are under way in March

13 Quoted in http://www.sheffield.ac.uk/news/nr/technician-career-funding-1.370405

2014 based on the data provided via the EDAM database tool, this is expected to bring significant savings to the cost of maintenance of the installed equipment as well as bring enhanced reliability and availability of these facilities. Projected savings, based on other such projects are predicted to be in the region of 15% versus current costs

- **Government Procurement Service agreements:** The UK Shared Business Service (UKSBS) acts as a research procurement centre for all pan-Government research activity, and supports the procurement of large items of capital equipment. One example is the work with four national MRC national hubs for genome sequencing This provided three main benefits, firstly aggregation of spend to create greater leverage with suppliers, improved supplier management and finally, more rapid access to technology by significantly reducing the procurement cycle.

The costs of running facilities can also be reduced by taking advantage of the Government Procurement Service. For example the Diamond Light Source has leveraged this position within the public sector by buying electricity through the Government Procurement Service which not only allows purchase at a more competitive price but also to buy-forward giving greater cost certainty.

4.5.2. High utilisation rates and greater load factors on existing equipment

There was significant evidence from respondents about the increased levels of utilisation of equipment. There are clearly a range of innovative practices within laboratories to maximise opportunities to use the equipment for all researchers. One respondent commented *"we look to maximise usage wherever possible, including at 2am in the morning!"* Some examples of practices include;

- **Businesses transferring equipment for use by other partners:** At the National Composites Centre (part of the High Value Manufacturing Catapult), Airbus have transferred their own equipment into NCC for their own in-house composites facility. This move was described as mutually beneficial for both Airbus and the NCC, *"if we [Airbus] transfer the equipment to the NCC, and get a high utilisation on it, it means that we can refresh the equipment faster, which is to the benefit of Airbus, and all NCC members"*.
- Some companies providing services free of charge –e.g. donations of equipment free of charge. This means they are credited for technician time when they pay to use equipment
- **Sharing operational / running costs of a facility:** The operational costs for the Emerald High Performance Computing facility are shared amongst the four members (Bristol, Oxford, Southampton and UCL). The resource has been administered by a single team and this pooling avoids the need for each institution to invest separately in duplicate resource.
- **Purchasing the highest specification of facility that could not be afforded or fully utilised by a single university:** The throughput and usage for an individual university would make the purchase cost of the instruments at Centre for Genomic Research at Liverpool unfeasible, but by operating as a shared facility it is possible to fully utilise and purchase this equipment. Similarly, through sharing High Performance Computing provision across 8 universities, the academics at the N8 universities can access leading edge HPC facilities. In addition, there is a marginal cost saving of capital (£735k on an asset with 5 year lifespan), plus a total revenue saving of £1.2m (equating to £30k per institution, per year) through shared provision compared to investing in a similar overall capacity in a distributed model. It is important to note although the two cases are broadly similar in cost, **the resulting scenarios are not comparable in terms of capability** [14]
- **Utilising redundant research equipment:** one of the project benefits from the Equipment Database and Maintenance project in Scotland is helping to identify redundant research

14 From: Jackson, S (2013) "Making the Best Better – Report for the Department for Business, Innovation and Skills", http://www.n8research.org.uk/assets/files/EfficiencyReportFinal.pdf

equipment. This equipment can then be re-used internally for teaching, sold/transferred to other Institutions or sold to external to sector organisations. This may provide wider benefits for the wider economy by offering equipment to third / private sector organisations.

- **Ensuring maximum utilisation at Departmental level:** Ensuring Departmental level equipment is fully shared, for example at University of Manchester Department of Chemistry, this reduces the demand on the public purse. Without sharing, the facility requirements would be over four times the current levels, and would require approximately £1.5m of investment in X-ray equipment alone. For NMR and mass spectrometry the funding required is likely to be still higher. One respondent commented *"Within a UK chemistry department, approximately £6M of funding supports a wide range of research activities. In US or German laboratories, the investment would be over £25m to achieve the same level of activity as an individual pieces of kit owned by individual senior Professors".* Work has also been done to increase the capacity of instruments at the Departmental level, and relatively small sums can enable some important changes to equipment. For example EPSRC funding supported adding an automated sample changer for an **NMR Spectrometer at Oxford University** which previously had no robotic capabilities. This allows multiple samples to be queued and analysed under automation without user intervention after initial system configuration. This means the instrument can be used during periods when it would otherwise be unattended, most notably overnight. The sample changer can accommodate up to sixteen samples and thus significantly enhances the operational hours of the spectrometer and increases its overall sample throughput. This is a further example of increased utilisation and productivity of sharing within an institution.
- **Ensuring maximum utilisation at mid-tier and national levels:** A number of facilities reported high utilisation rates and operating at maximum capacity. For example the utilisation of the Emerald High Performance Computing Facility peaked in February 2014 at 85%, with individual institutions making greater use of their allocated portions. Similarly, the utilisation rates for the Diamond Light Source are extremely high for a facility of this scale. Of the allocated days for operation, about 75% of beam time is used by external users, and about 25% of beamtime is used for maintenance, calibration, testing and internal research to develop the instruments – this is vital to drive the performance, future productivity and efficiency of the instrument. There is also some capacity built into the process for "urgent science" –this can be fast tracked out with the bi-annual application process

5. Progress on developing systems for sharing

5.1. Supporting transition and cultural change following changes to capital funding in 2010

Following the reduction in capital budgets in 2010/2011 and the 50% reduction to capital funding, Research Councils implemented new processes for handling equipment requests. This required significant change within institutions, with two elements to this transition:

1. **New systems:** putting in place the practical infrastructure to support equipment sharing
2. **Cultural change:** enabling the long term behavioural changes required to support use of research infrastructure in different ways.

The changes required, particularly around establishing new systems to comply with RCUK requirements, incurred additional transaction costs and the availability of transitioning funds by EPSRC supported rapid progress in the area. Framework Institutions were allocated approximately £150-200k each towards equipment sharing initiatives. The initial support to meet these costs was critical so that the sector could maintain and improve effectiveness as well as enhance efficiencies. These costs will reduce over time as organisations progress and move up a steep learning curve

This funding was important for a number of reasons:

1. It allowed institutions to make a quick and direct response to changes in capital funding
2. Institutions were able to focus this funding on areas where it was most needed within their own organisation
3. Many universities chose to focus on developing equipment and asset registers, categorising all pieces of research kit, over a certain level (typically around 15k)
4. Due to the imperatives of sharing, this has stimulated further coalescing of clusters of research intensive universities; firstly the N8, and followed by the M5, GW4 and most recently the SES.

The recent requirement and incentives for sharing regional equipment across clusters has accelerated the development of these groups, which may otherwise have taken significant longer to materialise

5. These collaborations have emerged organically, and have provided an important platform for research infrastructure planning and future investments. This is a significant opportunity which will have enduring longer term benefits, both for research excellence and research productivity in the UK. As such the emergence of clusters should be seen as an important spillover, and non-monetary benefit from the equipment sharing and efficiency agenda.

5.2. Clusters of universities and asset registers

Why does proximity matter?

The emergence of regional clusters of research-intensive universities is due to the importance of proximity in equipment sharing. For many types of capital assets, this is a key factor underpinning the economics of equipment sharing, taking into account travel time, depending upon the likely frequency, intensity and duration of use.

Table: Asset registers and formation of university clusters

Partnership	Items of kit registered on database
EDAM (Equipment Database and Maintenance) 19 Scottish Universities –	18,000 http://www.edam.ac.uk/
GW4 (Great Western Four) Formed in 2013 Bath, Bristol, Cardiff, Exeter	1,325 http://equipsouthwest.org.uk/search-equipment Each University has several hundred other items on their internal catalogues
M5 (Midlands 6) Formed in 2011 Aston, Nottingham, Birmingham, Leicester, Loughborough and Warwick	600 suitable for sharing across institutions http://www.m5universities.ac.uk/facilities/ Each University has several hundred other items on their internal catalogues
N8 (Northern 8) Formed in 2006 Durham, Lancaster, Leeds, Liverpool, Manchester, Newcastle, Sheffield, York	4,000 www.N8equipment.org.uk Each University has several hundred other items on their internal catalogues
SES – Science and Engineering South Formed in 2013 Cambridge, Imperial, Oxford, Southampton UCL	2,700 in phase one, progressing to 3,400 by Summer 2013

5.3. National Equipment Registers

In addition to these regional databases, EPSRC have also funded the equipment.data project which has created a National Equipment Portal – equipment.data.ac.uk. The website uses a relatively simple piece of programming technology that enables searching across published UK research equipment databases through one aggregation portal. It provides a 'shop window' for UK HE equipment and facilities, enabling greater accessibility and importantly encouraging conversations with the aim of improving efficiency and stimulating greater collaboration in the sector. Through the engagement activity of the project many institutions not in consortia see this as an opportunity to discuss access to research equipment and/or as an opportunity to collaborate in previously less accessible areas. For example;

– Edge Hill University
Edge Hill University in Lancashire has a strong research and enterprise function, undertaking research within its faculties of Arts and Sciences, Health and Social Care, and Education. As a small institution, Edgehill have welcomed the opportunity to access a database of equipment and facilities at larger institutions, at no cost to themselves. This also creates the potential for conversations around research access to equipment that had previously been unavailable.

– Kingston University
Kingston's facilities are funded through institutional and commercial contribution with a greater teaching, enterprise and commercial research focus. They are considering which facilities and equipment would be best placed to contribute to equipment.data.ac.uk and are interested in accessing the portal in order to utilise equipment and facilities at other institutions.

– Norwich University College of the Arts (NUA)
Conversations with NUA have identified not only the desire to share equipment from other institutions but also a database of suitable kit such as 3D printers, studios and machinery. The keen interest from NUA demonstrates the breadth of relevance the portal has across all types of institution.

The opportunities created by equipment.data for collaborations and equipment sharing across the breadth of research base is an additional significant benefit for the sector. This will enable researchers to pursue careers effectively in all institutions and also enhance the student experience through research-led teaching across the sector. This further benefit, which although cannot be quantified in cash terms, will support the diversity and long term health of the sector.

5.4. Research Assessment as a potential barrier

During discussions on this project, queries were raised over the impact of the Research Excellence Framework as a barrier to collaboration and culture change. Colleagues at HEFCE have investigated this issue based on the submissions for the 2014 REF exercise.

Collaboration and Research Assessment

The Research Excellence Framework (REF) has replaced the Research Assessment Exercise (RAE) as the new system for assessing the quality of research in UK higher education institutions. Submissions are made under 36 units of assessment, and assessed by expert panels. To inform the assessment of the Research Environment, data on research income is included, in addition to contextual information on the research infrastructure. Given the highly competitive nature of the REF, there have been some concerns that this could undermine the propensity and willingness to collaborate on research, and in particular in sharing equipment. For example, this could be the case where large items of shared equipment are awarded and utilised across a consortia, but only the institution that is responsible for the research expenditure for that item of kit will receive credit in the REF. More broadly, the recognition of science as a competitive field, and the increased administrative burdens from sharing could be *"seen as possibly impeding and slowing down the scientists work and their research groups' work overall.... Some mentioned that REF credits would not be awarded, co-publishing would not arise from most of this work so the measurable outcome for them was unclear"* [15]

Colleagues from HEFCE have looked into this issue and the assessment process for REF. There is no formal weighting for the research funding component and the main panels are weighting this differently as a proportion of the environment score. However looking across the range of potential scores, and the subsequent impact this may have on funding, the conclusion is that the effect will be a very small proportion of the funding outcome, and this should not be regarded as a barrier to collaboration. Indeed cross-HEI collaboration is evidenced as 32% of the outputs submitted to REF2014 involve two or more universities [16].

Given that the impact of sharing equipment on REF outcomes is not material, it may be important to communicate this as part of the process of disseminating lessons learned from the REF process in order to change perceptions or myths on this issue.

6. What more can be achieved and what needs to be done to make this happen

6.1. Quantify the benefits from Equipment Sharing

At present the development of sharing is illustrated principally by case studies and anecdotal evidence, supplemented by occasional surveys. To drive strategies for increased sharing, and to demonstrate efficient use of assets to stakeholders, a more systematic approach is needed to evidence the impact of equipment sharing. There is no one single metric that can be utilised, so we are proposing a basket of measures based on evidence of usage (inputs) and productivity (outputs). A key principle is to maximise the usage of data that already exists rather than adding to administrative burdens.

6.1.1. Usage evidence – increasing inputs

It is recommended that mid-scale facilities should operate electronic booking systems (already the case for most) and that these should systematically record the pattern of usage, including users from other institutions and from business or other external collaborators. It is also important to note the value and nature of the usage – both "operational" use by external visitors as well as "full service" work on behalf of visitors. This builds on the established requirement for TRAC-listed facilities providing records of usage as part of the TRAC return. Although the TRAC-listed facilities are a subset of the university equipment base, this approach will include research assets which are most appropriate for sharing. It would also be possible to focus on specific scientific techniques to understand patterns of sharing across different facilities.

15 Georghiou, L (2012), on behalf of the N8 Partnership, Sharing for Excellence and Growth, http://www.n8research.org.uk/assets/14137%20N8%20Sharing%20for%20Excellence%20and%20Growth%20Report_WEB.pdf

16 This is based on analysis to date using a small sample, so the margin of error is around 5%. The current plan is to analyse 400 outputs, which will give a margin of error of about 5%). The sample also includes single-authored outputs and a small number that don't have any UK HEIs in the author list, presumably the result of people moving from overseas.

