N8 Research Partnership
Sharing for Excellence and Growth

Workstrand Reports

Mrs Kathy Brownridge, Dr Gavin Burnell, Ms Deborah Cox, Professor Luke Georghiou, Professor David Hogg, Professor Edmund H Linfield, Professor Tom McLeish, Professor Mark Rainforth, Dr Thordis Sveinsdottir and Dr Catherine L Wearing.

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Professor Trevor McMillan – Chair, N8 Pro Vice Chancellors Group
Sarah Jackson – Director, N8

Background to the N8 Research Partnership and this project

The N8 Research Partnership is a partnership of the eight research intensive universities in the North of England – Durham, Lancaster, Leeds, Liverpool, Manchester, Newcastle, Sheffield and York. The N8 Research Partnership aims to maximise the impact of this research base by identifying and co-coordinating powerful research teams across the eight universities to work with business and other research users. Our previous work has concentrated on multi partner research in Regenerative Medicine, Molecular Engineering and social sciences. In addition, we have recently launched the N8 Industry Innovation Forum (N8IIF) to provide businesses with access to multi-disciplinary research teams and new knowledge and ideas from the N8 research intensive universities.

Following the publication of the Wakeham Review of efficiencies in research funding[1] we established a project, funded by the Engineering and Physical Sciences Research Council, to examine the opportunities, barriers and current best practice in relation to sharing the use of equipment between research groups. There were four workstrands to the project led by different universities in the N8.

Workstrand 1: Recommendations on the opportunities to address cost, cultural and logistical barriers to sharing challenges. (Leads: Dr Thordis Sveinsdottir, Debbie Cox, University of Manchester)
Workstrand 2: Asset register classification system and development of web interface for internal and external use (Lead: Edmund Linfield, University of Leeds)
Workstrand 3: Business models for access and costings
(Lead: Mark Rainforth, University of Sheffield)
Workstrand 4: Strategy for engagement using national facilities and opportunities for optimising use of medium scale facilities (Lead: Tom McLeish, Durham University)

This report contains the four workstrand reports which contributed to the main synthesis report by Professor Luke Georghiou. All the reports can be found on www.n8research.org.uk

1 RCUK / UUK Task Force (2010) Financial Sustainability and Efficiency in Full Economic Costing of Research in UK Higher Education Institutions – Chair Sir William Wakeham

Workstrand 1:
Benefits of and Barriers to greater equipment sharing within the N8 Universities

Lead: Professor Luke Georghiou
Project Managers: Dr Thordis Sveinsdottir and Deborah Cox
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1. Introduction and Background

Following the Government's announcements regarding capital budgets and the proposals in the Wakeham Review, the N8 universities have agreed to work together to maximise opportunities for access to research equipment and assets. The aim is to ensure that academics can work collaboratively to exploit fully the range of equipment across the research base where spare capacity exists and sharing is economic. This will also have significant benefits for business by making it easier and faster for them to access equipment, and exchange knowledge and ideas with multiple research teams.

In order to facilitate successful sharing of capital assets and large scale research equipment N8 partners have undertaken a programme of activity covering asset registers, business models for equipment access and strategic issues. This document reports on Workstrand 1 undertaken by the University of Manchester. The objectives of this Workstrand are:

1. Synthesis of material coming from other workstrands
2. Coordination with work outside N8 e.g. Russell Group and other groupings (formal or ad hoc) of research intensive universities
3. Coordination with national policymakers
4. Review of national and international literature on sharing and infrastructure issues
5. Small survey to test earlier findings on barriers and success factors for equipment sharing
6. Discussions with non-university equipment users in business, public labs etc to explore alternative approaches
7. Workshop with project leads and invitees to agree conclusions

This report addresses objectives 4 and 5 – the remainder are covered by the project synthesis report. The review of past work below outlines possible issues and barriers to sharing, as well as recommendations for successful implementation of sharing strategies. It is supplemented by the findings from 24 semi-structured interviews with researchers, technical and financial staff in N8 universities and two interviews with industrial equipment users.

1.1. The Wakeham Review and its implications

A task group, led by Sir William Wakeham, in 2010 undertook a review of the UK Higher Education Sector. The group's overall focus was to consider the financial sustainability of research undertaken in universities and other institutions of higher education in the United Kingdom. In addition to assessing the state of research funding, the group reflected on whether the sector is using the funding to ensure sustainability and whether higher education institutions are efficient and economical in their use of public funding.

It had two tasks; to firstly, examine ways in which the financial sustainability sought after is already being secured and demonstrated. Secondly, to seek measures that will improve the effectiveness of the research base and provide economies in the funding of research. After the assessment was completed the group made proposals for changes that, it feels would lead to a more effective use of public funds.

The group delivered 14 recommendations, the overall aim of which was to increase monitoring and assessment of research. There is a focus on financial sustainability of the research base. The recommendation points which are most relevant to the N8 Equipment exercise and that drive our work are points 7 and 14, which state that:

'a greater intensity of utilisation of assets by HEIs should be encouraged, particularly the sharing of research equipment and facilities.' (p.6)

and

'the assessment processes of the Research Councils should encourage more intensive use of existing assets across the research base.' (p.7)

Furthermore, in future equipment funding applications the Research Councils will ask whether appropriate facilities already exist within the research base and how the research community as a whole would benefits from the new facilities.

It is therefore clear that an increase in the extent of sharing of research equipment is required and needs to be facilitated. In designing the right framework it is necessary to take account of any barriers to sharing and to develop strategies to mitigate these.

2. Previous work on equipment issues

2.1. Definition of 'equipment' and consequent sharing arrangements

An important part of devising any research equipment sharing scheme is firstly, to define what counts as 'equipment', and secondly, to decide whether it is amenable to sharing. Furthermore, large scale research equipment may often need specifically designed buildings and facilities. In terms of calculating cost recovery and fee structure it needs to be decided whether use and depreciation of building and facilities are taken into account, or whether the equipment is defined as a stand-alone item. As an earlier report indicated:

'Also, the same equipment can be used for research, teaching, clinical applications, provision of testing or other services, and perhaps even administration, as in the case of computer equipment. The share of equipment time available for research is therefore an issue.' (Georghiou, Halfpenny and Flanagan, 2001:308)

The first major review of the state of research equipment in the UK was commissioned by the Advisory Board for Research Councils in 1987 and involved a census of all items in a specified range. In this 'Baseline' Survey, equipment was defined according to the following criteria:

- Equipment items need to be wholly or partly used for research
- Equipment items need to be physically located in the departments concerned
- Equipment items need to have a current replacement cost of between £10K and £1M.

'Equipment that was inoperable, or not in use, or was waiting to become operational, was also included in the survey. Multiple pieces of equipment connected to form an integrated system were treated as a single item. While free-standing computers were excluded from consideration, those dedicated to specific instruments were included. All research facilities – i.e. laboratory buildings and structures such as wind tunnels and clean rooms- were defined as outside the terms of reference for the study.' (Georghiou, L . and Halfpenny, P. 1997: 81)

In terms of designing a sharing strategy, a decision also needs to be made whether equipment of any age or in any state will be shared or whether and age/state threshold should be set. Furthermore, the question as to whether intangible assets such as grids and clouds are defined as equipment, and consequently shared, needs to be answered.

Once a definition of 'equipment' has been clarified, an asset register needs to be compiled with relevant fields of data. An important issue is the condition and spare capacity of the equipment. The 'UK survey of Research Equipment in United Kingdom Universities' in 1996 reported that more than a third of equipment has a spare capacity for additional use by researchers from outside the department. But equipment with spare capacity tends to have poorer technical capabilities and to be older (two thirds had been purchased before 1991). (Georghiou, L., Nedeva, M. and Halfpenny, P: 1996)

Key questions are:
- Does the equipment have spare capacity?
- Is the equipment classified as being in 'very good' or 'state-of-the-art' working condition?

The ABRC study revealed that this criterion reduces the number of underutilized instruments to 0.2 per cent of the population of instruments. It furthermore reveals that it is usually low cost items that are accessible, but higher-end equipment is in use most of the time.

We explored these issues in the interviews and found that overall, the task of categorising and classifying scientific equipment within the N8 universities will be a difficult task, as to date, universities have held minimal information on equipment. Also, in many instances different pieces of equipment may have been bought at different times and will thus end up in different places in the asset registry. For the purposes of sharing it will remain a task for experimental officers to classify each piece of scientific equipment in order for it to become a sharable piece of kit so that accurate costing can be carried out. These issues are being addressed by Workstrand 2 of this project through the development of a taxonomy of equipment types and functions and the ability to search each others' asset registers against a common core of data fields.

2.2. Negative incentives to sharing

The literature on equipment sharing highlights that potential barriers to sharing can be built in to funding systems, in that equipment funding is tied to a specific project and if industry funding is provided it may set similar limitations on the use of equipment. Georghiou and Halfpenny (1996:664) also point out the possibility that

'subsequent grants require deliverables that depend on the availability of equipment already purchased through previous grants. Failure to meet those deliverables (if compromised by equipment being used by other groups) then penalises successful groups in terms of further grant funding.'

2.3. Possible cultural and psychological barriers to sharing: The competitive aspect of science, and feelings of ownership

In the field of science, competition for and accumulation of scientific capital is of utmost importance. Scientists, institutions and research groups all compete over the limited resources of funding, recognition and visibility. (Bourdieu, 2004) Consequently, sharing schemes may be presented with some cultural barriers where scientists may be reluctant to share their facilities and equipment with others, who are seen as a direct competition for limited resources. However, by analysing scientists' collaboration strategies, Kelves (1995, cited in Bozeman and Corley, 2004) found that one of the factors that govern scientists' collaboration choices is sharing expensive or scarce scientific resources and equipment. In view of this one of our focal points was on exploring this apparent contradiction in our interviews with scientists and experimental officers. We found both viewpoints expressed. Greater collaboration was always discussed in conjunction with the idea of 'doing good science' and sharing was seen as being an important step towards fulfilling this perceived obligation of scientists.

Halfpenny, Georghiou and Yates (1997) point out that people tend to form attachments to the space in which they work and to the equipment they frequently use. Researchers may personalise their space, for example with family photographs or equipment by customising interfaces of instruments. This may lead researchers, despite any legal status, to feel personally entitled to and responsible for the piece of equipment. Tightly knit groups of researchers may behave as an individual and issues can arise 'whereby a group that considers itself as superior to a potential user may be reluctant to allow that user access to the equipment' (Institute of Physics)

Pertaining to possible psychological barriers, the literature on psychological ownership as reviewed by Pierce, Kostova and Dirks (2003) notes how feelings of ownerships are formed with items and ideas and how these feelings have strong links to a person's identity. They also note how owned items appear more attractive and are rated more favourably than objects which are not owned. They cite Porteus (1962) which offered three different satisfactions that derive from ownership: '(1) control over space per se; (2) personalization of space as an assertion of identity; and, (3) stimulation (achieved for example by thinking about, using, improving, or defending one's possessions/territory' (Porteus, 1962 cited in Pierce et al, 2003:7) Feelings of ownership within the practice of science will undoubtedly become an issue when greater sharing of equipment will be implemented as it is likely that the identity of a good scientist is in part formed by the equipment he or she feels they 'own'. A better equipped lab does strengthen the idea of good science being practiced and enforces the identity of a successful scientist within their field. What we found in the interviews was that in some cases scientists have themselves, or alongside, colleagues, worked extended hours on grant proposals for specific items and this work may fuel their perceptions that the equipment is rightfully theirs.

In light of this, it needs to be taken into account how sharing is viewed by scientists themselves and also consider whether future purchases of large scale research equipment is best housed in 'neutral locations'. We might also ask should sharing models only be applied to new equipment, rather than implemented on older kit with which users have formed personal bonds. These were all issues that were considered during our fieldwork and were further explored in interviews.