Recommendation: Funding is provided for retrospective analysis of TRAC-listed facilities for comparison of external usage level from 2010 onwards.

6.1.2. Productivity Gains- Working with Business and Research Users

The Higher Education-Business Community and Interaction Survey (HE-BCI) is an annual survey collecting information on knowledge exchange between universities and research partners. The data is collected by the Higher Education Statistics Agency (HESA). One of the categories is "Facilities and equipment related services". This category includes all income from external use (non-academic) of university specific facilities or equipment so would include use of expert kit for R&D through to rental income from incubation space. Although the table is not broken down by type of facility or equipment, it would be possible to look at income from end users categorised as SMEs, corporates or public sector, and also access individual institutional returns for the previous ten years.

Recommendation: The data on facilities and equipment related services, as collected in the HE-BCI survey is used as a proxy for business use of university research equipment.
Both these measures will give indications of the current scale of asset sharing activity, and provide a "baseline" for evidencing future progress.

6.2. Reform: Increase incentives, solutions

It is vital for the long term growth of the UK economy to remain at the leading edge of scientific excellence. In light of challenging public finances, equipment sharing is a key policy response in order to *"scale the twin peaks of excellence and efficiency"*. [17]

Greater **incentives** to accelerate academic buy-in and support the cultural change needed for equipment sharing should be considered as follows;

6.2.1. Allocation of credit on large grants.

The funding environment has changed significantly since 2010, with short term allocations or "pulses" of capital in addition to planned investment, together with an increasing use of research volume as an entry mechanism for RCUK funding calls and allocations. Although this is to be broadly welcomed as an efficient method of allocating certain tranches of funding, this does increase the importance of ensuring that collaboration and sharing are properly recognised in all award databases. This does not mean distributing funding via multiple grants (which could disrupt work planning, research flexibility and the delivery of research objectives) but instead the partners would agree at the outset an allocation of credit when submitting the proposal- for example the percentage of Principal Investigator and Co-Investigator time on the grant. This may also have additional behavioural and cultural benefits – for example it could support greater diversity ensuring more formal credit to female co-investigators, and enable better routes for career progression for early career researchers.

Recommendations:

- RCUK and Russell Group Heads of Research to explore how credit for shared use can be allocated in administratively efficient way both within and between institutions; the optimal timing for grant holders to report the credit split to RCUK, and whether this would apply to Capital and Revenue grants.

17 Greg Clark, quoting Professor Sir Ian Diamond at the UUK Conference, September 2014. https://www.gov.uk/government/speeches/higher-education-strength-in-diversity

– In so doing to consider defining good practice in internal allocation of credit to researchers to ensure that co-investigators get fair recognition.

6.2.2. Funders ensuring flexibility for the capital and operational costs of newly shared facilities

Given the increased revenue costs of operating a shared facility, together with significant capital contributions universities have already made on new capital items since 2010, it is suggested that there is flexibility from funders to vary the institutional requirements for shared equipment items. This could apply to both the **purchase costs**, and the **access and coordination costs**. Both the hosts [18] and visitors to a facility should benefit here. There is an analogy here to the situation in the 1980s during the introduction of collaborative research. The Government provided an increased level of subsidy in recognition of the increased transaction costs while colleagues moved along the learning curve, and this accelerated the cultural change that was needed. The same could apply for the transition period for equipment sharing.

Furthermore, it is currently the case that access and coordination costs are allowable expenses for RCUK grants, but anecdotal evidence of the rate of claiming suggests that the research community perceive these to be not allowable, or too high an expense that won't be funded.

Recommendations:

– As part of the implementation of the Science and Innovation strategy, BIS and RCUK consider the scope for further incentivising asset sharing by reducing or waiving the institutional contributions required from universities for shared facilities.
– RCUK publicise and communicate their policy on access and coordination costs for relevant capital calls.

6.2.3. Where appropriate, funding bids to include mechanisms for sharing as a key criterion

To incentivise long term behavioural change to support equipment sharing, credit could be allocated in the grant awarding process to those applicants who demonstrate their commitment and capability to share and ensure full utilisation of the equipment that is purchased. This would be less relevant in research grant applications, but could be a core part of capital funding schemes looking at specific infrastructure projects. Examples include the recent calls in Robotics and Advanced Materials in the Great Eight Technology areas and the EPSRC Core Chemistry Capability Call. There could also be explicit requirements to reference the operation of, and contribution to, shared research facilities in future Research Excellence Framework environment statements.

Recommendations

– RCUK to review the inclusion of sharing as a key criterion in all appropriate research capital calls.
– HEFCE to review inclusion of operation and contribution to shared research facilities in future Research Excellence Framework environment statements.

6.2.4. Utilise VAT Cost Sharing Exemption

The sector should continue to work together to implement the VAT Cost Sharing Exemption, where appropriate, in order to mitigate additional VAT costs which may be incurred through sharing. Given the Cost Sharing Exemption needs to be reviewed and implemented on a case by case basis we make no further recommendations in this regard, except to commend the good

18 The additional costs which a host institution incurs in sharing a facility (for example administration of invoicing, health and safety training for visitors) cannot usually be added to the TRAC charge-out rate calculation.

work of HEFCE, UUK and the British Universities Finance Directors Group (BUFDG) in progressing these arrangements.

6.2.5. Adding equipment to the National database

The national equipment database (equipment.data.ac.uk), funded by EPSRC, brings together the equipment inventories from UK universities and national research institutes. This **ensures state-of-the-art equipment is identifiable across the research base wherever it is located**, and that leading researchers from all institutions can gain awareness and access to research facilities. Funding for the project is due to run to April 2015.

Recommendations

- All new equipment purchased using public funding sources that is over the OJEU threshold will be required to be added to equipment.data.ac.uk
- All universities should engage with equipment.data.ac.uk to ensure existing equipment inventories are accessible on the national site.

6.2.6. Investment planning, smart specialisation, competition and collaboration

In order to maximise public investment in science facilities it has been suggested that infrastructure roadmaps could be produced, which form part of the evidence base for RCUK Capital Investment Roadmaps. These could be developed along the lines of the European Strategy Forum on Research Infrastructures (ESFRI) which look at new (or major upgrades of) research infrastructures of pan-European interest corresponding to the long term needs of the European research communities. It is suggested that, in any given equipment classification, similar roadmaps in the UK could look at a number of issues, *including*:

- The state of the equipment base in the UK.
- The position of the state-of-the-art and current gaps between UK provision.
- The investment that is needed to get to state-of-the-art provision, including leading national infrastructure, mid-tier facilities and items associated with the "well found" lab.
- Plans for strategic distribution of facilities, ensuring appropriate geographical coverage and smart specialisation where relevant.
- Frameworks for ensuring both competitive and collaborative funding mechanisms in the specific area.
- Plans for sustainability / cost recovery (including evidence of changes in levels of cost recovery since 2010 where RCUK capital investments required business cases)

Some initial work has been done in this area, for example on NMR for the Physical Sciences by Professor Mark E. Smith [19] and for Biomolecular NMR infrastructure by the UK Collaborative Computing project for NMR (CCPN).

This process would also address and mitigate two current weaknesses within the UK system. Firstly around equipment classes and techniques which span across Research Council portfolios, where the routes for developing strategies and funding infrastructure are perceived to be more problematic, and secondly around the funding and administration of mid- tier facilities. Equipment within the "well found laboratory" and at national level have clear routes for finance and management. For mid-tier facilities this is critical but somewhat opaque. These facilities are a large and growing part of the equipment base which needs to be integrated to regional structures across the UK, as part of asset sharing arrangements, in order to make this work. The importance

19 http://www.epsrc.ac.uk/newsevents/pubs/roadmap-to-provide-internationally-leading-nmr-infrastructure-for-uk-physical-sciences/

of QR funding in enabling institutions to be flexible and responsive to support equipment needs across the system is acknowledged.

It has also been suggested that national equipment-specific initiatives could provide significant learning opportunities with respect to the equipment-specific sharing initiative. Existing examples are the National e Infrastructure Project Directors Group, which has brought together new MRC-funded infrastructure with existing STFC- and EPSRC-funded resources to share learning, and the BioImagingUK group which coordinates a single response to major initiatives from the whole community.

Recommendations:

As part of the implementation of the Science and Innovation Strategy, RCUK and BIS to consider

- the potential for infrastructure investment roadmaps for the main equipment classes, developed by the sector on a cross Research Council basis, which would form part of the evidence base for RCUK Capital Roadmaps. The regional clusters of universities could play a significant role alongside the Research Councils in this exercise.
- the mechanisms for investing in these Roadmaps and processes for awarding funding to incentivise collaboration where it is appropriate.

6.2.7. The critical role and resourcing of the Research and Funding Councils

The Research Councils have played a significant role in progressing the sharing agenda, particularly EPSRC leading on behalf of RCUK. RCUK, together with the Funding Councils, should continue to develop innovations in policy and work with the research base to incentivise the changes in behaviour required. Whilst we make no specific recommendations in this regard, it should be noted that flexibility and innovation to develop new approaches and policies may be constrained in light of resource.

6.2.8. The Research Excellence Framework

Evidence collected for this report suggests that the Research Excellence Framework is not a barrier to the sharing of equipment, therefore we have not suggested any reforms in this area.

Appendix 1 – List of contributors

Name	Role	Organisation
Adrian Alsop	Director for Research, Partnerships and International Directorate	ESRC
Jamie Arrowsmith	Programme Manager	Universities UK
Denise Barrault	Executive Director of the Scottish Universities Life Sciences Alliance (SULSA)	University of Edinburgh
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Gavin Burnell	Lecturer in Condensed Matter Physics	University of Leeds
Jackie Carter	Functional Director, Communications and Impact, UK Data Service	Mimas, University of Manchester
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Appendix 2 – Case Studies

Centralisation and sharing of facilities within universities

Equipment Sharing in the Department of Chemistry, University of Manchester

1. Scientific area and how links to Great 8/Industrial Strategy	Great 8: Advanced Materials; Energy Storage, Big Data Industrial Strategy: Nuclear, Oil & Gas, Aerospace
2. Description of project What was shared?	The chemistry department at University of Manchester has over 60 academic staff, the vast majority are research active. Much of the equipment that supports the research activity is shared. There are 4 major services; **1.** x-ray crystallography - Supports activity of 30 research groups,including multiple European research council award holders and groups funded by industry **2.** NMR spectroscopy –40 research groups including research council and industry funded research **3.** Mass spectrometry – 40 research groups and part of the Michael Barber Mass Spectrometry centre **4.** Elemental analysis and separations – 40 research groups
Who was involved and how was it funded?	X-Ray Crystallographer – 2 experimental officers are funded to maintain the service and these costs are recouped through research grants. PhDs are also trained to utilise facilities. Academics are able to access the facility within timescale of approximately 2 weeks. Beam time at the Diamond Light Source is utilised to complement this facility, accessed through the peer review allocation process. The beam time at the Diamond Light Source is needed for specialised experiments, which are driven from the pipeline in the departmental lab - the quality of the lab equipment is now so high. NMR spectroscopy – again experimental officer support (3) funded through grants. PhD students trained to use some spectrometers. Access almost immediate for simple experiments, and within two weeks for more complicated experiments Mass spectrometry – experimental officer support (1.5) funded from grants, providing rapid access to facility. The Michael Barber Centre offers far more sophisticated MS techniques, which are done on a collaborative basis after discussion. Elemental analysis – technical support funded from grants, again with rapid access time. Utilisation rates- extremely high. These facilities are used at weekends and evenings, well beyond 9-5pm, 7 days a week.

What would have happened if sharing had not taken place?	If this equipment wasn't shared, the kit requirement would be over four times the current levels of equipment, approximately £1.5m of investment in X-ray equipment alone. For NMR and mass spectrometry the funding required is probably still higher. Therefore within a UK chemistry department ca. £6 M of funding supports a wide range of research activities. In US or German laboratories investment would be > £25m to achieve the same level of activity as an individual pieces of kit owned by individual senior Professors.
3. Research Outcomes - Excellence and impact	
3.1 multi-disciplinary work	X-Ray Crystallographer – supports work published in Science journals (Nature), Physics, Chemistry and Materials journals. NMR and Mass spectrometry supports work that crosses the chemistry-life sciences border, hence some kit is found in the Manchester Interdisciplinary Biocentre as well as in Chemistry department In addition to School-level equipment sharing, Chemistry/PSI run the EPSRC-funded national EPR Spectroscopy in Manchester. Research using these facilities has been published in joint papers, for example returned by both Manchester and Nottingham in the REF. The REF has not changed patterns of behaviours or collaboration.
3.2 collaborations with industry	**Suppliers:** Bruker sponsor the National EPR facility and fund a member of staff for 5 years. They have also provided a developmental machine to be part of the national facility. **Industry:** wide range of materials and pharmaceuticals companies involved in sponsoring research. EPR facility – work with GSK –an initial small service / contract research has grown to a funded Research Fellow within the Chemistry department. University sector provides equipment that industry partners do not realise they need or cannot afford to maintain on their own.
3.3 new science and technical advances	All research in the Chemistry Department is underpinned by use of equipment. Some examples include advances relating to the Nuclear industry, Graphene, Fine Chemicals, Information processing and information storage, nanofabrication, pharmaceutical sector.
3.4 improved training & skills Please comment on any specific benefits for UG or PG teaching	Final year of undergraduate programme - many students are trained on this equipment. This often leads to published papers, in part from work done by undergraduate students Masters students over 100 students per year perform final year projects that rely on this equipment. The School trains ca. 200 PhDs at present, again the vast majority rely on shared equipment.