2.4. Is sharing cost efficient?

When discussing increased sharing of scientific equipment, the issue of cost comes to the forefront as sharing ideally, as presented in the Wakeham review, should lead to savings overall. The question as to whether implementing greater sharing will end up costing facilities and individual scientists more in the long term becomes very important.

A study by Halfpenny, Georghiou and Yates 1997 revealed that equipment sharing requires substantial management input and is far from cost-free. Firstly, charging and access arrangements need to be established. Daily rates need to be calculated and these need to cover cost and depreciation to an extent. These may however not be so high as to act as a barrier for possible users, some of whom may have limited funds, such as PhD students and post-docs. Secondly, increased use will inevitably lead to higher levels of maintenance and these will need to be costed in. Thirdly, facilities and labs may need to hire additional staff to firstly, supervise and/or train possible users and also for managing bookings and access control.

The experience of the Bio21 Cluster in Melbourne Australia and Florey Neuroscience Institutes Melbourne Australia (Gibbs et al, 2010) touches on various points that need bearing in mind when discussing costing for access to equipment. The authors found that initial funding for a Platform Technology usually supports purchase and installation but does not provide funds for operational costs in the long term. Sustaining the facility beyond the initial establishment period is a major and complex challenge.

In some cases a simple and effective model is to set a fee structure that will cover all operating costs. In other cases however setting a high fee structure to meet 100% of the costs could be a disincentive to promoting innovative science and erects barriers. As Platform Technologies are often funded through public funds they must be widely accessible. They need to be affordable enough to encourage their use and to facilitate the experimentation which is essential for innovation and high-quality research outputs. Often 100% cost recovery is not a viable option as it prices out many academic researchers who are the major users.

2.5. Identified Sharing Arrangements

Broadly speaking, sharing arrangements can take three forms. Firstly, that of casual access whereby scientists are allowed occasional use of spare capacity on assets principally used by other researchers. Secondly, shared ownership whereby assets are acquired jointly across institutions with an explicit intention for joint use. Equipment is then usually located in a fixed location or a mobile pool for field equipment is established. Thirdly, central national or regional centres are set up, which provide controlled access or research services.

3. Findings from Interviews

The issues raised by previous studies and other points of concern were used to develop a guide for use in semi-structured interviews. The aim was to explore the investigators' and technicians' perspective on equipment sharing issues. The full guide used is in Appendix A. Key points covered in the questions were:

- Profiling the role of the interviewee and their use of equipment;
- Overview of availability of equipment;
- Experience of sharing, covering circumstances, organisation, exclusions, future plans etc.;
- Personal views of sharing, covering main benefits and barriers.

Face to face and phone interviews were carried out with twenty four university staff within the N8 Universities. Eighteen of the interviews were with academics within a variety of research based roles in the fields of Chemistry, Biology and Marine Science. Four interviews were conducted with Experimental Officers and two interviews with people within departments of finance. Two interviews were conducted with representatives of multi-national companies engaged in equipment sharing relationships with universities. Field visits were undertaken to scientific facilities at University of Sheffield, University of Liverpool, University of Leeds and University of Manchester. The interviews were semi structured and focused on discussing issues around the staff members' current work and their perceptions of and feelings towards greater sharing of scientific equipment.

3.1. Current Sharing Arrangements

With regard to the current equipment sharing within science we found that scientists already share their equipment to a great extent. The sharing arrangements can take different forms based on the equipment in question as well as the structure of the research unit itself. What also needs to be borne in mind is that the word *sharing* can be used to cover a range of different activities, from sharing ownership of equipment, offering services, for example, measuring samples for external users or opening up access to a range of instruments to external users. We found that researchers whose sharing involves measuring samples were more positive towards sharing than those whose sharing would involve having external users in the laboratory to share their space.

In our interviews we found that most sharing arrangements fall within one of three types corresponding broadly to those identified in the previous section:

Ad hoc sharing

Within our research group we hold research equipment in common and we share that equipment quite freely, we have no barriers. *'If one of my colleague's PhD student wants to use my cryostat that is fine. Then there are pieces of equipment that are the group's equipment and we have all contributed work towards a grant to get it.'* (Interview with a Researcher at an N8 University)

Researchers that work in research groups within universities tend to share equipment with their PhD students and post-docs, colleagues who work within the same group, department or faculty and sometimes across department and faculties. In some instances we also found evidence of sharing across universities, although these tended to take place within longstanding collaboration networks or relationships. These sharing arrangements have developed over time and scientists are generally extremely positive about sharing their equipment with people they know and trust. Most of the sharing within smaller research groups tended to take place ad hoc and be only minimally managed. More often than not some correspondence, a phone call or an email was enough to request time on a piece of equipment. Bookings were mostly made by pen and paper, as online booking systems are costly and time consuming to set up. The smaller the research unit the greater the sense of ownership tended to be and the issue of trust become more important. The piece of equipment was thus attributed to a scientist, usually the Principal Investigator on the grant proposal for that specific equipment and he or she oversaw management and time sharing.

Shared ownership

'The time when you have most problems is when you have communal equipment, which are things like spectrometers. We have a bigger lab upstairs where we prepare our samples; we actually share that lab with three other academic colleagues. However, the problem with any shared communal area is that you will have one messy person who does not clear up after themselves so you end up with a messy lab very quickly.' (Interview with a Researcher from an N8 University)

We also found evidence of the sharing model where two or more departments or faculties owned equipment together. A sense of ownership became less strong in these cases and a scientist commented that this was in some instances not entirely positive as this led the equipment to go largely neglected and common spaces around this equipment became run down and if things were damaged they were not quickly replaced or fixed. This indicates that feelings of personal ownership are not always a negative factor and can be helpful in managing and maintaining scientific equipment to a good standard.

Central facilities

The third model of sharing we identified was that of shared research facilities. In these instances equipment was grouped together within a shared central facility. All bookings were managed centrally and dedicated support staff on hand to assist with use and provide training for users. Scientists who worked at the facilities reported high satisfaction rates amongst users and the scientists we interviewed, that had used such facilities, were generally happy with their experiences. Both staff and users attributed the high satisfaction rate to the neutrality (absence of feelings of ownership) of the site, high end equipment on offer and dedicated and knowledgeable support staff on hand to run experiments, assist scientists or provide training. The issue of support staff arose in all the interviews we conducted with researchers, experimental officers and facilities managers who all claimed that having support staff to run, maintain and offer services to users was key to successfully sharing equipment across universities.

A flat hourly rate is most often charged to university researchers and commercial rates are applied to private and industry users. A facilities manager at one central facility described to us how this can potentially cause tensions if researchers perceive that commercial users are being given priority of access due to generating more income for the facility. The running of a high end equipment facility is expensive and income generation is important for continuing to offer good quality service and access to well-maintained equipment. Consequently there can be a tension between doing good science and generating income.

Case 1 – Shared facilities and the importance of support staff

In our interview with a facilities manager and experimental officer at a shared Small Research Facility (SRF) at one of the N8 Universities the following picture of equipment use, management and maintenance emerged:

The facilities manager classified the facility as an "old style microscopy unit" which holds a range of equipment. The facility has been an SRF for three years and now manages to cover its costs entirely. The facility is situated within one of the N8 Universities but offers services to external users as well. Its main users are researchers within chemistry and biology. Within the last few years they had 330 different users from 25 Universities. The user base has been steadily growing over the past three years. The facilities manager attributes this success to the range of equipment they have and especially to the experienced support staff that users have access to. He maintained that many of the users would prefer to come to the facility rather than using identical equipment in their own department due to the lack of support staff.

"Dedicated support staff is key to successful science. With specialised people you do get the best results."

The facility offers full service, managed access and self-service after training sessions have been attended. The majority of the facility's users are self-users who have been trained and who can then book in to use equipment, as and when they need.

With regards to training, the support staff offer one-to-one training to potential users. The length of training depends on the equipment they want to use and how specialised the experiments are. Training times range from one to ten sessions of training, where one session is three hours. The training covers use of the equipment and health and safety.

Equipment pools

This model of sharing was presented to us during interviews with scientists within the marine science field. This field of research has a longstanding history of equipment sharing where large items such as, large marine research vessels and remote controlled research data gathering submarines are available for loan for extended periods of time to scientists who are funded to undertake marine research in the UK. Some of the equipment is also available to international researchers who are involved in research collaboration networks. This ease of sharing is due to the fact that in some cases the equipment is not tied to a specific location. The international nature of marine research, international collaboration and visiting scholars means that shared equipment and data are high on the agenda and are seen as crucial for successful research within the field. A significant point emerging from the conversations with the marine scientists is that their fields of study are essentially national and international and so much of their equipment sharing cannot be restricted to a geographical limitation and transcend regional boundaries.

3.2. Possible Benefits of and Barriers to equipment sharing

Cost Barriers

One of the key concerns that academics expressed over increased sharing of equipment was that higher costs would be incurred, associated with increased maintenance, increasing use of consumables, and the hiring of extra staff for services and support. These concerns apply to those academics who are currently working within small research groups and are already sharing to a limited extent. These academics were also concerned with increasing workload for their existing staff, that would be spent on assisting other, and sometimes, competing academics within their dedicated field. All academics we spoke to agreed that the key to successful sharing was having available dedicated support staff to train users, oversee health and safety requirements were adhered to and assist with experiments. Academics agreed that it was not only the equipment itself that was needed for sharing purposes. Visiting academics would need additional space, such as laboratory space to prepare samples and office space where they could work whilst waiting for measurements and experiments to run their course. Academics also inquired as to how overnight stays and travel would be funded.

The culture of science and psychology of ownership

Science as a practice and the culture of science was frequently mentioned throughout the academic interviews. These mainly fall within two discursive strands:

- The pursuit of science

'One thing I have always believed is that if you have good equipment to do science and someone wants to use it you should let them use it. I am here to do science, not to make profits.' (Interview with a Researcher from an N8 University)

Equipment sharing was frequently mentioned as an important component of the work of doing good science. Academics speculated that an increase in sharing would mean that state of the art equipment would now be available to a larger group of scientists than before and that sharing could increase collaboration within and also between disciplines. The academics who were positive about sharing (mostly those who worked at large scale facilities) spoke frequently of their vision of doing good science, and how sharing would further this agenda.

- Science as a competition

'Am I going to have an academic benefit, am I going to have a paper out of it. If so, what is the value of that paper to me? Is it just me getting an acknowledgement in the paper somewhere, which is valueless or is it going to be a co-authored paper, if so, what kind of an impact type journal? Is it going to endanger my own PhD students' progress because now they don't have enough time on the equipment?' (Interview with a Researcher from an N8 University)

The recognition of science as a competitive field was mentioned by some academics. These admissions mostly came about when discussing the perceived burden that would inevitably follow increased sharing. This was seen as possibly impeding and slowing down the scientists' work and on the whole their research groups' work overall. They foresee a large part of their work, when sharing has been implemented, as being taken up by managerial and administrative tasks, and assisting visiting academics. They do not immediately recognise any benefits for themselves arising from this endeavour. 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. They made their wish clear and that was to work uninterrupted on their science instead of potentially assisting competing scientists further their careers.

Trust

'I suppose it is about, do you trust them enough so you can send your PhD students there and say 'go run this experiment' and you would be confident that they would come back and everything had happened. Also, if I ring up Manchester and say 'can we come and do an experiment' I would hope that they could actually fix up a time when I can do it, within the next three weeks rather than six months' time.' (Interview with an Academic from an N8 University)

In our interviews with academics, trust appeared as very important potential barrier to successfully implementing greater sharing of scientific equipment. Visiting academics spoke of trust in that they would worry that their PhD students and post-docs would not be well assisted in their experiments, and whether the equipment would be up-to-date, well maintained and fully working once they arrived. The academics, who foresee welcoming other academics into their lab spaces spoke of trust in that they would wish for visitors to treat their lab space with respect, use the equipment as instructed and not damage anything. The academics who were most concerned with the thought of others visiting their lab and using their equipment were those who currently work in smaller research groups and are used to sharing only with people they have collaborated with previously. They also mentioned concerns over whether they would now have to be more careful in their own lab due to issues of confidentiality of data and IP theft.

Ownership and personalisation

'But basically this is my cryostat because I put in the work into getting it.' (Interview with a Researcher from an N8 University)

There were very few mentions that could be interpreted as strong feelings of equipment ownership in the interviews throughout. There were however brief mentions of ownership in the sense that scientists may see equipment they have bought on a grant as theirs and therefore they see themselves as responsible for that piece of kit. Few academics we spoke to actually admitted to strong feelings of ownership in the sense that they would in any way hinder or deny other scientists access to their equipment outright. However, a few academics referred to an act that one of them called a 'soft denial', whereby a request from an outsider for use or measurement would be put to the back of the job queue and potentially then forgotten. It is difficult to ascertain how strong feelings of ownership are in interviews, due to scientists presenting socially acceptable answers regarding being good practitioners of science, rather than what they actually think and do. Interestingly, when issues of ownership arose in interviews some of the researchers discussed in a third person manner and described a stereotype of a old fussy academic who worked largely alone and would not allow others to use his equipment. Most academics attributed this attitude to be a child of its time and said that most of the younger generation of researchers are accustomed to sharing and collaborations in the name of science. Leaving aside ageist implications the impression is of a spectrum of attitudes and behaviours. It is therefore difficult to provide a definitive answer on the issue of ownership and personalisation, without further research, but we would recommend that researchers' views and feelings toward their workplace and the equipment they use be kept in mind when implementing sharing instructions.

Case 2 : Personalisation and ownership

The interview was with a PI at a research facility at one of the N8 Universities where he was asked about how he felt about the possibility of increasingly having to share research equipment that was in use within his research group. He was also asked about how amenable the equipment was to sharing and about past experience of sharing within the university and with external scientists. We identified three 'types' of barriers in the analysis of this interview: psychological, economic and cultural barriers.
These can be divided into two types of barriers, firstly one of personalisation and secondly issues to do with trust:

– Personalisation

The scientist mostly referred to the specific piece of equipment as 'his' which demonstrates that he feels a sense of ownership and responsibility for said equipment. He discussed at length how he felt that the equipment was his as he had put in the application for funding it. He also expressed that 'ownership' simply stem from use, i.e. when a person uses equipment frequently, then it might be considered as their property in a sense.

– Trust

The issue of trust ran through the whole of the interview. Firstly there were issues of trust in how the scientist perceived external users and he expressed the wish to be kept informed beforehand how they intended to use the equipment. Secondly, when the scientist discussed going to external science facilities either to directly use their equipment, or to ask them to run measurements for him, he wanted to know beforehand what the condition of the equipment was and whether the lab had all necessary equipment in addition to the actual research equipment, such as protective gear, gloves etc. Thirdly, the scientist expressed how he was mostly comfortable with people that he knew from earlier collaborations.

Logistical Barriers

The academics we spoke to expressed concern over sharing when it comes to discussing equipment they need to use frequently. They made clear that in this respect that one size will not fit all when it comes to implementing increased sharing demands. Some equipment is needed locally as the researchers will use that equipment on a daily basis. Furthermore, academics stressed that the fact that universities do have a teaching obligation and to meet this equipment for teaching students would be necessary at each department or faculty for the purposes of training undergraduate and postgraduate students. An academic we spoke to stressed the need for a lower specification NMR to be present at each university, for the purpose of testing samples before taking them to a higher specification NMR, which could then be within a shared facility further away.

In some instances equipment may be highly unsuitable for sharing, although it is not being used to its full capacity. An example of this is lasers. These take a long time to set up and fine tune for specific experiments. Experiments requiring lasers can take months at a time and although the laser is not being used every day during these months, sharing it during this time would require re-calibrating the lasers, which can take weeks or even months. It is therefore to be expected that some equipment is not very suitable for sharing and this needs to be taken into consideration when implementing greater sharing instructions.

With regard to increased travel for scientists, they expressed that they would be willing to undertake more travel to do their work but only if certain criteria are met. Scientists are willing to travel for using high end and state of the art equipment. They also want to see fully functional equipment that is well maintained. They want to be sure that there will be dedicated staff on hand to help them or train them in the use of equipment. They want to visit and send students to places where all health and safety checks have been made. They also want to know whether this increased travel and in some cases accommodation for overnight experiments is fully funded.

Case 3 – Logistics and training

Professor X works at an N8 University. She is very positive about sharing, but stresses that sharing is not a one size fits all due to the various types of equipment that is out there.

Logistics:
Different equipment has different usage patterns attached to it. For some equipment you can simply gather all your data and then take it to the equipment for measurement. For other instances it is much more complicated, e.g. in some instances you will find once you get to the lab that your sample is perhaps not suitable for a variety of reasons, or that the equipment is of a different spec than you expected. In some instances you would have to do a trial measurement first, and then the proper measurement and in the instance of the trial measurement going wrong you would need to go back and start again. In Professor L's view the equipment that is most amenable to sharing is the high end, occasional use equipment which you need to use over several days. The equipment that is not amenable to sharing is the equipment that you need for routine access.

Training:
Professor X recognises that there can be a lot of staff time and costs involved in sharing but she is very happy to share as long as all costs are recovered. She recognises that some users may have unrealistic expectations of how much training they will need to use the equipment successfully and they may have unrealistic expectations of how quickly experiments run and the level of analysis they are getting. In many instances external users are simply not willing to pay for all the extra cost involved.

3.3. Equipment Sharing with the Private Sector

According to our interviews with industry representatives within multinational companies whose work is reliant on state of the art research equipment, we found a general enthusiasm for greater equipment sharing with Universities. This is mostly due to the view of enhancing collaborations in science and to keep costs of equipment purchasing and maintenance down.

Due to the fast technological developments in their field the companies are now looking to increase sharing with universities and one is already sharing equipment with two N8 Universities. In one case a company collaborated in a joint bid to regional funding and the equipment was bought through a shared investment model. One of the corporations currently also shares equipment within its own sites in Europe and occasionally they will send samples further afield to their sites in China, US or India.

Increasingly, industry is looking toward sharing equipment rather than building or purchasing their own. The most important driver for sharing equipment is the drive to stay at the leading edge. One of the industry representatives took as an example the fields of biology and gene sequencing as a fast moving field within which it would make little sense to make vast investments in equipment as these would be out of date very quickly. Within this specific company they have a seven year depreciation time on equipment, but increasingly they find that within two or three years, something of higher specification has come along. Keeping at the leading edge is therefore becoming more costly and it consequently makes greater sense to share high end equipment with Universities.

A strong driver is the wish to share the maintenance, infrastructure and staff costs which can be extremely high in the case of high end pieces of equipment. What is needed is support to maintain and operate the equipment, and also computational and IT support, data protection processing and storage. It is no longer just about buying a piece of equipment, but funding all the requirements that come with owning it. Industry representatives also point towards increasing costs arising from risk assessments and health and safety, and training costs arising from each piece of equipment purchased.

This, however, does not apply to all equipment as industry representatives realise the need to have local equipment and some duplication for work that needs constant access to specific equipment. Lower level generic kits are therefore kept on each site whilst larger and higher end equipment is shared.

4. Summary of Findings and Recommendations

- The majority of scientists in our sample are positive about sharing but apprehensive about how greater sharing obligations will be implemented. They are especially apprehensive about what impact this will have on equipment funding and worry that this may lead to clusters of high end equipment forming in some places whilst other places go largely neglected in terms of funding for equipment.

- A significant proportion of the academics we interviewed are apprehensive about a potential administrative and cost burden on their staff and facilities. This would mean that senior managerial input is needed early in order to assist researchers with setting up and managing sharing within their facilities. We would also recommend that where possible, additional and dedicated administrative support staff be hired to take the burden off academics, in order for them to carry out their research uninterrupted.

- We strongly recommend, based on our interview findings, that research facilities which are extending the proportion of shared activity they undertake should take on additional technical support staff and experimental officers as these are seen by researchers to be imperative to successful sharing. These staff would offer services to and assist external users, maintain equipment and offer training. It is a clear message from all the researchers we interviewed that academics are more willing to visit sites that have dedicated support staff on hand for assistance. Adding to the expertise of research facilities would be a very strong incentive

- It is clear that one size will not fit all with regards to implementing greater science equipment sharing. Scientific disciplines have different needs and equipment has differing usage patterns tied to it. Some equipment is needed on a daily basis, whilst other is needed only intermittently. Some equipment, like lasers, can be out of use for months at a time due to the time it takes to set them up and calibrate for each specific experiment.

- Scientists are more positive about sharing assets that they do not perceive as 'theirs'. Issues of personalisation of equipment could prove to be a difficult barrier if the intention is to share equipment that scientists already feel they 'own'. This would indicated that the most successful sharing would take place on new items that are bought with sharing in mind, rather than sharing assets that have already been personalised to an extent.

- We would recommend drawing on the already positive attitude that scientists have towards sharing and make use of already established networks, such as the N8 collaborative and other research collaborations to facilitate sharing. It is also advisable to encourage the building of new networks. Scientists are already linked in to networks within their own field so the encouragement to form ties interdisciplinary would be beneficial. Sharing of equipment could here prove to be a good start to making new connections within different fields. To increase trust, we would recommend that up to date equipment and facilities information be available online, as this would allow scientists to view the facilities before visiting for the first time.

- In light of our interviews with industry representatives, we recommend that the N8 universities should critically evaluate and seek out to develop further links with industry, with the aim of furthering possibilities for equipment sharing of high tech equipment in specific fields.

Appendix A – Interview Guide

About the respondent

- What is your role in the department? [Head of department/school/section; PI; Technical; other]
- Are you currently working on equipment dependent research?
- What equipment are you mostly working with at the moment?

About the department's/school's/section's stock of equipment [Only to be asked to Heads]

- Do you consider your department as a whole to be well-founded in terms of the equipment it holds?
- Are there any important gaps that prevent or delay you from doing key research?
- Have you found securing equipment through grant proposals or internal sources more difficult in the past year than previously?

Use of equipment

- In your own research group who uses the equipment? Is it used only within the group or is it shared with other research groups/departments within the university?

Sharing of equipment past, present and future

- Do you have experience of sharing your equipment with users outside your immediate research group? Where were these users from the same department, the university, outside the university?
- Do you use equipment that belongs to or is situated with other research groups in your a) department b) university c) another institution or external facility?
- In each of these cases was the sharing successful? How was it organised? Pros and cons?
- If yes, how is/was the sharing organised? How is/was it costed?
- Is any of your equipment not amenable to sharing? If so, why? [fully committed in normal working hours; configured to perform particular experiments etc]
- In the near future, do you envisage buying any large research equipment? If so, what?
- How will it be funded?
- Do you envisage sharing it with others? If so, who? Will a) capital and b) running costs be allocated according to the amount of use made? If not what cost allocation model is used?
- What are access arrangements for different types of user?

Personal views on sharing

- In summary, what do you see as the main benefits of or success factors for sharing research equipment?
- And what do you see as the main disbenefits of or barriers to sharing research equipment?
- What actions or circumstances do you think make sharing most likely to succeed?
- What do you see as the main barriers to sharing to be overcome?