4. Efficiency outcomes Please describe where the following occurred	
4.1 Reduction in supplier costs – purchase or service cost	Capital requirement refresh from EPSRC has been enormously helpful and the Capital Consultation is a huge step forward in being able to plan and negotiate better discounts and time with suppliers. Short timescales tend to reduce value and discounts that can be leveraged.

Increasing the intensity of research equipment and facilities use, reducing costs and sharing scarce resources, University of Oxford

The University of Oxford invited proposals to increase the use of research equipment and facilities, to reduce costs and share resources. These proposals leveraged EPSRC Block Grant (Delivery Plan) funding with University cash or in-kind, and were about stimulating new approaches to support new science and greater utilisation of facilities across the world class research base.

The Oxford EPSRC Block Grant Committee funded 17 initiatives, with grants (normally up to £10k) matched by local cash and or in-kind support.

These small allocations of funding have
- increased effectiveness (machines available at higher capacity; new science through collaborations across disciplines)
- increased efficiency (e.g. machines operational for extended periods, remote access)
- stimulated new approaches to sharing equipment, which will have benefits in the longer term

Case Studies

1) Small laser fabrication facility

- Relocation of £300,000 worth of laser fabrication equipment to a larger laboratory providing access for several research groups.
- This is being set up as a small research facility (SRF) and will enable the number of supported experimental projects and user base to be expanded.
- Previously, the system was based in a small laboratory and was capable of supporting only one project.
- The relocation has increased the capacity of this system so that it can now support several lines of research.
- Higher capacity is achieved by the running of systems simultaneously through separate beam lines.
- The extra space also permitted more flexible system design that facilitates rapid changeover between applications.

Outcomes and Benefits

- The relocated equipment is central to several research streams that will enable scientific and technological advances through projects within the University and with external collaborators.
- Current applied research projects involve researchers from 4 departments alongside Engineering (Chemistry; Materials; Atomic Laser Physics, Astrophysics)
- Estimated use time per month is now up from 60% to 80%
- The system also supports its original role in the development of new optical methods for laser machining. The new arrangements permit the parallel development of applications and methods with reduced downtime.

2) Extending the operational capacity of an NMR spectrometer to allow multiple-sample data collection overnight

- New design of automated sample changer has been added to a NMR spectrometer that previously had no robotic capabilities.
- Allows multiple samples to be queued and analysed under automation without user intervention after initial system configuration.
- This means the instrument can be used during periods when it would otherwise be unattended, most notably overnight.
- The sample changer can accommodate up to sixteen samples and thus significantly enhances the operational hours of the spectrometer and increases its overall sample throughput.

Benefits

- The changer will allow the SRF staff to collect data on multiple samples during overnight periods and thus improve the efficiency of the analytical services provided across its existing user base.
- The higher sample throughput this allows will mean service time saved on the instrument can be made available to suitably trained research chemists, thus further promoting their research activities.

Outputs across the whole project

EPSRC funding has helped to

- Enhance capacity and sensitivity (Physics SQUID-based magnetometer)
- Train new users (Materials; JEOL instrument)
- Set up internet booking (Biochem, BMG-PherastarFS platereader)
- reactivate Differential Scanning Calorimeter (DSC) and thermogravimetric analysis (TGA) systems and incorporate them into the X-ray Crystallography SRF;
- Enable material researchers to study high temperature structural phenomena ("Supernova" single-crystal diffractometer SRF)
- Establish new collaborations between Engineering Science, DPAG, Oncology and NDORMS (multiphoton microscope, Eng Sci) make undergraduate lab instruments open to researchers

Sharing of Medium Range Facilities

Centre for Innovation / Emerald: High Performance Computing Facility

Summary:

The focus of this case study is a UK High Performance Computing (HPC) facility called Emerald. Funded by the EPSRC, and launched in spring 2012, Emerald is a large Graphics Processing Unit (GPU)-based supercomputer which facilitates computationally-intensive experiments. As a collaborative venture between the Universities of Bristol, Oxford, Southampton and UCL – together forming the Centre for Innovation (CfI), the cluster is of a significantly higher specification than any of the institutions would have been able to invest in individually. Emerald has driven cross-disciplinary academic, SME and industry engagement, and the partner institutions are actively working to train researchers and maximise utilisation of the resource. Continued investment will be necessary to sustain and develop Emerald in the future.

Introduction:

In March 2012, an EPSRC-funded High Performance Computing (HPC) facility called Emerald was launched. Emerald is a supercomputer built with Graphics Processing Unit (GPU) architecture, which at the time of launch was amongst the largest GPU-based systems in Europe, and remains the largest such system in the UK. It was launched jointly by the Universities of Bristol, Oxford, Southampton and UCL, which together form a consortium called the Centre for Innovation (CfI) and the system is hosted and operated by the Science & Technology Facilities Council (STFC) in a strategic partnership with CfI. The major aim of the CfI is to support the co-development and sharing of e-infrastructure capabilities (including hardware, software, people and skills) between the partners, and to develop links with other academic and industrial organisations. Emerald supports all of these objectives and has greatly benefited research output, industry collaboration and the training and development of users.

Research highlights:
By providing access to significant computational power, the Emerald cluster has enabled researchers to perform theoretical experiments in much shorter timescales. The outputs of these model investigations can be used to guide physical experiments.

Important research highlights include:
- UCL researchers are using the resource to simulate and predict the chemical processes that take place at the surfaces of metal and other materials.
- Scientists at Bristol are investigating how mutations of a key enzyme in H1N1 (the 'Swine influenza' virus) lead to the development of resistance to current antiviral flu treatments.
- Researchers at UCL are working with GPU specialists at Oxford to optimise the performance of a tsunami simulation code.
- UCL scientists are simulating the effect of gene mutations linked to the spread of cancer. This can aid the development of more robust and effective cancer treatments.
- Scientists at Imperial College London have been able to achieve unprecedented levels of accuracy in computational fluid dynamics, specifically relating to Unmanned Aerial Vehicles, allowing engineers to understand complex flow patterns and thus perform aerodynamic design, without flying an aircraft or even starting up a wind tunnel.

Industrial collaborations:
The CfI has actively engaged with industry through workshops at STFC and UCL, to publicise and promote the potential of GPU-based computing technology to industrial research applications. CfI has directly engaged with SMEs including NAG Ltd., Zenotech and Cresset Biomolecular Discovery Ltd. When allocating computing resource for Emerald, priority is given to collaborative work, especially between academic partners and industry.

Improved awareness, training and skills:
The CfI institutions are working hard to drive user engagement and facilitate training. NVIDIA, who manufactured Emerald's processors, offer training in CUDA, a programming model they developed to harnesses the power of GPU cores. This training is available across CfI partner institutions and a summer school is run every year at Oxford. Researchers are increasingly learning to code and are collaborating with internal and external software development teams to create and optimise algorithms that emulate real-life behaviours in a virtual world. Developing code that operates efficiently on multi-core systems is a challenge, and researchers frequently request Emerald resource to 'pressure test' their code at scale.

Polaris: N8 High Performance Computing Facility

1. Scientific area and how links to Great 8/Industrial Strategy	High Performance Computing – cross cutting across Great 8 themes.
2. Description of project What was shared? (please comment on the scale of facility, for example if this was individual laboratory level of sharing or if a centralised / collective facility)	A supercomputer, Polaris is shared equally between 8 universities on a "fair share" basis. The machine is a SGI High Performance Computing cluster based at the University of Leeds but management of the project is shared between the Universities of Manchester and Leeds with the technical management based at Leeds and the project management primarily based in Manchester. As well as the machine, the sharing of a HPC facility enables the sharing of HPC expertise and knowledge between the 8 universities. Several N8 universities are experts in running and managing HPC facilities with other N8 universities having no prior experience of providing such a service. Staff experience and knowledge of HPC also varies between the N8 universities, and mechanisms are in place to support these universities such as discussion mailing lists and regular meetings.
Who was involved and how was it funded?	The universities involved are Durham, Lancaster, Leeds, Liverpool, Manchester, Newcastle, Sheffield and York. There is buy-in at all levels in the universities, including PVCs for Research, several of whom are members of our Steering Group. The centre was funded by EPSRC in 2011.
What were the reasons for sharing?	The call was for a regional HPC centre and, due to the existing strong N8 research partnership it made sense for a N8 bid to be put forward. The machine is larger than many institutions currently have as their local resource either due to financial reasons or expertise levels in their institutions. The sharing of HPC technical knowledge will benefit those institutions with less experience of HPC through the upskilling of their staff. Part of the remit of the regional HPC centres is to promote business engagement between universities and industry. A large HPC machine can be used as a "seed" for industry engagement particularly with SMEs who may be unable to access such computing power elsewhere or who may be able to access HPC through commercial suppliers but not the required support. SMEs engaging with N8 HPC universities will not only benefit from access to academic researchers but also access to HPC and support.
What would have happened if sharing had not taken place?	Without a central shared machine, institutions would have to fund their own HPC machines if they were in a position to do so. The resulting machines may have been smaller and available to fewer researchers as a result. A shared machine also results in lower electricity and running costs as well as saving space in university data centres. A large HPC machine is an attractive incentive for business engagement. There have been many research grant applications which cite the use of N8 HPC and this may help in the grant success rate.
3. Research Outcomes - Excellence and impact (statistics from N8 HPC Annual Report 2013)	
3.1 multi-disciplinary work	There have been a number of case studies produced on research projects using N8 HPC resources. A case study on the N8 HPC website (http://n8hpc.org.uk/industry/casestudies/steppingstone) demonstrates how using N8 HPC can enable researchers to access larger national

	resources through their use of N8 HPC. This case study highlights how N8 HPC was used for a "proof of concept" for the development of software code.
3.2 collaborations with industry	Currently 20% of projects on N8 HPC have an industrial component involving companies from university spin outs, SMEs and blue chip companies, for example DeBeers, BBC and the Culham Fusion Energy Centre. We have also worked with Carmen Funes Museum, Plaza Huincal, Argentina. University spinout companies using HPC are working in areas such as medical diagnostics and semiconductors, with larger companies in the areas of technology, engineering, health care, construction, utilities and the nuclear industry. At the time of the annual survey in summer 2013 there were 7 existing industry-related PhD studentships utilising N8 HPC resources with another 7 studentships due to start. N8 HPC resources had been directly responsible for 6 instances of collaboration with UK companies.
3.3 new science and technical advances	There are currently over 100 projects registered on N8 HPC all of which are pursuing new science over a wide range of research areas. Research areas currently using N8 HPC include chemistry, engineering, earth sciences, electronics and computing, maths, life sciences and physical sciences.
3.4 improved training & skills	N8 HPC has helped to upskill technical staff across the 8 universities. It has also been used by a large number of research students and HPC will be utilised by students in the new Centres for Doctoral Training. N8 HPC has recently been used for training by PhD students from the Fusion Doctoral Training Network with students from a number of N8 and non-N8 institutions.

Centre for Genomic Research, University of Liverpool

1. Scientific area	The Centre for Genomic Research operates as an open access, collaborative facility that enables research underpinned by high-throughput genomic technologies and computational analyses.
2. Description of facility	The CGR is a dedicated centre that facilitates cost-effective access to multiplatform sequencing and array technologies for researchers worldwide. The Centre offers a wide range of applications, with associated informatics and analytical processing of data and functional interpretation. Equipped with state-of-the-art next generation and 3rd generation sequencing platforms, coupled with complementary robotics, sequence capture and array capabilities, the CGR can offer optimum, tailor-made solutions across a wide range of biological applications.
Who was involved and how was it funded?	Profs Andrew Cossins, Anthony Hall, Neil Hall, Steve Paterson, Dr Christiane Hertz-Fowler. (Part)-funded through MRC, NERC and the University of Liverpool as well as a operational business model based on cost-recovery.