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Workstrand 2:
Identification of equipment sharing opportunities

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Executive Summary

Workstrand 2 was aimed at delivering an asset register classification system, and developing a web interface for internal and external use. Its four primary objectives were to contruct:

- A three level taxonomy of equipment function that can classify all equipment > £25k;
- A standard data schema for equipment items in asset registers;
- A web based interface to the asset register for internal/external searches on equipment;
- A web based interface which will allow key researchers, responsible for individual equipment items, to update technical information about their equipment directly.

Initial implementation would be at the University of Leeds, with subsequent phased adoption at other N8 Universities of all, or part, of this functionality.

Workstrand 2 has proved highly successful. A common three-level taxonomy scheme has been agreed across all N8 Universities to classify research equipment, and all N8 institutions have agreed a common data schema that can be made externally-visible. Furthermore, equipment within the University of Leeds can now be accessed externally through a web-based search engine (https://esms.leeds.ac.uk/). This has allowed clustering of equipment across campus, and opportunities for achieving more effective usage of equipment assets to be identified.

To develop the workstrand's activities in the future, a methodology for establishing an N8 common searchable research equipment system has been identified, and it has been agreed that the Universities of Leeds, Manchester and Sheffield will work together to demonstrate its implementation, in the first instance. The N8 has been pro-active in engaging with other academic institutions, and an RCUK-funded project has been initiated between N8, SEESEC, SET2, and M5 to consider best practice in working together to maximise use of equipment assets across the UK.

Throughout the project, information from this workstrand has been provided to funders (e.g. RCUK, HEFCE) to support their work in protecting investment in the UK equipment base. This information has been used in presentations to BIS/Treasury.

Background

Workstrand 2 was aimed at constructing a taxonomy that could classify equipment items by primary function. It was envisaged that asset register schema would be refined and augmented to facilitate use of asset registers as tools for researchers to identify existing capabilities and capacities. Asset register schema would also allow identification of strengths and weaknesses in the functional spectrum of the regional equipment base, together with possibilities for shared support and maintenance. Furthermore, the development of web based tools would allow distributed maintenance of technical descriptions of capabilities and specifications of equipment, and to present views of the asset register (appropriately filtered) to external bodies such as partner Universities, funding bodies and the private sector.

The workstrand can be broken down into three key activities:

1. Classification of existing equipment into the taxonomy, adjusting and augmenting the taxonomy as necessary through negotiation with key equipment stakeholders to ensure relevance for all academic disciplines.
2. Implementation and refinement of the data schema required to support better use of the asset register by the researcher community and as an MIS tool.
3. Implementation of web based front ends that would: (a) support update of technical information about equipment items by research staff responsible for this equipment, and (b)

provide user-friendly searches on the asset register customised for appropriate target audiences, including both internal and external academic users, and the private sector.

Three principal outcomes were thus associated with Workstrand 2:

- An agreed taxonomy for the N8 to classify research equipment by primary function;
- A standard data schema to represent equipment in a common format across the N8;
- A web based front end to present equipment assets both to the N8 and the private sector.

Development of a three-level taxonomy

A three-level taxonomy was developed at the University of Leeds, and verified by implementation to all research equipment (>1100 items in total) of >£25k value within the Institution. Details were supplied to N8 partners on 1 August 2011. The top level ('class') in the taxonomy describes the general stage of experimental process e.g. sample production, materials characterisation, specific sample analysis. The second level 'order' classifies by a broad approach or group of techniques e.g. spectroscopy, surface probe microscopy, cryogenic measurement. The final level 'genus' identifies a specific technique or instrument type e.g. uv-spectroscopy, atomic force microscopy. An iterative optimisation of the taxonomy was then undertaken, with feedback being requested, received, and implemented in January and March 2012. Each iteration of the taxonomy has been made available electronically[1] by the University of Leeds, with associated guidance notes. A current version of the taxonomy is listed in Appendix 1.

A final version of the N8 taxonomy will be delivered on 30 June 2012, although it should be noted that as new equipment becomes available, there will always be an on-going need for any taxonomy to be refined and updated.

It was confirmed (at a meeting of N8 partners at the University of Leeds on 24th April 2012) that all N8 partners would have classified their equipment using the common taxonomy by 30th June 2011.

Development of common data schema

All equipment of >£25k value at the University of Leeds was initially classified using the three-level taxonomy and a set of other key identifiers: Owner; Technical Contact; Location; Anticipated Lifetime; Usable Condition and Availability; Supplier; Age of Equipment; and Service Contract Status. This classification of each item was incorporated into the University of Leeds corporate database – SAP. Furthermore, SAP was adapted to ensure that all new equipment is automatically classified on purchase, and that this information is recorded in SAP.

For future sharing of equipment assets, it was considered essential that all institutions utilise a common data schema for information that they are prepared to make externally visible. An agreed common N8 data schema was finalized on 31 January 2012 (see Appendix 2). It was recognized that each individual institution would also hold their own specific information about their equipment assets (e.g. cost, location, etc), which would not be made externally available, and would vary from institution to institution.

1 See: http://researchsupport.leeds.ac.uk/index.php/academic_staff/research_equipment_infrastructure/

Web-based searching of the University of Leeds equipment inventory

Following classification of all equipment of >£25k value at the University of Leeds, web-based solutions were provided to allow a full search of the University's inventory. Initially, an internally-facing web interface was established using *'Qlikview'* software, and this allowed researchers within the University of Leeds to view all equipment within the Institution. This immediately allowed implementation of the RCUK requirement from the Wakeham review that, when bidding for new equipment, the University did not replicate an existing capability. A disadvantage of using 'Qlikview' is that, owing to site licence restrictions, it can only be used within the University of Leeds. A web-based front end was thus developed (https://esms.leeds.ac.uk/), and made available externally on 24th April 2012. Any organisation can now search for high-value items of equipment at the University of Leeds.

The site https://esms.leeds.ac.uk/ gives the ability to search for equipment at the University of Leeds either through the three-level taxonomy, or through the common N8 data schema. In addition, though, it provides researchers the opportunity to upload *inter alia* photographs, videos, key publications/notes, and a description of the equipment. This will prove invaluable for identifying pieces of equipment suitable for sharing across the N8, and beyond. It should also allow the SAP-based inventory to act as the data source for School/Faculty marketing, and avoid promoting equipment in isolation. Furthermore, it will prove invaluable for investigating how equipment can work more efficiently across campus. Specifically, it will enable strategic asset planning since, if estimates can be made of lifetimes of equipment (using, for example, figures proposed by the MRC), it will allow evaluation of the investment required to maintain the research equipment base at its current level. This will allow representation to be made on behalf of the HEI sector to funding bodies, and to BIS/Treasury during future comprehensive spending reviews. By 30th June 2012, it will be possible to update key information (but *not* purchasing records) at a local, research-group, level, for example by laboratory managers, post-doctoral researchers and technicians.

Clustering of equipment and developing asset management at the University of Leeds

Having classified all equipment at the University of Leeds, and enabled a web-based search of the complete inventory, it has become possible to start the development of strategies for more efficient usage of the University's assets. Interrogation of the database has given, for the first time within the University of Leeds and (probably) any other UK institution, a fascinating snapshot of the distribution of equipment with similar functionality ('clusters' –groups of similar equipment at the 'genus' level of the taxonomy). As an initial step, clusters of equipment users were identified in: chromatography, scanning probe microscopy; x-ray diffraction; scanning electron microscopy; Raman and mass spectrometry. In each there are multiple systems (with different functionalities) across the Institution, and there are users from multiple Schools/Institutes/Faculties. To demonstrate the capability of having a web-based search capability, graphs showing the distribution of instruments across the organization, and by manufacturer are given in Appendix 3. *[Please note that, in some case, names of manufacturers have changed since initial purchase (or separate manufacturers have merged), and so instruments from a single manufacturer may appear under different names. This is currently being addressed.]*

Having identified such equipment clusters, researchers from each school within a given cluster were invited to a set of meetings to explore the possibilities of more effective collective use of equipment across campus. Each meeting generated significant enthusiasm for working more closely together.

From these initial cluster meetings, a number of opportunities and challenges have been identified, and these are presented below. Discussions are now taking place on how to address some of the significant barriers that currently exist to making most efficient use of equipment across campus. A number of common themes emerged, which include:

Challenges

- Increasing knowledge of the availability of equipment, its capabilities, and the associated expertise across the University, and ensuring up-to-date inventory data is maintained.
- Ensuring provision of the necessary technical staff to support equipment, together with appropriate levels of funding for equipment maintenance, to allow equipment to be run continuously with state-of-the-art performance.
- Demonstrating sustainability in facilities such as Small Research Facilities/Medium Research Facilities, and putting in place appropriate charging mechanisms. Provision of support for non-FEC research activity, especially for PhD students, was noted as being a significant and specific difficulty.
- Ensuring unified approaches are used for marketing of research equipment externally to the University of Leeds.

Opportunities

- Joint bids, based on equipment clusters, for state-of-the-art equipment purchases and for ensuring better utilisation of equipment stock.
- The potential for cross-faculty technical support, and collective negotiation of service contracts. The latter relates not only to high-value equipment but also to low value equipment contracts such as for calibrating and certificating balances, pipettes and centrifuges.
- Collective cross-cluster equipment workshops and training courses, together with improved communication channels within clusters (e.g. about methods, equipment repair, the potential availability of other equipment, and the management of external requests for equipment access).
- Open days to promote and encourage use of equipment within equipment clusters, both for industry and academia.

Some immediate, medium and long term actions were also identified. These included:
Immediate actions:

- equipment cluster web pages – completed;
- equipment cluster mailing lists – completed.

Medium term actions:

- industry open days;
- combined internal and external training courses;
- combined service contracts.

Long term actions:

- standardised risk assessments;
- shared technical support;
- potential for equipment clusters across the N8.

The opportunity for organisation of research assets through equipment clustering was thus clear, and future extension to N8, and other UK academic institutions, would increase such opportunities significantly.

N8 Common Searchable Research Equipment System

In order to capitalise on a common taxonomy and common data schema, methods need to be developed for searching the complete N8 assets register with a single, searchable system. This would, inter alia, allow the advantages of equipment clustering identified within the University of Leeds to be replicated on a far wider scale. In developing a solution, it is felt important that each partner institution retains control over their own inventory data and has some flexibility in local policies as to when and how research inventory data is made available. It is also important that the proposed route is based on existing corporate information systems where in use or alternatively using commodity database systems.

Proposed Implementation

The core of the proposal solution is a shared web-based front end that could be hosted on a dedicated, non-institution specific domain. This will communicate using a well defined and published software interface to each participating partner's research equipment inventory system. Results of the search will conform to the published data schema (essentially the agreed N8 Core Inventory Schema) allowing results from all partners to be collated and displayed in a single search interface. The overall scheme is illustrated schematically in figure 1.

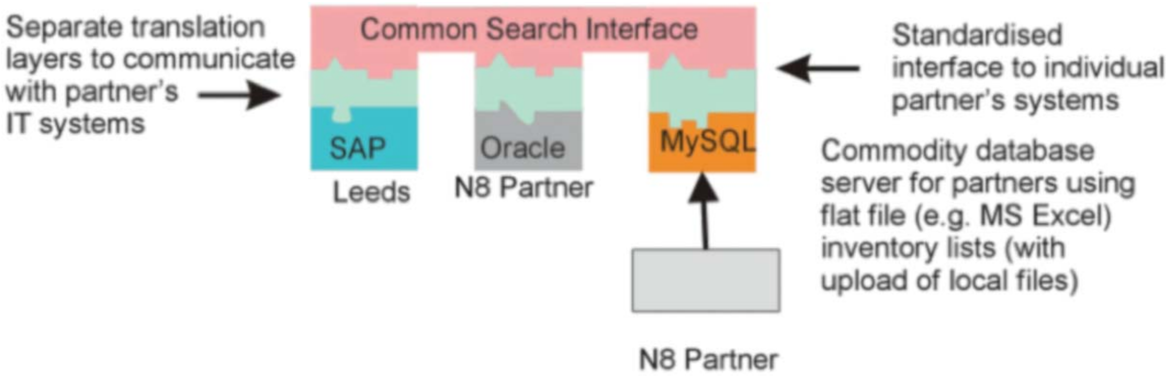

Figure 1 Schematic overview of system with searchable front end, common software interface to partners, individual translation layers to corporate MI systems and provision of a simply commodity database for partners using flat file inventory lists.