What were the reasons for operating as a shared facility?	State-of-the-art array and sequencing instruments are priced beyond the reach of individual labs but are necessary to perform cutting-edge genomic research. A shared facility maximises both cost efficiency due to economies of scale as well as technical expertise. Affordable access to a high-tech shared facility enables leading-edge, competitive research, perpetuating further grant success.
What would have happened if sharing had not taken place?	The CGR is an important asset to the University of Liverpool. The technologies housed within it underpin a number of key strategic research themes / priorities at the University. Although some standard, smaller projects could have been completed using external service providers, this would have resulted in grant money being spent with commercial companies rather than remaining within the University. This would also have prevented the development of in-house expertise that has led to advances in biological and bioinformatics research. Without the availability of these shared facilities and in-house expertise, some grants may not have been awarded and large, complex and novel genomic projects such as the wheat genome project would not have been possible using a commercial service provider.
3. Research Outcomes - Excellence and impact	
3.1 multi disciplinary work	The CGR is involved in numerous collaborative, multidisciplinary projects with academic groups, industry and government departments. These projects span biomedical and clinical projects (addressing cancer genomics, transcriptomics, human genetics, outbreak analysis); genomics, population structures and evolution of pathogens and their hosts; nutrigenomics, health and 'wellness'; pathogen detection; biotechnology; environmental and evolutionary biology; mechanisms and biomarker discovery in pharmaco and eco-toxicology and disease resistance; biofuel species and sustainable energy production; agri-tech, including food security, processing and husbandry; archaeology, anthropology and zoology, including sequencing and profiling of ancient DNA.
3.2 collaborations with industry	The CGR is involved in collaborative projects with pharmaceutical companies such (e.g. AstraZeneca) as well as companies such as Unilever, Shell and several SMEs (e.g. Oxitec Ltd). Due to the rapid advancement of this field of research, it is not economically viable for commercial ventures to obtain the necessary equipment. The CGR provides access to facilities and expertise otherwise not available.
3.3 new science and technical advances	Advances include improved laboratory workflows, new and improved bioinformatic pipelines, novel published genomic data sets including de novo sequencing of non-model organisms and improved methodologies for metagenomic analysis.
3.4 improved training & skills	Centre staff benefit from specialised training and experience as a consequence of the diverse nature of the work handled. High standards are demanded due to handling other people's samples and the need for a reputation for excellence. The CGR also hosts seminars and workshops to provide education and training for the wider scientific community.
4. Efficiency outcomes	
4.1 Access to equipment of a higher specification than would have otherwise been affordable by a single HIE	The majority of equipment in the CGR would not have been affordable for a single HEI. This is particularly true for the higher spec instruments such as the Illumina HiSeqs and PacBio 3rd gen sequencer. These instruments generate high data output (HiSeq) and extremely long reads with an ability to detect base modifications (PacBio) and these data would not be possible using lower purchase cost instruments, or the overall all cost and time to

	generate the same data would not be viable. The throughput for an individual HEI would make the purchase cost of these instruments unfeasible.
4.2 Reduction in supplier costs – purchase or service costs	The CGR has been able to benefit from large-scale reagent discounts based on future commitments, such discounts are passed on to collaborating groups. Additional discounts are available as part of the Certified Service Provider programs that a number of technology companies offer (e.g. Agilent, Illumina, Roche NimbleGen) and which the CGR belongs to.
4.3 Increasing load factors	The CGR is embedded within the Technology Directorate (TD) at the University of Liverpool (http://www.liv.ac.uk/technology-directorate/). The TD was established within the Faculty of Health and Life Sciences in 2011 to achieve greater utilisation of assets by the Faculty and thus drive academic excellence. The same ethos applies to the investments the MRC and NERC have made into equipment housed in and accessible through the CGR. As a consequence, the CGR has been able to obtain all major technologies, and equally importantly, has been able to keep pace with changing technologies, allowing the facility to provide access as well as academic expertise to individual groups needing to make use of these technologies on a cost-recovery basis. This means that fewer individual pieces equipment (that would probably not be used at capacity) are required, hence reducing the overall cost to RCUK.
Future plans	To continue to obtain and provide access to cutting-edge genomic and complementary technologies, including the expansion into a DNA synthesis facility.

Collaboration between UCL Genomics and Barts Genome Centre

Summary:
This case study describes collaborations between the genomics centres at two large London-based research-intensive universities, UCL and Barts and The London School of Medicine & Dentistry (part of Queen Mary). In 2008 the two centres signed a memorandum of understanding, committing to share equipment access and best practice, carry out research in partnership, train users and develop the local genomics community. Though the alliance brings many tangible benefits for the partners and more broadly, current VAT rules have seriously undermined direct sharing of equipment and are thereby limiting the potential for this shared resource.

Introduction:
Genomics is a rapidly-progressing, resource and data-intensive scientific field, requiring expensive equipment with relatively short useful lifespans. Genomic investigations are pertinent in a large number of distinct scientific areas ranging from immunology to ecology. Thus, expert guidance is very helpful to researchers in designing and conducting appropriate experiments and harnessing the technology to maximum potential to answer the desired questions. The UCL Genomics Centre and the Barts Genome Centre, both established over a decade ago, were created to meet these evolving needs, initially within their own institutions (UCL and Queen Mary, respectively). They continue to provide assistance to researchers at all stages of investigation, from early proposal to data analysis. Both centres run under cost recovery regimes at their respective universities, recovering all running costs from charges levied to end-users.

However, genomics equipment is expensive, depreciates in value quickly and is susceptible to breakdown. Individual institutions are limited in their ability to procure funds for and house the latest equipment, and the intensity of some experiments exceeds the capacity of single centres to conduct them.

In 2008, UCL and the Barts Genome Centre signed a memorandum of understanding to grant one another equipment access, not only to establish mutually complementary resources and avoid inefficient duplication, but also to provide backup in the event of system breakdown or overload. A suite of high-tech equipment is now available for sharing, including the cutting-edge Fluidigm BioMarkHD and C1 systems, Illumina microarray and sequencing machines and other quality control equipment. The two centres also sought to work more closely on research, to share expertise and assist one another in the training of users and the promotion of genomics services in the region.

Efficiency outcomes:
Since this collaboration began in 2008, the institutions have undertaken major projects that would otherwise need to be outsourced at greater expense. The combined staff resource has allowed investigations to be conducted in-house that would otherwise be just too immense to handle as individual centres. Moreover, through task sharing between the two groups, projects can be completed at an accelerated rate, thereby allowing a greater volume of work to be taken on. Barts and UCL staff have also sat on one another's facility review boards, to help their partners identify strategic priorities for development, with the collaboration in mind.

The two institutions jointly secured funding for a Fluidigm fluidic PCR machine and a higher-capacity autoloader array system than would have been possible through individual bids, and this equipment is now available for shared access.

Research outcomes:
The partners have established a shared Illumina genotyping facility with multi-field applicability, supported by staff with expertise in the technology itself and in its applications for bioinformatics, the laboratory and the clinic. They have contributed to a number of important experiments, leading to major publications in top-tier journals. For instance, the centres took part in a large international study investigating the links between specific genomic signatures and autoimmune disease[1]. They also participated in a European-wide effort to identify the genomic variants associated with coeliac disease[2].

Training, user and community engagement:
Barts organises regular technology-based symposia and seminars to raise local awareness and promote use of the facility. UCL has arranged meetings for the London Next Generation Sequencing user group, which exchange information on current pricing so as to obtain the best deals from suppliers, and discounts ranging from 5-30% are regularly achieved. The partners also organise the London Illumina Users conference, which brings together researchers from across the capital to share expertise and best practice.

Benefits to teaching:
Students (especially at PhD level) regularly use the genomics facilities at UCL and Barts, either in collaboration with staff, or as trained and independent users of the equipment. MSc students benefit from tours of the facilities and receive lectures from experienced staff based at both sites.

The future of this collaboration:
Recent interpretation of the VAT legislation, which requires the two centres to levy VAT when charging to each other's grants, has made equipment sharing unfeasible. This has unfortunately hindered the collaboration. Although the two centres still share knowledge, best practice and facilitate training and intend to continue doing so, it is difficult to envisage significant equipment sharing occurring between the centres, so long as the current VAT stipulations remain in force.

Publication references:
1 Hunt et al. Rare and functional SIAE variants are not associated with autoimmune disease risk in up to 66,924 individuals of European ancestry. *Nat Genet.* 2011 Dec 27; 44(1):3-5
2 Trynka et al. Dense genotyping identifies and localizes multiple common and rare variant association signals in celiac disease. *Nat Genet.* 2011 Nov 6; 43(12):1193-201

University of York Bioscience Technology Facility – a Mid-Scale Facility

1. Scientific area and how links to Great 8/Industrial Strategy	Bioscience Technology Facility: Supports research in Life sciences, genomics and Synthetic Biology; Regenerative Medicine; Advanced Materials and Agri-Science, with applications in Health and Life Sciences and Agri-Tech sectors. The Facility also supports significant research on the environment and climate change especially in genomics and bioinformatics.
2. Description of project What was shared? (please comment on the scale of facility, for example if this was individual laboratory level of sharing or if a centralised / collective facility)	The Bioscience Technology Facility provides bioscience research support, services, and solutions to leading academic and industrial bioscientists. We offer integrated access to a wide range of expertise and state-of-the-art equipment which allows us to drive forward your research efficiently and cost effectively. Bioscience expertise is focused in the following core areas: – Imaging & Cytometry – Genomics & Bioinformatics – Proteomics – Protein Production – Molecular Interactions The activities fall into four categories: – **Access & Support** – we provide access to our state-of-the-art equipment, with support as required. – **Training** – we train academic and commercial bioscience researchers and technicians. – **Contract Research** – we undertake a wide range of research services on behalf of our users. – **Research Partnerships** – we collaborate with researchers and instrument manufacturers on how best to address complex bioscience challenges and also project manage the work.
Who was involved and how was it funded?	Initial funding from Joint Infrastructure Fund – DTI; Wellcome Trust and BBSRC provided £21m capital and small revenue funding to develop biosciences at York which included the creation of the Facility. Opened in 2002. Now self-funded - 70% cost recovery, and deficit met by the host Department in the University of York. Facility is used by many Departments, although only one meets the deficit – "Cost where the benefit is".
What were the reasons for sharing?	Ensuring PIs have access to cutting edge kit and expert staff Central, neutral facility – supports equitable usage and access. Greater efficiency and stability through a central facility with respect to both equipment and expert staff Removing the inertia barrier to accessing advanced technology
What would have happened if sharing had not taken place?	Biology would not have developed with the same strength and vibrancy. Has supported an increase in staff and critical mass, increased league table performance since 2002. Has been a critical tool in recruitment. Same amount of funding, used to purchase kit scattered across PIs would not have same outcome.

3. Research Outcomes - Excellence and impact	
3.1 multi-disciplinary work	Users from physics, chemistry and archaeology, in addition to biology Breadth of facility – allows one stop shop. One external project has used 4 out of the 5 labs available. Outputs- 43 publications in last 3 years have facility staff as co-authors, of these around one quarter include other departments or other HEIs. On average, 30 different external academic groups use this facility each year. Facility driven by a range of areas in biology and facility staff are highly technical but not active, biological researchers– this removes a lot of barriers and potential conflicts. Part of broader ecosystem in related research areas – for example Cancer Research UK on Correlative Light and Electron Microscopy, Liverpool – Next Generation DNA Sequencing Proteomics Methods Forum, Flow User Group – set up to share best practice and expertise.
3.2 collaborations with industry	20 different commercial users per year, 67 in last 6 years Very flexible arrangements– contract research, KTPs, CASE studentships, research collaborations SMEs like flexibility and the different arrangements Large companies also use the facility, for example AstraZeneca, and also Government labs – FERA
3.3 new science and technical advances	Method Development- work on correlative light and electron microscopy approaches, label-free mass spectrometry, protein solubility screen, flow cytometer sorting of pollen grains, and algal cells – range of different areas Working with seven different equipment manufacturers - Proof of concept, training courses, demonstration site, alpha- and beta-test sites. Applying emerging technologies- method development work. Brukker (global) and Phase Focus (SME in Sheffield). Courses for service engineers for awareness on biological terminology Breadth of biology and department means significant range of applications for new methodology
3.4 improved training & skills Please comment on any specific benefits for UG teaching	CPD courses – standard and bespoke. 115 external and 106 internal attendees (including PhD students) on last year's 16 courses Masters courses – MSc Bioscience Technology – established to develop skills base for the technology of the future UG – final year projects are completed using the equipment.
4. Efficiency outcomes	
4.1 Access to equipment of a higher specification than would have otherwise been affordable	Mass Spec – funded as part of Centre - this wouldn't have been funded unless shared equipment, and being embedded as centre of excellence Many examples of early access to novel instrumentation and follow on funding due to established infrastructure Efficiency of usage and quality of data obtained – highly trained facility staff lead to better training and troubleshooting which gives a better guarantee of quality results and ensuring appropriate set up and usage of kit.
4.2 Reduction in supplier costs – purchase or service cost	Collaboration with manufacturers – range of goodwill and discounts due to the site being proper demonstration site Lifetime warranties sometimes provided for no charge When involved in training, will provide servicing free of charge. This is possible due to high levels of human capital– world leading technologists and reputation of the staff and their ideas

4.3 Increasing load factors	Has allowed better equipment, better maintained and better supported Maximising use as far as possibly can – *"always available at 2am in the morning!"*
5. Benefits for teaching	See 3.4
Future plans	Importance of replacing legacy/workhorse equipment which is now 12 years old. Capital investment is often targeted at large or mid-range kit that is novel, but there is a need to have local instruments feeding into a shared advanced instrument, in order to maximise research productivity and the full benefit of the larger equipment. It is encouraging to see EPSRC looking holistically at the "well found lab". We also plan to use N8 to promote the sharing agenda further

Sharing facilities across Life Sciences cluster in Scotland

1. Scientific area and how links to Great 8/Industrial Strategy	Life Sciences is a priority sector for Scotland, and is supported by the local research council: Scottish Funding Council (SFC), and the local enterprise agency: Scottish Enterprise (SE).
2. Description of project What was shared? (please comment on the scale of facility, for example if this was individual laboratory level of sharing or if a centralised / collective facility)	Scottish Universities Life Sciences Alliance (SULSA) is a research pool that focuses on the life sciences, and interdisciplinary sciences that intersect with the life sciences. The pool is a strategic partnership between the universities of Aberdeen, Dundee, Edinburgh, Glasgow, St Andrews and Strathclyde. SULSA carries out a number of different actions to enhance research excellence in the life sciences in its member universities. Creating a suite of shared core facilities is a strand within SULSA's main activities. In 2008 a review of all life sciences facilities in SULSA universities was carried out to establish a strategy for developing the most critical ones and to ensure they would remain at the cutting edge. The best performing facilities were selected and granted a total funding of £8M to offer their services nationally. As a result SULSA facilities now comprises 22 cutting-edge facilities that are open to all researchers of SULSA universities.
Who was involved and how was it funded?	The project was funded by the SFC with £8M. The universities of Aberdeen, Dundee, Edinburgh, Glasgow, St Andrews and Strathclyde were involved in the project. SULSA created a Facilities Committee, with a representative from each of the partner universities.
What were the reasons for sharing?	It was acknowledged that many facilities in Scotland were underused, but also that the resulting spare capacity was not been "sold" onto other commercial or academic institutions, meaning that facilities were essentially wasting capital investment. It was also noticed that a lot of duplication of facilities was present in Scotland, meaning that because of restrictions in funding, they were not all at the cutting edge. Furthermore, many facilities were run by temporary staff linked to a particular research project, so with their departure the knowledge about the equipment was lost, causing lots of down time whilst inexperienced staff struggled to use them. Taking these three observations into account, and through a process of rationalisation, it was decided to identify the facilities in Scotland that were considered most critical to life sciences research excellence, and to promote them in a number of different ways. Firstly, they were give significant funding to access the most cutting edge equipment. Secondly, they were given core staff to help run the equipment and to train users, allowing continuity. Lastly, they were required to share access to this equipment with other SULSA universities to avoid duplication and to be promoted for use to these new customers.

What would have happened if sharing had not taken place?	The old patterns would have remained: inefficiency of use, duplication of equipment and lack of staffing continuity.
3. Research Outcomes - Excellence and impact	
3.1 multi disciplinary work	All of our facilities have multiple projects that are collaborations between SULSA universities. Around 20% of the capacity in SULSA facilities is used by researchers from "away" SULSA universities. In 2008 this figure was at around 4%.
3.2 collaborations with industry	Industry users have increased from 2% of capacity to 5% capacity. There is clearly still room for improvement here.
3.3 new science and technical advances	Since the inception of the SULSA shared facilities, they have serviced 3111 customers, published 522 papers collectively, been acknowledged in over 1500 papers, and brought in 114 grants worth around £110M. The facilities have also created a number of research tools, such as databases, applications, reagents that are made available to the SULSA community. In AY2012 for example these included a panel of monoclonal antibodies of medical importance, new controller software for bio-imaging applications, novel metabolomics analysis tools, a new metabolomics database, a database containing activity profiling of plant extracts and natural products against a panel of common bio-assays, several novel bacterial and yeast cloning, expression and purification systems, and new methodologies in identifying and analysing protein binding kinetics.
4. Efficiency outcomes	
4.1 Access to equipment of a higher specification than would have otherwise been affordable	The £8M pump-priming investment has allowed the chosen facilities to be at the cutting edge. This is evidenced in the level of equipment that is present in these facilities (OMX microscope as an example). The initial boost has had a catalytic effect and allowed facilities to pursue larger amounts of ongoing funding for further improvement.
4.2 Reduction in supplier costs – purchase or service cost	Facility sharing has led to the EDAM project, which aims to identify and pursue possible savings in maintenance contracts through a joint tendering and purchasing strategy.
4.3 Increasing load factors and any reduction in equipment requested from RCUK or purchased for HEI use	We do not have figures on this yet, and do not even have a strategy to acquire them! Any help on how we would do this would be appreciated.
5. Benefits for teaching Use of equipment by UG or PG students	Many of our SULSA students have accessed SULSA facilities during their PhDs to conduct their research. Around 15% of our students access a SULSA facility outwith their university every year. Many of the facilities also provide training to the students thorough a number of lectures and workshops, which can be counted as credits towards their degree skills training, where this is applicable.
Unanticipated consequences – good and bad	Good: Two facilities chose to join to pool to share their equipment and services, even through they have not received any funding from SULSA. Good: New projects are still being identified beyond the initial funding period. Bad: It is sometimes hard to keep the momentum going for new projects, when the immediate benefits (such as cash injections) are not present, but we are asking people to work towards achieving savings (which are less tangible).
Future plans	We aim to bring on more facilities into the sharing pool. We aim to continue promoting the facilities. We aim to identify further cost savings such as VAT and maintenance.

Facilities selected for sharing: Glasgow polyomics, Edinburgh Genomics, The Scottish Structural Proteomics Facility, CTCB - Edinburgh Protein Production Facility, CTCB - Biophysical Characterisation Facility, SULSA OMX, Electro Cryomicroscope Facility, Centre for live cell imaging and molecular physiology, Bioworkstation, PET imaging facility, IVIS spectrum imager, Scottish Hit Discovery Facility, Drug Discovery Portal, Scottish Bioscreening Facility, Scottish Biologics Facility, Aberdeen Marine Biodiscovery Centre, Transgenics facility.

National Facilities

Diamond Light Source facility, Harwell Science and Innovation Campus in Oxfordshire.

Diamond is the UK's national synchrotron facility and is a medium energy source. Operational in 2007, it is funded by the UK Government through STFC (86%) and the Wellcome Trust (14%) through a joint venture company set up to build and operate the facility and ensure sound management of the project throughout its lifetime.

It represents the largest UK-funded scientific facility to be built for over 40 years and could ultimately host up to 40 beamlines for scientific research. In 2012/13 (financial year) there were about 2,500 unique users who made about 6,300 user visits to the facility.

The applications of synchrotrons cover virtually all sciences – fundamental physics, engineering, environmental, medicine, biology, chemistry, cultural heritage and more. Through the ESRF and Diamond, STFC is helping to keep UK science at the forefront of ground-breaking research worldwide.
The long term strategy of Diamond defines which instruments are built;

- **The first instruments were largely based on known designs**, aiming to serve strong, established communities. Later designs still took into account the strength or potential strength of the community to be served, but some were also more experimental in design, aiming to push back the boundaries of what is technically possible and thus providing unique scientific opportunities.
- **The equipment is optimised for particular specialisations** and specific communities- e.g. materials chemists, crystallographers.
- **Beam time is mostly allocated through a competitive application procedure** based on peer review. These are reviewed purely on the science criteria; beamtime can also be accessed for proprietary research on a contract (paid) basis.
- **Increasing the breadth of research areas requires additional critical mass** – this may lead to building new instruments (timescale 3-5 years). Diamond staff are engaged in "outreach work" and highlighting the relevance of these instruments to a range of research questions. This can deliver new scientific insights and areas of research.

Multi-disciplinary nature of the facility:

The facility is used approximately 60% for physical sciences and 40% for life sciences, with a range of projects including;
- pioneering research into developing new cancer therapies that can be tailored to the individual patient
- working with metal munching earthworms to establish new ways to clean up polluted soil and improve the environment
- improving the efficiency of hydrogen storage to make it a realistic option for a sustainable energy source
- solving the molecular structure of the foot and mouth disease virus, leading to the development of an effective vaccine
- taking the metal lead from mussels and clams to create new robust and environmentally friendly materials for engineering and biomedical use

- understanding how metallic nanoparticles behave under changing conditions, leading to electronic, optical and medical applications
- helping to preserve the centuries old timbers of King Henry VIII's favourite warship, the Mary Rose, for future generations.

Utilisation Rates

- These are extremely high for a facility of this scale
- About 75% of beam time is used by external users, and about 25% of beamtime is used for maintenance, calibration, testing and internal research.
- There is also some capacity built into the process for "urgent science" –this can be fast tracked out with the bi-annual application process.
- Industry partners are also purchase beam time on a commercial basis – 70 companies have used the facility including multi-nationals such as GSK and Heptares

Training

- There is extensive training element to the facility, at a range of levels
- PhD students are jointly funded with universities- 30 FTEs at any one time
- In addition, several hundred students will utilise Facilities for PhD studies and are trained by beam-line scientists at Harwell
- Partnerships with over 15 Doctoral Training Centres to provide training, in combination with other STFC facilities.
- Specific training courses are provided on X-Ray physics
- Outreach programme for undergraduate students – 30 summer interns per year - are given one-two month project and training opportunities.
- The Diamond is also a very valuable source of highly-trained technical staff and engineers who develop their skills further while employed at Diamond, and in some cases move to other companies who require such skills and experience.

Procurement costs and efficiency savings – possibly more detail

- In procurement we seek where possible to leverage our position within the public sector e.g. by buying our electricity through the Government Procurement Service agreements which not only allows us to buy a better price but also to buy forward giving us greater cost certainty. Inevitably much of the equipment we buy is exceedingly specialist in nature and falls outside the scope of government arrangements.

- Diamond has a high fixed cost base and so it follows that adding more beamlines, as is happening with Phase III, will make it more efficient, ensuring full use of all the beamlines that are available i.e. maintaining high utilisation rates.
- Diamond continues to search for ways of reducing its underlying operating costs. Over the last few years it has reduced electricity consumption by >13% through investment in more efficient plant and by changes to the operating practices: similarly it has been able to reduce the consumption of liquid nitrogen. Other cost reduction measures have included in sourcing plant maintenance activities and facilitating remote user access which not only reduces costs (travel & subsistence) but facilitates better utilisation of the facility and is generally more convenient for users.

- 24 hour operations ensuring that the efficient use of the facility is maximised;
- Increased use of remote access/working (with 2,300 remote scientific users in FY13/14);
- Increased automation/robotics/sample handling

The various phases of construction of Diamond

The initial construction (Phase I) comprised the machine, experimental hall, seven beamlines, and an office building (Diamond House).

The second tranche of 15 beamlines (Phase II) became operational over the period 2007-2012

Phase III of Diamond provides for the design, procurement, construction and commissioning of an additional ten state-of-the-art beamlines, and become operational between 2013 and 2018. They will complement the seven beamlines that have been built under Phase I and the 15 completed under Phase II, and will extend the overall technical capability of Diamond and its reach to the scientific and industrial arena of the UK. The proposal also provides for a detector and instrumentation development programme to ensure that great potential of Diamond is fully realised

Catapults: Specialist translational facilities for business and academia

National Composites Centre– part of the High Vale Manufacturing Catapult

1. Scientific area and how links to Great 8/Industrial Strategy	National Composites Centre – supports the development of 4 of the Great 8 Technologies: Advanced Materials, Robotics, Nanotechnology, Energy / Energy storage Industrial Strategy sectors: Aerospace, Automotive, Construction, Oil and Gas, Offshore Wind, Space. Biggest exports in UK – motor vehicles, aircraft wings & engines are looking at the development of composite products. NCC supports the development of the biggest industrial projects and the R&D for next generation of composite products. Products generate billions for economy and require full suite of equipment for development.
2. Description of project	All equipment in the facility is shared- all available for use by industry as part of membership arrangements or on a pay-as-you-go basis. Equipment includes: **Autoclave technology** – focused on aerospace industry, emphasis on quality, fail safe technologies. Products are high value **Automatic tape laying machines (£2.5m each + software)** – precision application of 4mm wide strips of carbon fibre tape. Machine has independent robotic heads, the clamping tool can also move separately – allows manufacture of highly complicated shapes. Unique in UK, c.80% utilisation rates (based on 48 hour week). This equipment mitigates labour costs and allows production of highly complex parts which could not be produced using conventional materials. Provides increased durability & reliability and reduce costs of assembly of final product. Retains applications knowledge base in UK. **C-Scan Non-destructive testing (£1m+)** – sophisticated detection of defects within the structure of test parts. **Computerised Measurement Machine (£1.5m)** – analysis of the production detail of finished parts – allows examination of production process, looking at how this has deviated from the desired finished article. Is a feedback tool to assess the fitness for purpose of finished product. **Through Thickness Reinforcement (£1m):** brand new patented technology which improves toughness of composite structures. New equipment fully commissioned in March 2014.

	The NCC has access to a wide range of sophisticated design tools and can demonstrate these to SMEs and other companies but cannot allow these to be shared because of licencing agreements. **Extension of NCC** This extension is over 8000m2 and more than doubles the size of the current building. There are a number of customers identified which will use the following equipment (and space). **Large hydraulic press (£2.5m)** – next generation press. Fast cycle time, 3600 tonne capacity – can be used for car bodies' and possibly aircraft components. Smaller, development press to complement large facility **(£1m)**. Delivered and commissioned for September. The press and ancillary robotic equipment will facilitate the development of high-throughput composite manufacturing to meet the needs of the automotive and other volume applications. Cornerstone of UK based open access facility for retention and re-shoring of high volume automotive composites application engineering. A new extension opening in October 2014 will be used by Airbus for the development of the next generation of aircraft which has been secured in the face of international competition. More than half of the NCC's members have overseas ownership. All these companies are investing in innovation / new product development in the UK.
Who was involved and how was it funded?	Phase 1: Initial capital costs were funded by BIS, Regional Development Agency and European Regional Development Funds. Running costs public / private match Depreciation – covered by Catapult grant Refresh to state-of-the-art is a continuous challenge
What were the reasons for sharing?	High costs of capital equipment means no one company could justify investment in such equipment. Sharing resolves indivisibility of asset, and allows a range of blue chip companies of all sizes and from all sectors to access this equipment
What would have happened if sharing had not taken place?	If platform technologies & innovative equipment not funded, investment would have been made overseas and reduction of R&D spend and capacity in the UK.
3. Research Outcomes - Excellence and impact	
3.1 multi disciplinary work	Critical mass of specialist engineers with experience in disciplines such as design, simulation, stress, materials and automation.The facility provides an environment which supports linkages between Universities and Industry.
3.2 collaborations with industry	Large global companies- Airbus, Rolls Royce. These companies provide long term contracts and funding security. Membership of NCC grown from 5 to 37 members since 2011 Over 100 SMEs have used / paid for facilities Over 1.000 visitors a month at NCC, many SMEs 20 universities engaging with NCC
3.3 new science and technical advances	Patents, trademarks & disclosures – over 40 registered so far, and new ideas are in the pipeline. Multi national company– removed 45% of time on specific process Working with the NCC has helped Airbus' UK operation to increase the number of engineers trained in composites, increase productivity by 10%-15% and register five patents relating to aircraft wings which have enabled a cost saving of 20%, and a weight saving of 15%.