The search interface will resemble the already-established interface that the University of Leeds has implemented for its searchable equipment inventory system, which in turn is based on web-based citation search systems familiar to academics in an effort to present a low learning barrier to the average researcher.

The search interface will communicate to the individual partners using a published web services API that will be developed based on the one developed for the University of Leeds system. At each partner site, this will be passed to a custom translation layer that will communicate with the specific information system used within each partner. For those partners that do not intend to hold inventory data on a corporate information system, a simple database that would hold inventory data according to the agreed schema, along with code that could implement the Web Services API, will be developed.

Data Control and Data Security

In designing the system, a conscious choice has been made as to where the data should be held. The possible options are:

- A single common database created by merging datasets from all partners. In many senses this would result in a simpler system to develop – once the core schema is agreed there is no need for a common Web Services API and the mechanics of searching are easier. The disadvantages are a possible reluctance of partners to export their data wholesale, the probability that data would get out of date, and the need to resynchronise with partners on a regular basis.
- Each partner continuing to hold its own inventory data. This is more complex to implement as a single search system as it requires distributing the search across a number of different databases and collating the results. It also requires a common software interface between the search front-end and each partner to be implemented. On the positive side, it ensures that each partner retains their own data, and that each partner can store additional information about their own equipment to suit local needs and yet have any updates to their data made available instantly to the search engine.

The common software interface (Web Services API) provides the key to ensuring that access to data is carefully controlled and in particular that sensitive data cannot be exported beyond the institution. The prototype Web Services API developed in Leeds includes mechanisms to identify positively that the website requesting data is the expected one, to verify the identity of users requesting access to more sensitive data, and to ensure that only non-critical fields (i.e. not those relating to asset value or key financial information) can be accessed. A further advantage of this approach is that it allows institutions to build searches of the common inventory into other corporate systems such as research grant management tools simply by using the published standard API to interface with the inventories. It is not envisaged that the shared search system should offer the capability to update data stored in the inventories, this is properly the function of local systems such as the system developed in Leeds which has this capability for restricted University of Leeds users.

Core Provision

The core provision of the N8 system is being planned to provide the following components:

1. A common search front end branded with the N8 identity and clearly indicating the individual participating Universities. The front end will be largely based on the design of the Leeds system with adaptations to match the core N8 schema and latest N8 taxonomy. The front end will allow users to produce lists of equipment that meet arbitrarily complex combinations of search terms, filtering and refining searches as needed. It will, for example, be possible to search for all items of equipment within a given order but not in a given genus that were hosted in the Universities of Leeds, and Sheffield, but not Manchester.
2. A Web Services API used by the search will be established and published, making it a public standard to which any organisation could write either a matching search interface or backend to a database (the API automatically ensures that only authorised sites can search against inventory data).
3. Reference translation layers will be provided that implement the search against the inventory databases at Leeds, Sheffield and Manchester in the first instance.

Requirements for each N8 Partner

Participating N8 partners will implement their own translation layers between the published Web Services API and their own corporate information systems. It is possible that several partners who share common MIS platforms could cooperate in the development of these translation layers. Those using SAP would benefit from the Leeds experience and all partners would have the option of using a commodity database system.

Current status

The Universities of Leeds, Manchester and Sheffield have agreed on a programme to work together in producing a common searchable research equipment system.

Developments outside the N8

The work on Workstrand 2 has attracted considerable interest outside the N8, and on-going discussions are taking place with key research groupings in the UK. e.g:

- M5 (Birmingham, Leicester, Loughborough, Nottingham and Warwick);
- SEESEC (Oxford, Cambridge, UCL, Imperial, Southampton);
- University of Bath;
- Queens University Belfast;
- University of Bristol;
- University of Surrey;
- University of Edinburgh;
- BBSRC;
- NPL;
- University of Cape Town.

Specifically, in part based on the findings from Workstrand 2, RCUK have funded a project between SEESEC (led by the University of Southampton), SET2 (University of Bath), M5 (Loughborough University) and the N8 (University of Leeds).

The project aims to deliver coherent approach to Research Equipment and Facilities Inventories, as required to deliver efficiencies. Specifically, the project will look at:

- Demonstrating regional strengths and weaknesses in the equipment base;
- Identifying potential efficiencies e.g. in service contracts, key suppliers;
- Encouraging effective collaborative research.

The first steps in the project will be to provide a common language to describe research equipment and facilities on a national scale. To achieve this, the project will:

1. Map existing schema vocabulary and taxonomy;
2. Engage key sector stakeholders to establish views on long-term ownership;
3. Consult academia more widely to establish current practice and consensus for the introduction of guidelines and standards in research equipment and facilities publishing vocabulary;
4. Evaluate current systems used in data management, and the publishing of research equipment and facilities, to establish the capability of these systems to implement the proposed taxonomy and/or vocabularies, including their capability to interoperate with each other;
5. Develop proposed draft guidelines and recommendations for the community to take these guidelines forward.

Key components will be associated with standardising the common vocabulary (or schema): What common (core) information do we hold? What is the semantic meaning of each field? The project will also review how an optimum taxonomy is constructed. Should it be by research-based equipment types? Should it be hierarchical, flat or fuzzy? Should there be more than one taxonomy? The project will also consider interoperability. At an institutional level, the systems proposed look good, but can they be extended outside the institution?

Members of this national project have been invited to participate in the design and development of the N8 Common Searchable Research Equipment System with a view to working towards a demonstration of a inter-regional inventory system.

In summary:
- The project is about building consensus;
- Input from as many players in sector as possible is needed;
- Discussions will take place with stakeholders – RCUK/HEFCE/BIS/JISC etc to establish the long term future home of standards;
- Discussions will take place with Universities to set standards;
- Technical input from corporate IT developers/architects is needed;
- Scientific input from researchers is required to ensure standards are fit for purpose and useful;
- A national conference will be arranged in September.

Implementation of Workstrand 2 at the University of Leeds

Workstrand 2 at the University of Leeds was led academically by E H Linfield (Electronic and Electrical Engineering) and G Burnell (Physics), and managerially by K. Brownridge, J.R. Johnson (Research and Innovation Service). The work was supported through core funding from the University of Leeds EPSRC delivery plan, and allowed appointment of 1 FTE database administrator to support the academic and managerial leads, as well as the IT provision for the necessary web-based developments. Evaluation of the workstrand was against the following milestones, all of which have been, or are expected to be, delivered (completion dates as given):

Milestones

- M2.1: First draft taxonomy and data schema available for distribution to N8 (1 August 2011) – complete;
- M2.2: Data schema standardised across N8 (31 January 2012) - complete;
- M2.3: Final sign-off of taxonomy across N8 (30 June 2012);
- M2.4: Externally-visible searchable web based front end for Leeds inventory (24 April 2012) – complete;
- M2.5: Updatable technical information storage through web based front end (30 June 2012);
- M2.6: Evaluation of potential for Cloud hosting of N8 equipment inventories (30 June 2012).

Immediate future plans

It is planned that the work undertaken on Workstrand 2 will be taken forward beyond 30 June 2012, using funding provided by the 2012/2013 EPSRC Delivery Plan Grant to individual institutions. Specific plans include:
- Demonstration of an N8 common searchable research equipment system through an initial study undertaken by the Universities of Leeds, Manchester and Sheffield.
- Liaison with partners outside the N8 to agree common taxonomies and data schema.
- Evaluation of current levels of depreciation and equipment asset values, initially within the University of Leeds.

Appendix 1
Draft Equipment Inventory Taxonomy

Introduction

The purpose of this equipment inventory taxonomy is to provide a way of grouping and classifying medium and large scale research equipment (i.e. typically with values > £25k), and associated inventory items, according to their primary function. In many cases, the function of a piece of research equipment is synonymous with a particular experimental technique, at other times a similar technique may be used in two different pieces of equipment, yet they have distinctive uses and purposes. The taxonomy aims to accommodate this by focusing on the conventional way in which equipment is described by users within research disciplines.

Structure of the Taxonomy

The taxonomy is based around a three level hierarchy – class is the top level, order is the middle level and genus the lowest level. Thus, in functional terms, one would expect instruments in the same genus to have broadly the same function, those within the same order to have related functions, and those within the same class to have the same scope of functions.

Classes

The top level attempts to describe the equipment according to its place in the basic experimental cycle of: specimen/sample/material production/preparation; generic characterization of material or sample properties; and specific measurement or characterization of a specimen or sample. Finally there are items of equipment/facilities that provide infrastructure and support services to a research environment.

The classes defined in the taxonomy are:

- Process Equipment – Physical This covers equipment which produces a sample or specimen through physical or mechanical means or through chemical routes, but excluding biochemical and biomolecular processes.
- Process Equipment – Biological This covers equipment that produces a sample, material or specimen through biological means, and associated non-biological techniques to refine and isolate.
- Materials Characterization This class describes equipment that provides generic techniques to characterize samples, materials or specimens. The defining characteristic is that these items of equipment could equally be applied to a portion of the sample or specimen as to the whole.
- Sample Characterization and Analysis Equipment in this class carries out specific measurements and analysis techniques on samples and specimens. The differentiating characteristic of equipment in this class, compared to the Materials Characterization class, is that it is a complete or whole sample or specimen that is used.
- Large Scale Instruments This is a specialized class that is used to describe the small number of items of equipment that have unique functionality, or are comprised of many smaller units that themselves are significant items of inventory but could not be used separately.
- Infrastructure This class covers all equipment that is not directly used in sample or specimen production and characterization yet which forms a discrete part of the infrastructure of a laboratory (in the way that benching, fume hoods etc do not).

Orders

The order within each class groups the equipment into broad categories of related function or technique. Thus, for example, all spectroscopy techniques are in the same order, and all techniques that analyse proteins and nucleic acids are in another. As far as is possible, this grouping is done to reflect customary usage within the appropriate primary discipline.

Genus

The genus is the lowest or most specific level of the classification. Each item of equipment is assigned to a least one genus, and then each genus is assigned to a single order, and each order to a single class. The genus aims to group equipment into common primary functions – recognizing that even so, within a given genus, individual items of equipment may be better or worse suited to a given application.

Depth Versus Breadth of Taxonomy

In designing the taxonomy, a balance has been struck between the breadth of the taxonomy (that is the number of classes, the number of orders within a class, and the number of genera within an order) and the depth. Clearly, a more refined classification of any given item of equipment can be made by extending the number of levels, This, though, is at the expense of it becoming inefficient to navigate because of the number of steps taken to reach the final item of equipment. On the other hand, too broad a taxonomy, makes finding items inefficient, because there are too many possibilities to consider at each level. As a rough rule of thumb, we have aimed to have between four and ten sub-items at each level in the hierarchy. This design goal needs to be considered carefully when proposing any additions to the taxonomy.

Classifying Items into the Taxonomy

In practice this is normally relatively straightforward, especially if there is a partially populated taxonomy to compare with. The primary questions to ask about an item of equipment are:

- What is the main purpose or function of the equipment (and where it might be used in more than one discipline, does every discipline use it in the same way)?
- Is this used to make something on which further processes would be carried out? Is this characterizing something that has been made/extracted/grown/discovered? If so, could one use a representative portion of it equally well?