3.4 improved training & skills Please comment on any specific benefits for UG teaching	High specialised : currently 20 vacancies unfilled High Value Manufacturing Catapult –skills training at Midlands Technology Centre and Advanced Manufacturing Park. NCC will deliver level skills in the Phase 2 expansion which will open in September 2014. Companies demanding pipeline of skills to keep pace with the technology.
3.5 economic growth	Working at NCC has helped Airbus' UK operation to lead the activity to secure the engineering lead, and a "ground based demonstrator" for the next new aircraft wing within the UK. Has helped to secure the manufacturing of this new aircraft wing in the UK, which is anticipated to lead to 2,000 new jobs in the UK, and an increase in Airbus' contribution to UK GDP from £4 billion to £6 billion by 2033.
4. Efficiency outcomes	Use of the automated tape laying capability has accelerated speed to market for GKN in developing world-leading industrial facilities in this technology in the UK for global market.
4.1 Access to equipment of a higher specification than would have otherwise been affordable	Airbus have transferred their own equipment into NCC for their own in-house composites facility. This move was described as mutually beneficial for both Airbus and the NCC, as *"if we [Airbus] transfer the equipment to the NCC, and get a high utilisation on it, it means that we can refresh the equipment faster, which is to the benefit of Airbus, and all NCC members"*
4.2 Increasing load factors and any reduction in supplier costs – purchase or service cost	Some companies providing services free of charge –e.g. donations of equipment free of charge This means they are credited for technician time when they pay to use equipment
5. Benefits for teaching Use of equipment by UG or PG students	Increasing applications engineering knowledge for postgraduate students, and creating long term demand for their skills. Shaping future course content, including recent multi-University Engineering Doctorate scheme.

Centre for Process Innovation (part of the High Value Manufacturing Catapult): Leading edge facilities supporting new innovations in the process industries.

Background and Facilities

The Centre for Process Innovation (CPI) is the UK's national technology and innovation centre to serve and support the process manufacturing industries. CPI work with key UK Universities and academic spin-off companies to develop, prove, prototype and scale up the next generation of products and processes. CPI helps clients to accelerate new concepts (often started in research institutions) to commercial reality by working in the innovation space between the discovery of an idea and the delivery of a product or service to the commercial market.

The Facilities and Equipment available at the Centre for Process Industry include:

- The National Industrial Biotechnology Facility: To scale bioprocesses from 1 litre to 10,000 litres batch or continuous production, to develop biorefining processes and improve anaerobic digestion systems.
- The National Printable Electronics Centre: To scale printed electronic processes and devices to Gen2 scale including ink formulation and application, barrier coatings, integrated smart systems and device prototyping.
- The National Biologics Manufacturing Facility (in construction): To support the development of novel processes for the production of biological pharmaceuticals.
- Formulation and Flexible Manufacturing Centre: Developing processes and applications in novel

formulation and continuous manufacturing processes including 2D particle production and dispersion, novel continuous production techniques and formulation processes.

- hermal technologies centre: To develop high temperature processes in collaboration with Tata Steel Teesside Technology Centre.

Examples of Industry/University/CPI Collaboration:

- **CPI Northern Way Printable Electronics Programme:** CPI prototyping facilities including in materials, ink formulation and optoelectronics were utilised in a programme involving Leeds, Liverpool, and Manchester universities and companies such as bio-photonics light therapy specialist PolyPhotonix, global packaging supplier Chesapeake and security print manufacturer Tullis Russell
- CPI provided a combination of technical know-how, technologists and prototyping facilities to allow the North of England's established industrial and academic base in chemicals, materials, process equipment, printing and electronics to explore and engage with the emerging Printed Electronics industry.
- A host of end user product demonstrators were developed as part of this project, including low cost printed gas sensors, intelligent pharmaceutical packaging samples and printed electronic control systems to name a few.
- Working with the **University of Huddersfield IBS Precision Engineering and scale up Ultra Barrier Defect Detection Tool to Pilot Scale (TRL 6-7)**, CPI have supported the design and manufacture a state-of-the-art Wavelength Scanning Interferometer system.
- This enables the fast surface measurement of low contrast defects at pre-industrial scale using 3D technology, and is able to perform at the speed required for ultra barrier films at proof of concept scale.
- The wavelength scanning interferometer will be housed in CPI's clean room, which is crucial in providing a high quality test environment for new devices under pre-manufacturing conditions.
- Future development work has been devised, with a technology roadmap aligned to advance the development towards wider industrial applications in thin film quality assurance.

Training Benefits through utilising CPI facilities for University College London

- CPI assisted University College London in the delivery of its Industrial Biotechnology and Biorefining module, looking the challenges associated with the commercialisation of products and processes related to the biotechnology and biorefining industry.
- CPI's National Industrial Biotechnology Facility can develop biotechnological processes from 1 to 10,000 litres, with world class capability in process development, pilot production and demonstration scale manufacturing. One aspect of the module was to identify the steps needed to optimise and scale processes at laboratory scale using CPI's 1 litre and 10 litre fermenters.
- The findings derived from the laboratory were then used to discuss how the students would upscale their process to ensure that it is robust and cost-effective at a larger scale, attractive for potential investors.
- The outcomes from working with CPI's Industrial Biotechnology Facility enabled the students to attain an understanding of how to set up a demonstration scale plant, the likely cost of manufacturing, and the production of data and material to help support the delivery of a reliable and consistent process.

CPI Working with Partners to Convert University Research into Viable Technology Businesses:

- CPI start up company PolyPhotonix have developed Noctura 400® sleep mask sleep mask for the home treatment of Diabetic Retinopathy, one of the most common causes of blindness.
- Polyphotonix have worked with the University of Liverpool's Eye and Vision Science Department to accelerate the commercialization of the Noctura 400® sleep mask through a series of safety and efficacy trials. CPI has enabled PolyPhotonix to test, develop and scale up their prototypes in an infrastructure unaffordable to a start-up company. They also had the ability to trial new ways of working

using the pilot production line.

- Plaxica, a spin-out from Imperial College London, has worked with CPI to access laboratory facilities to help develop and scale up the production process for their product: a greener, cleaner and stronger form of plastic made from natural feedstock such as sugar and corn starch, and can be used for a variety of consumer packaging and clothing applications.
- After early stage trials were successful, Plaxica approached CPI to use CPI's biorefining lab scale facilities to optimise and scale their initial process, the trials have been successfully taken from bench to pilot scale (20 litres in scale)
- Plaxica now occupy two laboratories with 20 staff at CPI (having started with one bench unit)

Transport Systems Catapult

Efficient transport systems are essential to the health and wealth of the UK, its businesses, its economy and its people. Within the UK, there are constraints on availability of space and capital for infrastructure investment, whilst at the same time predicted growth and increased demand for mobility. The Transport Systems Catapult will support UK industry in exploiting the massive global market for new products and services that will drive better understanding, decision making and integration of transport and its systems. Utilising existing transport infrastructure is critical for intelligent mobility, and this can be supported by better linkages & integrating testing across transport networks

Some of the early challenges that will be addressed through the Catapult include seamless journey systems, remote asset management and monitoring, traffic management and control systems, and novel economic and business models.

To address these challenges, the Catapult has adopted a strategy of leveraging large investments made in UK science and technology facilities as he key to unlocking greater intelligent mobility. For example

- Working with Science and Technology Facilities Council to use High Performance Computing Capability for large scale transport systems modelling. High Performance Computing facilities will enable the modelling to be done at scale and capacity – increasing the size of jobs that is possible

- This will be part of the intelligent mobility platform, bringing together different models, data sources and processing services for companies to use on a commercial basis. The models that are used by organisations such as London Underground and Transport for London are currently not integrated. The Intelligent Mobility Platform will provide an interface for models and data to be brought together

- MK Smart is an £8m HEFCE funded project to develop innovative solutions to support economic growth in Milton Keynes. The Transport Systems Catapult is linked to the state-of-the-art 'MK Data Hub' which will support the acquisition and management of vast amounts of data relevant to city systems from a variety of data sources. These will include data about energy and water consumption, transport data, data acquired through satellite technology, social and economic datasets, and crowd sourced data from social media or specialised app. It will be linked to the intelligent mobility platform and provide data at a city-wide level to allow transport modelling at this geographic scale.

- The Catapult has developed a Strategic Partner programme where 14 universities have been selected based on their relevant expertise, infrastructure and coverage across range of transport systems.

Sharing assets across the social sciences - UK Data Service:

The ESRC has been investing in research data for more than 40 years, developing a rich infrastructure and a diverse collection of data that are regularly archived and reused in research that informs both policy and public opinion.

The UK Data Service builds on this legacy, providing an easy-to-use web portal to an expanding range of high-quality digital data including UK census data (1971 to 2011), government surveys, international macrodata, business microdata, longitudinal studies, qualitative resources, and data from individual research projects. All are available to search and download from a public website, and come packaged with detailed metadata, related documentation and clear citation information. They are backed with expert guidance, training and helpdesk support to meet the needs of researchers, teachers, data owners and other stakeholders. The Service and its predecessors, along with the ESRC Research Data Policy, has ensured that the social sciences remain at the forefront of a data sharing culture, while fully protecting the privacy of data subjects.

These investments have returned numerous benefits to those who use data:

- Over 24,000 users – from all sectors and across the globe – are registered with the UK Data Service
- Data are being downloaded a rate of 61,000 datasets a year.
- Users can look in the data catalogue for a list of academic publications that have used each data series (for example, the Quarterly Labour Force Survey).
- There are over 100 research case studies demonstrating how data are used in specific projects, for example research into alcohol pricing policies, business labour practices during the recession, and buy-to-let landlords.
- An additional 32 teaching case studies showcase how teachers are integrating real-world data into their studies to strengthen both research skills as well as provide an evidence base for economics and social science courses.
- A 2012 independent report of ESDS (the precursor to UK Data Service) found that for every pound invested in data and infrastructure, the Service returns at least £5.40 in net economic value to users and other stakeholders.
- A 2014 report commissioned by Jisc found that the Service generates a healthy return on investment, as it *"facilitates additional use which realises additional returns that could be worth some £58 million to £230 million over 30 years (net present value) from one year's investment expenditure – effectively, a 2.5- to 10-fold return on investment."*

The UK Data Service is now providing a basis of expertise for the UK's national Big Data strategy. In 2013 it received funding to establish the Administrative Data Service, facilitating research access to routinely collected data from businesses and local governments in a way that maximises research outputs while protecting personal information. It will also play a coordinating role in two further phases of the Big Data Network.

Development of Infrastructure to Support Sharing

Project EDAM – Equipment Sharing in Scotland

Introduction

The EDAM initiative is a joint venture between Advanced Procurement for Universities and Colleges (APUC - the Centre of Procurement Expertise for Scotland's Universities and Colleges) and Scottish Universities Life Sciences Alliance (SULSA - a research pooling partnership between the Universities of Aberdeen, Dundee, Edinburgh, Glasgow, St Andrews and Strathclyde), taking the lead on behalf of the other research groupings across Scotland.

In early 2012, APUC and SULSA therefore commenced this collaborative project to put in place an Equipment Database and Maintenance (EDAM) requirements solution.

The two fundamental aims of the project were to:

- Put in place a solution that would enable the rationalisation of laboratory equipment maintenance contracts and much improve our ability to identify collaborative contract opportunities for equipment maintenance, and
- To provide a tool to provide where relevant, visibility of equipment that may be available for sharing or re-sale etc that would allow increased and more sustainable utilisation of equipment and meet Wakeham review requirements in respect of research grant bids

Before this project, implementing effective collaborative agreements for lab equipment maintenance had been virtually impossible owing to the lack of information on the installed estate of lab equipment.

Project Outcomes (go-live was September 2013):

- Provide a robust tool to record and track the laboratory equipment estate across all institutions in Scotland.
- Deliver cost savings by allowing researchers to check for availability of particular pieces of current equipment available for sharing or purchase / re-use; thus potentially removing the need to purchase equipment for new research projects.
- Easy identification of redundant research equipment. This equipment can then be re-used internally for teaching, sold/transferred to other Institutions or sold to external to sector organisations. This may provide wider benefits for the wider economy by offering equipment to third / private sector organisations.
- Investigate possibility for collaborative equipment maintenance agreements following regular population / update of the EDAM database.
- Lowering the cost of maintenance of research equipment will lower a barrier to having the equipment maintained will lead to increased numbers of pieces of equipment being placed under support contracts, extending its working life and ultimately enhancing the quality of research.
- As of March 2014, there were around 18,000 pieces of equipment recorded on the database across 19 institutions.

The first wave of tenders for maintenance are now under way (March 2014) based on the data provided via the EDAM database tool, this is expected to bring significant savings to the cost of maintenance of the installed equipment as well as bring enhanced reliability and availability of the equipment.
Moving forward, it is planned to work with other groups across UK HE (N8 Partnership, equipment.data etc) to explore joining up the asset management projects throughout the UK, sharing with them the particular attributes that could also allow their databases to be used for delivering the data to optimise the maintenance procurement process that is currently enjoyed via EDAM.

Benefits Summary Table

Below is an analysis of the Benefits, both proposed in the bid to the SFC and delivered as a result of the project.

Proposed Benefits	Delivered Benefits	Additional Benefits
Deliver a tool to record and track the laboratory equipment across HEI's in Scotland	Construction of the Project EDAM (Equipment Database and Maintenance) database	Identification of areas for potential collaborative maintenance agreements.
Allow colleagues to meet conditions of grant funding application in respect of the Wakeham review	Facility for inter and intra-institution information sharing	Potential cash and non-cash benefits from collaborative maintenance agreements.
Identification of redundant laboratory equipment, facilitating re-use or re-sale.	APUC have investigated the scale of and now have visibility of the installed lab equipment in Scotland.	Higher utilisation rates of equipment owing to better information.
Ability to let laboratory equipment maintenance agreements on a collaborative basis.	Sought and secured engagement and contribution from academic and procurement stakeholders	Projected saving, based on other such projects are predicted to be in the region of 15% versus current costs

N8 Shared Research Equipment Inventory

T*he University of Leeds, on behalf of the N8 Research Partnership, has developed, a unique system to classify and locate research equipment and facilities. This inventory system underpins a fully searchable online database of research assets across the N8 that can be used to identify opportunities to share equipment with academics and business and plan for future requirements. During 2014 there have been over 4,000 unique visitors to the site, viewing nearly 35,000 pages, with a trend towards increasing use.*

The success of any equipment sharing initiative is intrinsically linked to the ability to understand what equipment is available, locate specific items and find contact details of people able to facilitate access.

Researchers at Leeds identified that in order to share efficiently across institutions or disciplines you first had to define a common language to describe assets that was not reliant on local or subject specific terminology. This led to the development of an equipment inventory system that classifies research equipment according to its primary research function in a way that is intuitive to the end user. It is based on a simple three level hierarchy (designated as Class → Order → Genus) where Class describes the general stage of experimental process, Order classifies by a broad approach or group of techniques and Genus identifies a specific technique or instrument type.

The six Classes are defined as:
- Process Equipment – Physical
- Process Equipment – Biological
- Materials Characterization
- Sample Characterization and Analysis
- Large Scale Instruments
- Infrastructure

All research equipment across the N8 has now been classified using this system.

The next step was to develop a web based portal that aggregates the individual University equipment registers into one fully searchable online database; the N8 Shared Research Equipment Inventory System – www.n8equipment.org.uk. This database is freely open to anyone to search and can be used to locate and request access to nearly 4,000 items of equipment across the N8 partnership. This portal automatically pulls in data feeds from the individual University asset registers every night and therefore remains up to date without manual intervention.

A search function on the home page allows the end user to locate specific items of equipment if they know what they are looking for. Individual records contain descriptions of the equipment, including make and model, along with academic and technical contact details to allow specific enquiries and requests for access to occur directly. Additional functionality allows the equipment owner to add in further details, such as enhanced descriptions, photographs and technical manuals.

It is, however, the incorporation of the classification system described above that truly unlocks the full potential for equipment sharing and planning across the N8. This allows researchers to browse across groups of related equipment according to functionality and refine by classification, location or subject specific requirements. For example, locating NMR systems across the N8 can be done in two ways; a simple search on NMR via the home page or via the classification menu (Materials Characterisation → Spectroscopy → Nuclear Magnetic Resonance). Results can then be narrowed down to systems within chemistry, biology or engineering departments or by manufacturer allowing the end user to locate the most appropriate system for their research area.

This system is scalable and could be used to aggregate equipment inventories across a wide range of sources and data sources. The classification system enables analysis of clusters of research equipment that is invaluable in understanding the current asset base and planning for future requirements and opportunities to share or reduce duplication of purchases. On a national scale this could be used to provide a detailed picture of the status of UK research facilities and underpin any roadmap for future investment.

equipment.data – The National Equipment Portal

Introduction

equipment.data, The 'National Equipment Portal', is an EPSRC funded project in response to the need to improve visibility and utilisation of UK higher education research equipment. The website uses a relatively simple piece of programming technology that enables searching across published UK research equipment databases through one aggregation portal. It provides a 'shop window' for UK HE equipment and facilities, enabling greater accessibility and importantly encouraging conversations with the aim of improving efficiency and stimulating greater collaboration in the sector. As we are finding through the engagement activity of the project many institutions not in consortia see this as an opportunity to discuss access to research equipment and/or as an opportunity to collaborate in previously less accessible areas.

With simple methods of contribution to equipment.data available we are noting a number of institutions are keen to publish directly to equipment.data as in the case of Bournemouth University, Royal veterinary College and the BBSRC Research Institutes, many having simply used excel spreadsheets identified by the Organisation Profile Document.

Figure 1: Equipment.data status page

Data.ac.uk | more Data.ac.uk sites

Feedback

equipment.data

Compliance | Status | FAQ | Uniquip

Status Report

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The data from each organisation has been normalised into Uniquip Spreadsheet Format and RDF encoded as Turtle (.ttl) and using the OpenOrg pattern for equipment and facilities data.

Organisation		Datasets						
		Raw Source	Type	Download*	Records	Timestamp	Issues	Compliance
	The Babraham Institute ID: ukprn/10032038	dataset (OPD)	uniquip	HTML, JSON, CSV, TSV, RDF (TTL)	45	Mon Mar 24th, 2014 11:42	None	Gold
	University of Bath ID: ukprn/10007850	dataset	pure	HTML, JSON, CSV, TSV, RDF (TTL)	729	Mon Mar 24th, 2014 11:42	1	Bronze
	University of Bournemouth ID: ukprn/10000824	dataset	uniquip	HTML, JSON, CSV, TSV, RDF (TTL)	49	Mon Mar 24th, 2014 11:42	None	Bronze
	Cardiff University ID: ukprn/10007814	dataset	pure	HTML, JSON, CSV, TSV, RDF (TTL)	60	Mon Mar 24th, 2014 11:41	1	Bronze
	The Genome Analysis Centre ID: other/X5	dataset	uniquip	HTML, JSON, CSV, TSV, RDF (TTL)	21	Mon Mar 24th, 2014 11:42	None	Bronze
	The Institute of Biological, Environmental and Rural Sciences ID: other/X7	dataset (OPD)	uniquip	HTML, JSON, CSV, TSV, RDF (TTL)	137	Mon Mar 24th, 2014 11:42	49	Silver
	Institute of Food Research ID: other/X4	dataset	uniquip	HTML, JSON, CSV, TSV, RDF (TTL)	54	Mon Mar 24th, 2014 11:42	1	Bronze
	The John Innes Centre ID: other/X2	dataset	uniquip	HTML, JSON, CSV, TSV, RDF (TTL)	100	Mon Mar 24th, 2014 11:42	None	Bronze
	University of Leeds ID: ukprn/10007795	dataset (OPD)	rdf-n8	HTML, JSON, CSV, TSV, RDF (TTL)	1096	Mon Mar 24th, 2014 11:41	1	Silver
	University of Loughborough ID: ukprn/10004113	dataset	kitcat	HTML, JSON, CSV, TSV, RDF (TTL)	62	Mon Mar 24th, 2014 11:41	None	Bronze
	University of Newcastle Upon Tyne ID: ukprn/10007799	dataset (OPD)	kitcat	HTML, JSON, CSV, TSV, RDF (TTL)	138	Mon Mar 24th, 2014 11:41	None	Silver
	University of Oxford ID: ukprn/10007774	dataset	rdf	HTML, JSON, CSV, TSV, RDF (TTL)	6	Mon Mar 24th, 2014 11:42	2	Bronze
	The Pirbright Institute ID: ukprn/10033892	dataset	uniquip	HTML, JSON, CSV, TSV, RDF (TTL)	60	Mon Mar 24th, 2014 11:42	None	Bronze
	The Roslin Institute ID: other/X1	dataset (OPD)	uniquip	HTML, JSON, CSV, TSV, RDF (TTL)	42	Mon Mar 24th, 2014 11:42	None	Gold
	Rothamsted Research ID: other/X3	dataset (OPD)	uniquip	HTML, JSON, CSV, TSV, RDF (TTL)	70	Mon Mar 24th, 2014 11:42	None	Gold
	The Royal Veterinary College ID: ukprn/10007779	dataset	uniquip	HTML, JSON, CSV, TSV, RDF (TTL)	8	Mon Mar 24th, 2014 11:42	None	Bronze
	University of Southampton ID: ukprn/10007158	dataset (OPD)	rdf	HTML, JSON, CSV, TSV, RDF (TTL)	350	Mon Mar 24th, 2014 11:41	1	Gold
	University of Surrey ID: ukprn/10007160	dataset	uniquip	HTML, JSON, CSV, TSV, RDF (TTL)	323	Mon Mar 24th, 2014 11:41	20	Bronze
	University College London ID: ukprn/10007784	dataset (OPD)	kitcat	HTML, JSON, CSV, TSV, RDF (TTL)	462	Mon Mar 24th, 2014 11:43	None	Silver

Totals

This archive contains 3,812 items from 19 organisations.

The above screenshot of the equipment.data status page illustrates the information the website automatically generates for data management; it provides browsers and institutional contributors an indication of overall level of contribution along with items per institution. Each line entry also provides the data in a range of downloadable formats for analysis purposes etc, although the full dataset can also be downloaded.

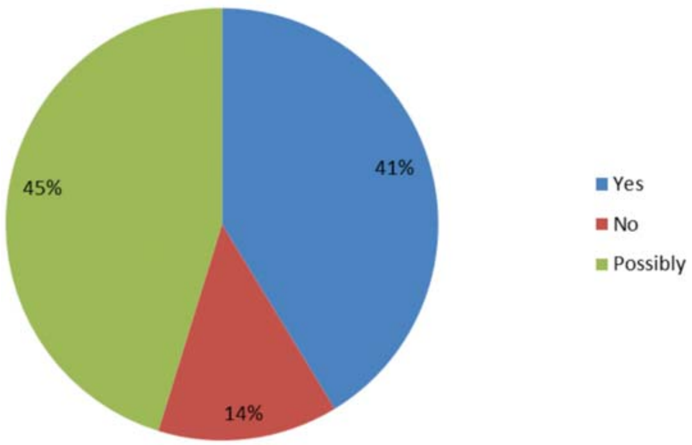
Supporting our aim to make the site as self-sustainable as possible we have also introduced a range information fields. These include a timestamp for the last data ingest and an 'issues' field providing details on quality of data harvested (i.e. duplicate entries or items without contacts) and finally a 'compliance' field aimed at improving sustainability of the data aggregation. Essentially the silver and gold standards indicate data is auto-discovered whilst bronze is manually identified data where institutions have to inform us where the data is published.

Landscape study

Commenced in September 2013, the study aims to contact all UK HE institutions [20] to establish interest in the equipment.data portal and its relevance to each organisation. As of March 2014, the below figures illustrate some initial findings and conclusions drawn.

126 institutions have been contacted at this point, 40 of these are in the initial stages of the communication process e.g. we're establishing who the right contact is etc. The 23 members of the four major regional consortia groups (SES, GW4, M5 and N8) have all been contacted separately to the landscape study and so are not included within the figures below, Scottish Universities are also not included although have been engaged by the project through a Scottish universities "Equipment Sharing" workshop and subsequent follow up communications.

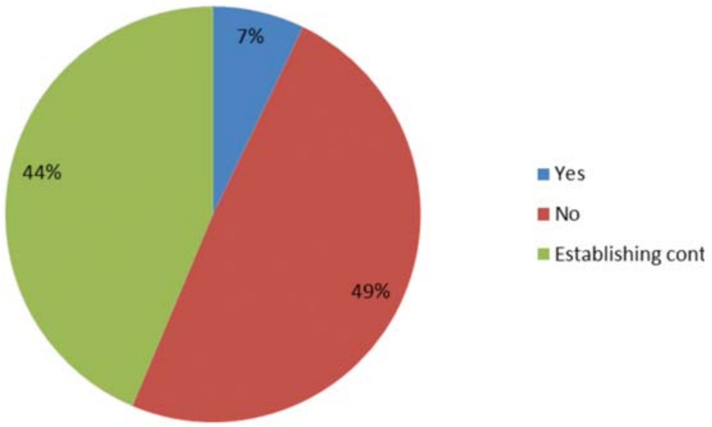
– How many institutions want some level of involvement with equipment.data?



These figures show the overwhelming majority of those contacted either want involvement or possibly want involvement with the portal (86%). This participation may be contributing data, accessing data from other institutions or both.