This will identify the correct class for the equipment. At this point one needs to consider which order it most naturally comes under and then which genus. It is not practicable to give advice to cover every possible scenario, however there are a few commonsense rules of thumb:

- If there are similar items already in the taxonomy, then these should be used to guide the choice of order and genus, likewise if a possible genus contains items of equipment that are distinctly different in function, then it suggest that the wrong genus is being used.
- The taxonomy is only as useful as it works for experienced practitioners of a discipline – customary ways of thinking about the function and scope of equipment evolve slowly, so picking the genus that makes the most sense to the users of the equipment is probably the right thing to do.

Extending and Modifying the Taxonomy

Occasionally it will become obvious that the taxonomy does not work well for some particular item of equipment. In these cases it may be necessary to extend the taxonomy. However, this needs to be done in a careful and controlled way to ensure that the taxonomy does not become unnecessarily broad, nor overly specialized. Co-ordination of requests can often reveal a common solution that may not be obvious from an isolated request. In proposing an addition the following points should be considered:

1. Adding a new genus to an existing order is preferable to adding a new order, likewise adding new orders is preferable to adding new classes.
2. Orders and most particularly classes should not be specific to one discipline.
3. Adding an additional genus to an order with relatively few genera is better than adding genera to already full orders.
4. New genera should have an expectation of containing a reasonable number of items of equipment. Other than in the large scale equipment and infrastructure orders, one would not expect a genus to contain less than five items of equipment as a general rule.
5. It is better to change the name of existing genera or orders than to introduce new ones that would be under-populated.

Class	Order	Genus
Process Equipment – Physical	Thin Film Deposition	Evaporator Molecular Beam Epitaxy Sputterer Pulsed Laser Deposition Chemical Vapour Deposition Electrodeposition Ion Beam Deposition
	Lithography	Optical Electron beam Ion Beam Laser (Direct-Write)
	Etching	Reactive Ion Plasma Laser Mechanical Ion Beam Milling
	Controlled Environment	Furnace Rapid Thermal Annealer Glove Box Atmospheric Reactors
	Packaging	Wire Bonding Dicing Encapsulation
	Characterisation	Ellipsometry Profilometer
	Chemical Reactor	Crystallisation Distillation Parallel Synthesis Particle Formation Automated Extraction Automated Synthesis
	Sample Manipulation	Liquid Handling Robot Stopped Flow
	Textiles	Textiles Production Textiles Printer
Process Equipment – Biological	Growth and Manipulation	Bacteriology Virology Cell Culture Fermentology
	Centrifuge	Ultracentrifuges High Speed
	Tissue Processing	Tissue Processor Cryostat Microtome Immunostainer Dehydration Cell Disruptor
	Sterilisation (continued overleaf)	Autoclave Water Purification Irradiation

Class	Order	Genus
Process Equipment – Biological (continued)	Sterilisation (continued)	VHP Decontamination
	Characterisation	Fluorescent Readers UV Infra-Red Cell Counters Plate Readers Analysers Scintillation Counters
Materials Characterisation	Spectroscopy	Raman Infra-Red Nuclear Magnetic Resonance Optical EPR X-ray Photoemission Fluorescence Circular Dichrometer
	Spectrometry	Spectrophotometry X-ray Mass Spectrometry
	Imaging	Magnetic Resonance X-ray Infra-Red Ultrasound In Vivo Fluorescence
	Optical Microscopy	Confocal Near Field Transmission Reflection Microdissection Live Cell Fluorescence Stereo
	Electron Microscopy	Scanning Scanning Transmission Transmission Detectors Sample Manipulation
	Surface Probe Microscopy	Atomic Force Scanning Tunneling Magnetic Force
	Surface analysis	Charge Adsorption
	Diffraction	X-ray Low Energy Electron High Energy Electron
	Magnetometry	Vibrating Sample SQUID Kerr Effect
	Mechanical Properties (continued overleaf) Mechanical Properties	Tensometer Rheometer Load

Class	Order	Genus
Materials Characterisation (continued)	(continued)	Hardness Tribometer Vibration
	Chemical Analysis	Air Analysis Distillation Analysis Water Analysis Solids Chromatography Macromolecular Electrophoresis
	Physical Properties	Particle Size Analysis Zeta Potential Thermal Geometric Balance Fibre Analytical Centrifuges
Sample Measurement/Analysis	Cryogenic	77K 4K 1.4K He3 milli-Kelvin
	Electronic	Network Analyser Microwave RF Oscilloscope
	Motion	High Speed Video Low Speed Video Telemetry Fluid Haptics
	Laser	Characterisation Dye Excimer Fibre High Power Opto-Acoustic Systems Pulsed Femtosecond YAG
	Optical	Quantum Information Surface Plasmon Resonance Dual-polarisation Bolometric High Resolution Imaging
	Proteins/Nucleic Acids	Arrays PCR Sequencers Synthesisers Electrophoresis
	Bio-Medical (continued overleaf)	Cardiovascular Orthopedic Wear

Class	Order	Genus
Sample Measurement/Analysis (continued)	Bio-Medical (continued)	Dental
		Whole Body
		Cells
		Tissues
	Acoustic	Doppler
		Ultrasound
		Audio
	Field Deployable	Solids
		Liquids
		Gases
		Plasmas
Large Scale Instruments	Simulated Environments	Acoustics
		Combustion
		Driving
		Flight
Infrastructure	IT	Server
		Storage
		Workstation
		Parallel Computing
		Data Management
		Display
	Mechanical	Hydraulic
	Workshop	CNC Machines
		Drill
		Grinding
		Joining
		Lathe
		Milling
		Sawing
		Sintering
		Other Cutting
	Laboratory	Fluids
		Medical
		Controlled Atmosphere
		Controlled Environment
		Growth Room
		Controlled Environment Storage
		Electromagnetic Screening
		Optical
		Field Deployable
	Cryogenic	Liquefier
	Vehicles	Personnel
		Equipment
		Agricultural
	In Vivo	Washing and Watering Systems

Appendix 2 – N8 Data Schema

The core data fields that the N8 universities will be collecting about each piece of equipment within their equipment inventory.

Data Field	Description
Manufacturer	
Model Number	
Technical Identifier	A free text field that is used for a local name that distinguishes between similar equipment items.
Is a sub-part of a larger instrument/facility	Identifies whether this equipment item is part of another (larger) equipment item or facility and which facility.
Description	Free text
Classification	One or more genera from the taxonomy
Images	
Other Documents	User manuals, sample results, extended descriptions.
Host Organisation	Academic school or research unit in which instrument is housed.
Academic Manager and contact details	Academic with overall management responsibility for the equipment item, including access e.g. PI on purchasing grant and their email and telephone contact details.
Technical Contact and contact details	Experimental officer, technician or PDRA who can answer specific technical questions about the equipment item and their email and telephone contact details.
Campus	

Appendix 3 – Equipment Clusters

Figure 1: Pie Charts showing the distribution of Chromatography equipment (n=63) at the University of Leeds by a) School and b) Manufacturer.

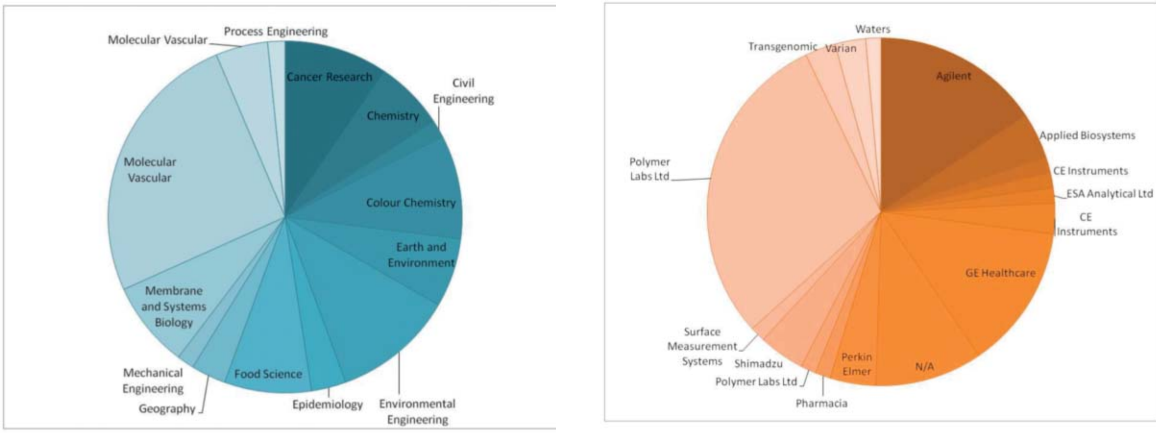

Figure 2: Pie Charts showing the distribution of Electron Microscopes equipment (n=26) at the University of Leeds by a) School and b) Manufacturer.

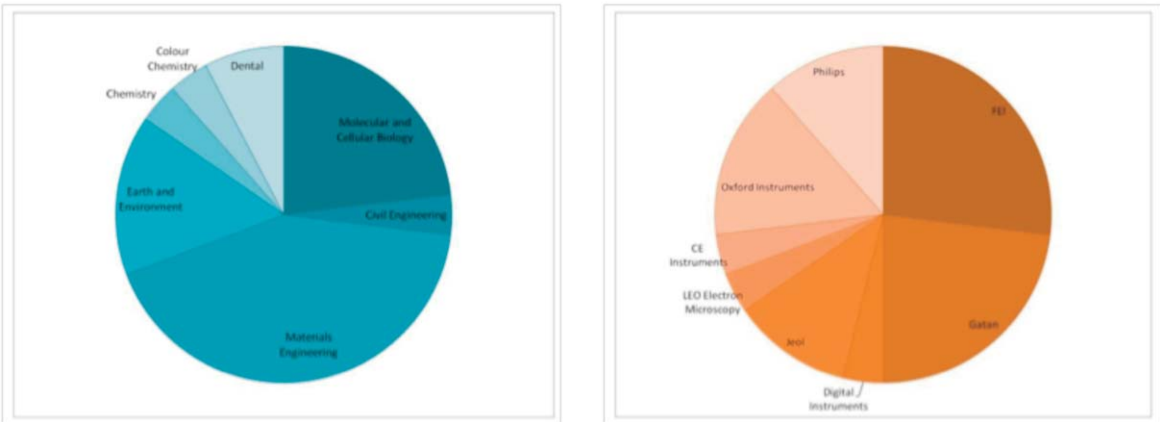

Figure 3: Pie Charts showing the distribution of Mass Spectrometer equipment (n=30) at the University of Leeds by a) School and b) Manufacturer.

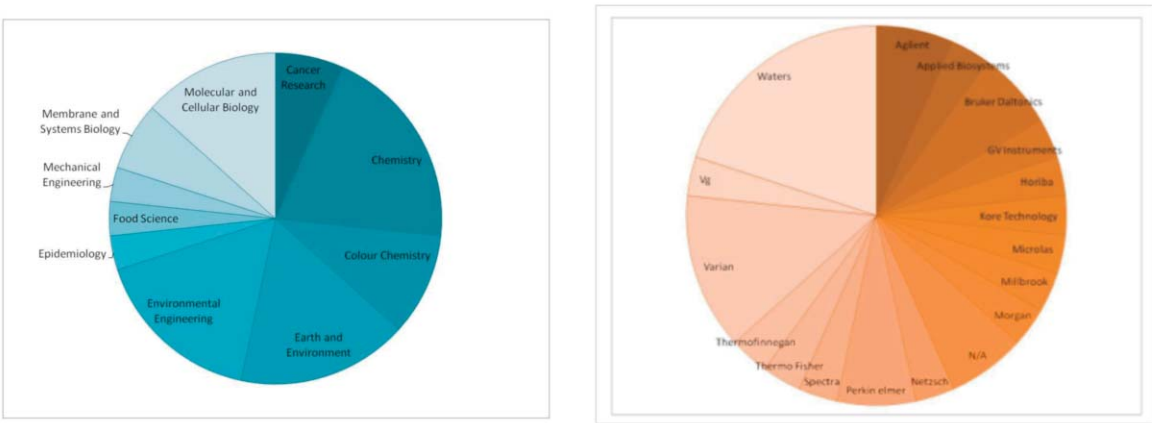

Figure 4: Pie Charts showing the distribution of Raman Spectroscopy equipment (n=7) at the University of Leeds by a) School and b) Manufacturer.

Figure 5: Pie Charts showing the distribution of Scanning Probe Microscope equipment (n=29) at the University of Leeds by a) School and b) Manufacturer.

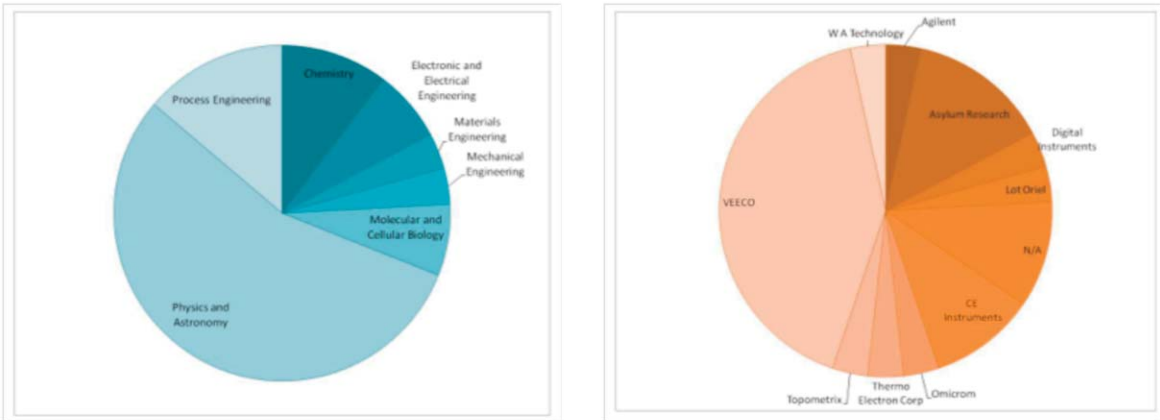

Figure 6: Pie Charts showing the distribution of X-ray diffraction equipment (n=11) at the University of Leeds by a) School and b) Manufacturer.

Workstrand 3:
Business models for access and costings

Lead – Mark Rainforth, University of Sheffield – based on case studies and analysis of best practice at The University of Sheffield and at other institutions.

Description of the workstrand

The workstrand sought to establish a range of cost models based on case studies of existing examples of good practice and to discuss the issues that must be addressed in introducing such cost models. Information was gathered from established Research Facilities that had experience of operating equipment sharing, from a wide range of facilities (e.g. from imaging to animal facilities). It became clear that despite major differences in the research topic, most of the issues associated with the cost models and equipment sharing were similar. Equally, there are important differences in how costs are calculated (e.g. depreciation), with good reasons for these differences. A cost model is proposed which is already used widely, which allows the flexibility that local differences can be addressed and which has been accepted through TRAC. While there are several examples of good practice, a culture change is still required across much of the community to ensure that research facilities are established in order to ensure sustainability of the Universities equipment base.

Objectives/what will be delivered

The original objective of this workstrand was to propose several business models for the effective sharing of equipment with a value of >£25K. Based on an extensive analysis of our existing research facilities that offer best practice and on discussions with senior finance personnel, it is clear that only one model is required. This model (excel spreadsheet can be accessed at www.N8research.org.uk) provides the flexibility to allow individual research facilities to develop a business model that suits their operation. The model allows different methods for costing equipment, and provides a template for project delivery.

Overview of the key activities

1. Charging models: What are the methods for calculating clear, sustainable, and fair access charges? What are the VAT implications?

There is a costing model in place that has been used by Small and Large Research Facilities for some years. It has evolved to the point where it has the flexibility to meet individual's needs, for example, it can be used for both Small and Large Research Facilities, and is flexible about how depreciation costs are dealt with. The output is a realistic view of the true cost of running a facility. The model has been audited through TRAC and is therefore robust. The advantages of using the cost model are clear – it provides a robust indication of what is required to make the facility sustainable.

It is clear that there cannot be one rule fitting all for the costing. Research activities vary considerably (e.g. animal facility vs electron microscopy lab), for example, the differences in how depreciation is treated (Large Research Facilities should charge full depreciation, while Small Research Facilities have the option as to whether depreciation is included or not). Equally, there are differences in how space charges are included. One additional and important difference (which is not immediately obvious) is that there are differences in how much time a piece of equipment is available for, i.e. how is routine and unplanned equipment down time treated and how can the loss of income through equipment down time be accounted for? However, the cost model is flexible and these differences can easily be taken into consideration.

It is clear that there are differences in the manner in which host departments ensure the financially sustainable running of facilities. One important difference is how the facility owner addresses access from non FEC costed research, for example, access by PhD and MSc students. The most appropriate method is that the access charge for these students is paid directly from the

Faculty/School/Institute, so that the Facility can then run independently and sustainably. This therefore has no impact on the cost model.

Based on the cost model producing a true cost value, external users of facilities should pay the same as internal users, i.e. the true cost. Commercial work is outside this remit and can be charged at a commercial rate.

A summary of the financial questions that need to be asked in setting up a Research Facility is provided in Appendix 3.1. In addition, there is now a clear steer on the VAT position, which is in effect confirms that VAT is not charged.

There are a host of examples of good practice and three such case studies are available and are provided in Appendices 3.2-4.

The cost model in setting up and running a Research Facility is clear. However, there needs to be a major culture change to get academics to set up Research Facilities. One aspect of this will be clear leadership from senior management.

2. Access: How is spare capacity identified and communicated? How is access to the equipment prioritised, granted, and scheduled?

Examples of best practice of Access and Equipment Scheduling already exist and given in the three Case Studies (Appendices 3.2-4). Having dedicated managers to run facilities is central to ensuring widespread access.

While it may appear trivial, one of the barriers to equipment sharing is the considerable additional administrative burden that can arise from booking instruments, arranging training and subsequent invoicing the costs. One way in which this additional burden can be reduced is by using a robust on-line booking system. This is not a trivial task as such a system must be sophisticated enough to treat each item of equipment differently, to provide automatic costing data and to be secure against users hacking into the administrative side of the system. A system is currently being developed that will have a core that can be used as a generic tool for other research facilities.

3. Legal arrangements: Who owns the data generated by shared equipment? Who has liability for any damage or injury?

The legal and IPR agreements need to be based around a standard sliding scale template and agreed on a case-by-case basis. For example, if a guest organisation is paying industry rates to use the facility, then the data is owned by that organisation; equally, where the guest user is paying full cost and is providing an equipment operator, then the guest user would expect to own the IPR. However, guest users/organisations not paying full cost/industry rates and who rely on the intellectual input of the host equipment operator would negotiate with the facility manager and agree an individual IPR arrangement. The need for strong data management and security is a key issue. Data storage back up is essential for internally and externally owned data, with the associated costs recognised in the cost model.

The liability for damage caused by visiting researchers was something that the facility owner must take into consideration. In practice, the facility owner takes a view on the skills of the guest operator and can decide whether the risk is acceptable, the risk would be acceptable with further training or the risk is unacceptable and an existing operator should be provided. In practice, the host Research Facility takes the risk that they will have to pay for damaged equipment.

4. **Technical arrangements: Is the equipment available on a "service", "managed access" or "self-service" basis? What level of support and training are available?**

Technical arrangements needed to be considered on a case-by-case basis relative to the sophistication of the equipment available in the facility. In order to ensure that facility managers have the relevant knowledge and understanding to provide a bespoke and responsive service, they needed to be appropriately technically qualified. Equipment sharing requires that there are sufficient staff to cover training on the instruments, or to provide a service. This must be taken into account when the running costs of the service are considered.

5. **Administrative arrangements: How is the equipment managed? How are the contracts and invoices handled?**

General payment process management would be based around agreed university terms and conditions and executed on an individual basis for each facility. Securing payment upfront was a methodology currently utilised by many facilities and lessened the administrative burden of issuing individual bills and invoices.

6. **Culture: How was the culture of sharing developed? Are research staff willing to travel to use the equipment?**

The culture for equipment sharing has changed across institutions in recent years, with several examples of good practice. However, in a large number of cases, the concept of an SRF or MRF is not understood and indeed there is hostility towards such facilities as they are (incorrectly) seen as increasing the cost of research. Therefore, there is substantial work needed to highlight the benefits and promote the importance of change. Management processes and policies needed to move in-line with any cultural changes to promote and support their implementation.

There is ample evidence that research staff will travel to access equipment that they cannot obtain at their host institution.

Resources and Leads (academic and managerial)

Academic Leads: Professor RAL Jones, Professor M Rainforth
Managerial Leads: S.A.Fulton, Terry Croft

End products/outcomes

A cost model is presented that fulfils the requirements of most Research Facilities.

Appendix 3.1
Making Best Use of Research Facilities and Equipment – Financial Considerations

1. Introduction

This guide is intended to highlight the financial considerations to be taken into account in the use of facilities and equipment that form a Small or Large Research Facility. It should explain the financial issues that need to considered in ensuring that a facility is financially sustainable.

2. Running Costs

All equipment has running costs associated with it. These might include:

- staff time to run or supervise the equipment;
- energy to run the equipment;
- materials and consumable items need to run the equipment;
- maintenance, spares and repairs;
- staff time spent administering access to the equipment;
- maintenance of the space which the equipment occupies (heating, lighting, cleaning, security)

Some of these costs may appear directly in the same account as the purchase cost of the equipment. Others will be accounted for in other departmental or university accounts and may therefore be more difficult to identify and quantify.

However, all of these are real costs that should be considered when developing the business case and any charging policy for access to the equipment.

3. Depreciation

Depreciation is an often misunderstood but important way of recognising the cost of capital equipment (i.e. equipment with a purchase price over £25k). It is important not to ignore depreciation even if an item of capital equipment was funded by a grant from an outside organisation. Recognising depreciation can be an important device in ensuring that funds are available to replace equipment once it has become obsolete. It does not matter how an item of capital equipment has been funded, the way in which depreciation is calculated will be the same.

Depreciation is a way of spreading the cost of a capital asset over its useful life so that it more accurately matches the value obtained from having the asset. An example of how depreciation works is set out in the box below. It can be seen in the example that by the end of the useful life of the equipment, the department has generated a cumulative reserve of £60,000 which is held by the University as cash. If necessary this cash could be used to replace the original equipment. Where an item of equipment is leased using an 'operating lease' it is not necessary for depreciation to be charged, as the equipment does not belong to the University.

Example of Depreciation

Department X buys an item of equipment at the start of year 1 which costs £50,000 and is paid for out of departmental reserves (which the University holds as a cash balance and has been generated as a result of previous years' reserves). It buys the equipment because it knows that it is essential for research projects that between them will generate £12,000 per year in research income (the value that it generates from the equipment) which is paid in cash by research sponsors.

If there were no such thing as fixed assets and depreciation to spread this cost, the University would have to account for the equipment and the income from research in the following way.