20 (Base data from http://learning-provider.data.ac.uk/)

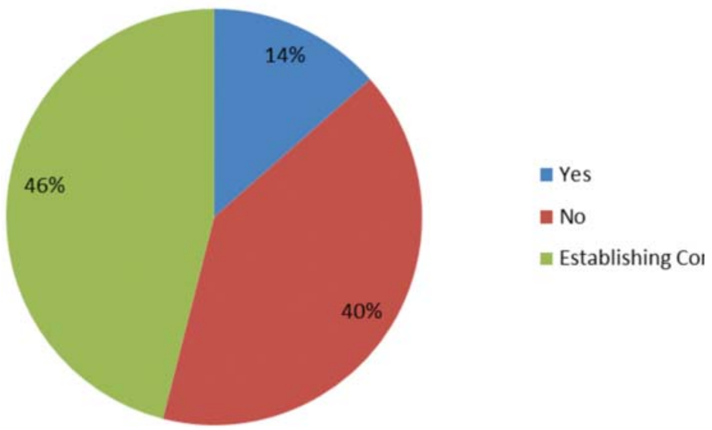
– How many institutions already have an equipment/facilities database?



49% responded "no" to already having a database, although what we have gleaned from many of these conversations is that whilst a respondent thinks there's no database there may in fact be the start of one in existence in the shape of an asset register or similar. This highlights some education is still needed in the sector in terms of how an equipment/facilities database may be developed within an institution and where to begin ascertaining if one exists. We are now working to increase awareness around the asset management process' role in equipment databases through activity with BUFDG and vendor engagement developments enabling a better understanding of the how improvements and efficiencies can be established.

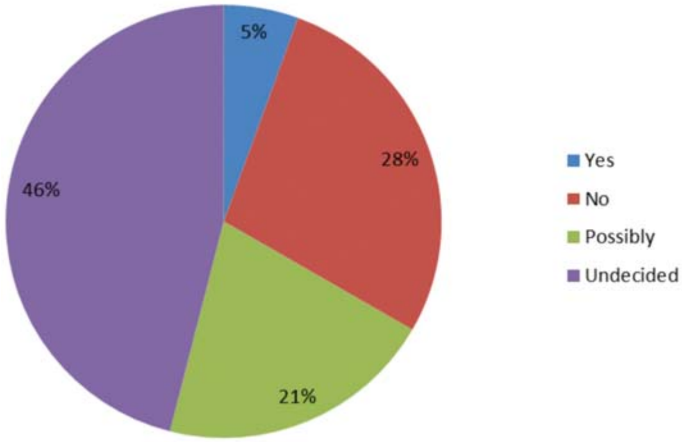
The 44% identified as 'establishing contact' are those organisations that have yet to confirm to us whether they have a database and initial contacts have been asked to identify who is best placed to respond to our enquiry.

– How many institutions are developing an equipment/facilities database?



The results to this question are encouraging in that there is a good sized group of institutions developing databases. The 46% 'establishing contact' are those where the contact is unsure if one is in progress, meaning there are potentially more in development. There is a relatively large number that unfortunately answered "no" to this, some of these are institutions where a database isn't relevant to them - for example they don't have equipment to share or it's not a business engagement objective. For the others, we are continuing to work with them in demonstrating the benefits of collaborating and encouraging them to contribute to equipment.data.

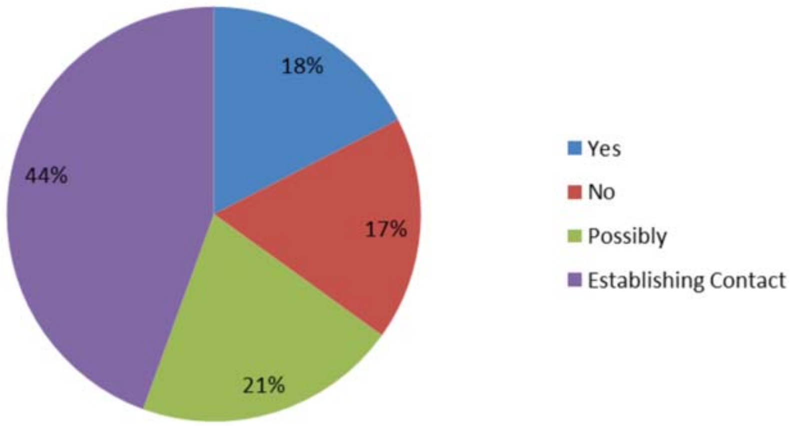
- How many institutions asked for 'access only' to equipment.data?



There is a small number who have answered with a definite "yes", with a larger contingent of "possibly" or "undecided", making up 67% of respondents. This is largely due to the following reasons:

- They do not have any suitable equipment or facilities to contribute to the database
- They are not funded by RCUK so feel no obligation to or that there is no business case for them contributing
- There is uncertainty as to whether they have equipment which could be shared, or
- They feel their data is not ready to publish yet in terms of comprehensiveness and quality although may use the portal but not contribute.

- How many institutions feel that they will need technical support?



The responses highlight that a large percentage of institutions need or will possibly need technical support in order to publish their data; although the technical element to contributing is very simple, therefore the challenge may be one of internal development enabling contribution – this is a statistic we are constantly monitoring to ensure technology doesn't become a perceived barrier.

Regional consortia

Across the regional consortia projects there are still noted concerns within some institutions in establishing acceptable data quality, in a number of instances, impacting on willingness to publish openly, along with some institutions still working on final database developments.

Case studies

The landscape study has initiated a number of interesting conversations; these have provided us with insight into approaches and attitudes to equipment and facilities sharing.

– Edge Hill University

Edge Hill University in Lancashire has a strong research and enterprise function, undertaking research within its faculties of Arts and Sciences, Health and Social Care, and Education.

When contacted by equipment.data, Edge Hill was immediately interested. They currently share equipment internally and where and when feasible regionally as well. As a small institution, the opportunity to access a database of equipment and facilities at larger institutions, at no cost to themselves, would open up the potential for conversations around research access to equipment that had previously been unavailable.

– Kingston University

As an institution Kingston is not currently in a position, like many others we have spoken to, to publish its equipment data to equipment.data. Early conversations have established Kingston's facilities are not funded via RCUK instead through institutional and commercial contribution with a greater teaching, enterprise and commercial research focus. However, they do see the benefits presented by equipment.data and will be considering which facilities and equipment would be best placed to contribute. In the meantime they are interested in accessing the equipment.data portal in order to possibly utilise equipment and facilities at other institutions to support activity and are keen to learn more through our ongoing engagement.

The access only role is one that equipment.data is happy to accommodate and is a large part of the reason for the open data ethos of the site.

If larger institutions can help smaller ones that have no equipment to share, by sharing with them, and in turn the smaller ones can strengthen an equipment bid for a larger institution because they too would use the kit and produce good research, this demonstrates the importance of the access only role.

– Norwich University College of the Arts (NUA)

An arts college may not, at first glance, be the type of institution that would obviously have equipment and facilities suitable for sharing. However conversations with NUA have identified not only the desire to share but also a database of suitable kit such as 3D printers, studios and machinery.

The keen interest from NUA demonstrates the breadth of relevance the portal has across all types of institution.

– Queen Mary and Westfield College, University of London

Queen Mary and Westfield College is in the unique position in that it is a member of the research intensive Russell Group and yet doesn't currently sit within a defined regional consortium of universities. Therefore when it comes to equipment and facilities sharing, this institution is still 'going it alone'.
This has meant Queen Mary has shown a keen interest in being involved in equipment.data as it will hugely increase the visibility of its own kit and provide them with access to other equipment and facilities both regionally and nationally.

The portal is playing a vital role here in enabling sharing for institutions that can't currently take advantage of sitting within a regional grouping which shares on that level.

Developing VAT Cost Sharing Groups

Work has been undertaken by the N8 universities in an attempt to facilitate the cost efficient sharing of research equipment between universities.

Without utilising the exemption, there is an additional 20% VAT cost, which is a barrier to increasing research productivity and efficiency through sharing.

The N8 universities have developed the following structure
- Each university establishes its own Cost Sharing Group
- The university invites other institutions to be members, according to which HEIs want to share their equipment
- In order to benefit all universities must become members of each other's CSGs, if they do not do so then the exemption cannot apply when they seek to use equipment from a university where they are not a member of that CSG.

The CSGs of the universities will perform various tasks for their host university, supplying it with a qualifying service and the members receive the qualifying services of usage of equipment. Set out below are some of the tasks the CSG will perform, indicating the complexity required in order to comply with the VAT exemption requirements.

- The CSG will ensure the equipment database is up to date, liaising with the 'host' university
- The member universities select the equipment desired and place order through the CSG to have access to the equipment
- The CSG places the order with the host and invoices the member for the 'usage' and collects the fee
- The host university invoices the CSG and collects the fee
- The CSG reports on hiring activity to the host university and assists in resource planning

Due to these onerous requirements, there is additional administration in order to meet the criteria and gain exemption. However, if this is widely adopted as a way of working it will in itself become a more streamlined and efficient process, thereby increasing ease of sharing and savings.

Although this solution has been signed off from HMRC Policy team as meeting the terms of the VAT exemption there are still a number of challenges to be overcome including

- Setting up the legal structures, including approval of the Cost Sharing Groups by each University Council
- Developing new financial processes and practices for where equipment is shared between institutions.
- The cost implication: administration of the CSG company, audit fees, raising of invoices between host university and CSG movement of funds between parties, however providing there is sufficient use then the benefits will outweigh the burden.
- Over time the CSG may be used for sharing other services, rather than simply equipment, which will lend more substance to its operations and also more 'familiarity' with the concept.
- N8 has established, based on current recharges for use that the VAT saving benefit for sharing a single large piece of centrally funded equipment is around £10,000 VAT per member.

This indicates it will only need the group to share five similar assets across the members to save £0.5m.

UK Shared Business Service

The UK Shared Business Service (UKSBS) acts as a research procurement centre for all pan-Government research activity.

The UKSBS supports intelligent and collaborative procurement; mainly working with Research Councils, Central Government bodies and Universities. This work includes supporting the procurement of large items of capital equipment. One example is the work with four national MRC national hubs for genome sequencing - these were sited at Cambridge, Edinburgh, Liverpool and Oxford. When the grant applications were reviewed by MRC, UKSBS highlighted some of the common categories of equipment needed, and the potential to broker better deals.

UKSBS played a key coordinating role, bringing together the four universities to establish the potential for collaborative procurement for the Centres of Excellence. This provided three main benefits, firstly aggregation of spend to create greater leverage with suppliers, improved supplier management and finally, more rapid access to technology by significantly reducing the procurement cycle. Since its creation, there are now 40 client organisations using the agreement

Through the collaborative procurement capability of UKSBS, substantial savings estimated at £1.5m per year are being achieved on the purchase of equipment and reagents.
A further key driver is to reduce the cost of sequencing the human genome which will enable this technology to be accessed in the clinical environment.

There is huge potential to scale-up this approach, and current projects include a pan Government agreement on microscopy, mass spectrometry and bio banking, to drive further savings, which are anticipated to be in the region of several millions of pounds.

Developing human capital, knowledge and expertise

HE Modernisation at the University of Sheffield – developing a professional and technical workforce.

There is an increased demand for higher skilled technician roles

- 1.5 million Science, Engineering and Technology job opportunities will be created across the country by 2020, with nearly a third of these in the higher skilled technician roles [21]
- The UK must educate another 450,000 technicians across all sectors by 2020 to address a massive skills shortage [22]
- On average, UK Higher Education institutions will lose between 25-35 per cent of its highly skilled professional technicians in the next three to five years as many reach retirement age.

There is also a change in demand for the types of skills required in technician roles

- The needs of the HE sector are changing- technicians are critical in supporting new and modernised teaching methods, new research / "grand challenge" areas, maximise space and infrastructure utilisation and asset sharing across institutions.

The University of Sheffield is leading work to modernise, develop and embed career pathways for the technical workforce as follows

- Looking at the needs base for professional and technical provision to support peaks in teaching activity during term time, and flexibility to support research activity at other times.

21 Research by the Gatsby Foundation quoted in http://www.sheffield.ac.uk/news/nr/technician-career-funding-1.370405
22 Research by the Technical Council quoted in http://www.sheffield.ac.uk/news/nr/technician-career-funding-1.370405

- Creating "hubs" and different way of structuring teams, across departments within a Faculty.
- Skills planning – including skills audit and skills shortage, succession planning
- "New blood" training courses to address a gap in training for technical staff at the basic level by creating consistent training and assessment structures which can be used at apprentice and graduate level.

This activity is funded by a 400k grant from the HEFCE Catalyst fund. One of the key objectives is to further develop the HE sectors Professional Technical Support Staff into a multi-skilled, highly flexible and agile workforce professionally accredited with proven competences to meet current and future strategic needs. A framework is being developed which will enable universities to adopt and develop their local workforce but within a national (modernised) structure of career pathways and role activities.

This scheme will run alongside the National Professional Technicians Registration Scheme now offered by the Institute of Science and Technology (IST), which proves technicians have the necessary credentials and competency to utilise specialised equipment.

This is a long term, change management process to achieve new ways of thinking and working needed in a fiscally constrained environment

The N8 is a partnership of the eight research intensive universities in the North of England: Durham, Lancaster, Leeds, Liverpool, Manchester, Newcastle, Sheffield and York.