Income and Expenditure Account

	Year 1	Year 2 onwards
Research Income	£12,000	£12,000
Expenditure – Equipment	£50,000	–
Surplus/(Deficit)=reserve	£(38,000)	£12,000

Balance Sheet

	Start of Year 1	End of Year 1	End of Year 2
Cash (from previous reserves)	£50,000	£12,000	£24,000
Liabilities	-	-	-
Total Net Assets	£50,000	£12,000	£24,000
Represented by: I&E Reserve from previous years	£50,000	£50,000	£12,000
Annual Reserve/(Deficit)	-	(£38,000)	£12,000
	£50,000	£12,000	£24,000

A user of these financial statements could interpret this to mean that the University has a serious financial problem at the end of year 1 because of the significant deficit on the income and expenditure account. This would need an explanation to show how the deficit in year 1 is not a problem because it is expected to be recovered from reserves in future years. Also the balance sheet does not reflect the value of the equipment to the organisation. Accountants therefore use fixed assets and depreciation to present a more meaningful picture of what is happening in terms of the organisation's financial health.

In the example above the equipment cost is above the capitalisation threshold of £20,000 . The University therefore treats it as capital equipment. The University's accounting policy assumes that capital equipment has a useful life of five years after which it is assumed that the equipment will need to be replaced.

The charge that the University calculates for depreciation for each year is the original cost of the equipment divided by the useful life in years. So in this case the depreciation that the University will charge each year is:

$$\frac{£50{,}000}{5 \text{ years}} = £10{,}000/\text{year}$$

At the end of Year 1 the University's financial statements will therefore show the following:

Income and Expenditure Account Year 1		Balance Sheet at end of Year 1	
Research Income	£12,000	Fixed Assets – Equipment	£50,000
Expenditure – Depreciation	£10,000	Less Cumulative	(£10,000)
		Depreciation	£40,000
Surplus/(Deficit)	Surplus/(Deficit) £2,000	Cash (from Research Income)	£12,000
		Liabilities	–
		Total Net Assets	£52,000
		Represented By: I&E Reserve from prior yrs	£50,000
		Year 1 Surplus	£2,000
			£52,000

And, all other things being equal, at the end of Year 2 the financial statements will show:

Income and Expenditure Account Year 2 (and each year to year 5)		Balance Sheet at end of Year 2	
Research Income	£12,000	Fixed Assets – Equipment	£50,000
Expenditure – Depreciation	£10,000	Less Cumulative	(£20,000)
		Depreciation	£30,000
Surplus/(Deficit)	Surplus/(Deficit) £2,000	Cash (from Research Income)	£24,000
		Liabilities	–
		Total Net Assets	£54,000
		Represented By: I&E Reserve from prior yrs	£52,000
		Year 2 Surplus	£2,000
			£54,000
		Balance Sheet at end of Year 5	
		Fixed Assets – Equipment	£50,000
		Less Cumulative	(£50,000)
		Depreciation	–
		Cash (from Research Income)	£60,000
		Liabilities	–
		Total Net Assets	£60,000
		Represented By: I&E Reserve from prior yrs	£58,000
		Year 10 Surplus	£2,000
			£60,000

The example shows that the Income and Expenditure Account shows a consistent picture from year to year and the University is generating £2,000 additional net assets each year.

4. Replacing Equipment at the End of its Useful Life

Once the equipment reaches the end of its useful life, a decision has to be made as to what to do next. It may be that the equipment does not need to be replaced because the research is no longer necessary. However, it is probably likely that the research needs to continue and the equipment will need to be replaced in some way. For the research to be financially sustainable it must be possible to fund the replacement of the equipment once it comes to the end of its useful life.

The example above shows how, by accounting for depreciation and recovering the cost in the charges made to equipment users, it is possible to ensure that there are sufficient funds available to replace the equipment when it reaches the end of its useful life. If this is not done the research is not sustainable on its own and is having to be cross-subsidised from other activities. Inevitably this means that it may not be possible to continue the research activity if it cannot be shown to be a higher priority for those resources.

However, the example shows charges to equipment users of £12,000 per year compared to a depreciation cost of £10,000. This is not an accident but is a result of taking account of the expected replacement cost of equipment when the amount to charge users is calculated. This means that, whereas the depreciation is actually charged based on the historic cost of the equipment when it was originally purchased, the amount charged to users is based on replacement cost depreciation.[1] In taking this approach it is possible to allow for potential increases in the replacement cost over the lifetime of the equipment.

At the end of each financial year, it is possible to ensure that the amount recovered from users during the year, less any direct costs incurred in operating the equipment, is reflected in a departmental reserve.

5. Calculating the Charge for Users

Calculating an appropriate rate to charge users for access to a facility or equipment is crucial to ensuring that funds can be recovered to operate the facility sustainably.

In making the calculation of the rate it is necessary to consider:

- On what basis will the charges be made (per day, per event etc.)?
- The full cost of running the facility/equipment including the replacement cost depreciation (see above).
- The likely demand for use of the facility/equipment
- A 'reasonably efficient' level of use of the facility where this differs from the likely demand

Charging basis

The charging basis determines how you will charge for use of the facility. It could be on the basis of time (an amount per day/hour) or it could be on the basis of the number of events (an amount per scan/test). This should be decided taking account of how the facility is used and the most efficient way of measuring its use.

1 The guidelines for charging for the use of research facilities and equipment agreed by the Research Councils require the calculation of charge out rates based on replacement cost depreciation.

Full Cost

The charges made to users should take account of the full cost of operating the facility or equipment including:

- Staff costs – (academic and support staff) for the time spent running and managing the facility/equipment (including an apportionment of cost where they are not directly funded from the same account or do not spend their whole time on the facility/equipment)
- Non-staff cost – repairs and maintenance, consumable items, stationery, insurance cover etc.
- Estates costs – The estimated cost of the space that the facility or equipment occupies (if it is a material amount)
- Replacement Cost Depreciation – (see above) which should include the cost of installation, building modifications, set up, testing and de-commissioning.

These costs should be estimated for the whole useful life (in years) of the equipment and then divided by useful life to give an average annual cost. This average cost should be expressed at current year price levels (and will therefore need to be revised each year).

Charging the full cost
Recharging the full cost including staff, estates costs and replacement cost depreciation helps to ensure that the facility is financially sustainable.

Likely use and reasonably efficient use

In estimating the likely use of the facility or equipment it is important that account is taken of all use that will be made, whether or not this has historically been charged for.[2] A reasonably efficient use for a university environment should also be estimated. Again, the use should be estimated over the whole useful life of the equipment and then divided by the number of years to give an average volume of use per year.

Calculating the Charge-out Rate

To calculate the charge out rate use the following equation:

Charge-out Rate = Average annual full cost ÷ Average annual use

Where the average annual use is the *higher* of the expected use or the reasonably efficient use.

This charge-out rate is then used as the basis of charging users for their use of the facility or equipment.

Under or Over Recovery of Costs

Because the charge-out rate is based on estimated costs and estimated use of the equipment, it is unlikely that the actual amount charged to users over a year will exactly match the amount originally estimated when calculating the charge out rate. This will mean that there will be some under or over recovery of estimated costs.[3] As long as these amounts are relatively small it does

2 The rates that Research Councils will fund must be based on the use made by all users including those who have previously not been charged. It is not permissible to inflate the rates for RCUK projects to compensate for 'free' use by other users.
3 fEC rules require charge out rates applied to research projects to be based on costs (including estimated replacement cost depreciation) but they should not include a 'profit' element. Deliberate significant over-recovery of costs should therefore be avoided.

not constitute a problem however, if there is a large over or under-recovery this should be factored in to the review of charge out rates for the following year.

A large under-recovery will result in an overall shortfall of funds at the end of the useful life of the equipment. This means that it is important to estimate the usage as accurately as possible at the outset.

It should be noted that the Research Councils will not allow any 'profit' element in the charge out rates that are applied to their projects. Rates must therefore not be artificially inflated to boost recovery beyond the level of estimated replacement cost.

6. Charging Costs to Research Projects

The rules for costing and pricing research on a Full Economic Cost (fEC) basis require institutions to charge for large items of equipment and research facilities as a 'directly allocated cost'. Directly allocated costs are those where the cost is not attributable to a single project but are shared across a number of projects or activities.

The manager of the equipment or facility should ensure that these charges are made to all the relevant research projects at least once each financial year for their use of the equipment or facility during that period. The charges should be made using the internal trade process.[4]

4 fEC rules also require the charge-out rate applied to a particular project to be inflated to take account of expected price changes over the lifetime of the project. The rate applied to individual projects will therefore increase each year.

Appendix 3.2
Best Sharing Practice: The Sorby Centre for Electron Microscopy

Background

The Sorby Centre has a comprehensive series of electron microscopes, ranging from basic machines for training and routine use to high performance instruments for high level research. For example, the Sorby centre houses routine materials science instruments (e.g. FEI Tecnai 20 transmission electron microscope (TEM)), instruments modified for a particular purpose (e.g. JEOL 3010 300kV TEM) dedicated to dynamic in-situ experiments and instruments that perform a wide range of high performance functions (e.g. FEI Sirion Field Emission Gun Scanning Electron Microscope (SEM)), which allows both high resolution EBSD and energy filtered SEM imaging). In total, the Sorby Centre houses 12 major instruments (4 TEMs, 7 SEMs and a Focused Ion Beam (FIB)), and a wide range of specimen preparation equipment.

1. Charging models: What are the methods for calculating clear, sustainable, and fair access charges? What are the VAT implications?

There is a simple business model for charging, which is applied equally to internal and external academic users (but not commercial work). The cost is calculated as follows:

a. Cost of maintenance contracts. This is clearly known for each instrument.
b. Cost of spares. This is estimated for each item of equipment based on the previous three years expenditure.
c. Cost of staff. Based on usage levels over the last three years, staff costs are apportioned between instruments.
d. Depreciation charge. There is a depreciation charge for each instrument over a 10 year period.
e. Fair usage. This is the most difficult item to judge. All instruments have down time, which maybe a result of planned maintenance or from a component failure on the instrument. While the microscope is down, no income is received, but clearly there are costs still incurred (the maintenance contract and staff time). The cost per hour on the instrument is calculated on 100% usage minus known routine maintenance downtime based on prior year experience. The inevitable cost of downtime through breakdowns cannot be predicted and therefore buffer needs to be put into the system to account for lost revenue.
f. A contribution is calculated for the space charge.
g. VAT is not charged for academic work.

Access: How is spare capacity identified and communicated? How is access to the equipment prioritised, granted, and scheduled?
Access to equipment is simple- anyone who is an approved user can book the appropriate instrument. There is a maximum booking allowed on each instrument (typically 2 sessions). External users contact the Centre and request access, which is normally granted, following discussion of need.

Spare capacity is communicated through word of mouth- where one instrument is in high demand certain users are encouraged to move to an alternative lower demand instrument. The charges for each instrument tend to help; lower demand instruments tend to be cheaper than high demand instruments.

Generally there is little spare capacity, so there is no attempt to publicise the centre in this respect. However, our reputation for open access is clearly important in ensuring that almost all of the equipment is used all of the time.

Legal arrangements: Who owns the data generated by shared equipment? Who has liability for any damage or injury?

The user always owns the data. We expect some recognition of IPR when the instrument is operated by Sorby staff and the experiment requires significant skill input. This would typically be through joint publications in the literature.

Liability for injury is in-line with standard University procedures, i.e. visitors are covered by University indemnity. Liability for damage is more tricky. In general, we expect that if we have trained users to a sufficient standard, any damage incurred during operation would be covered by the Centre; this is no different for internal and external users. However, reckless damage would probably result in a request for compensation from the user (or supervisor).

Technical arrangements: Is the equipment available on a "service", "managed access" or "self-service" basis? What level of support and training are available?

The equipment is available at all levels. Each case is judged individually. Where the work is extensive, the "customer" will be trained. Where the work is limited, or the skill level of the "customer" is adjudged to be inadequate, the Sorby staff will perform the work. The Centre operates with 4 staff, all of whom provide training.

Administrative arrangements: How is the equipment managed? How are the contracts and invoices handled?

In addition to an academic Director, we have a staff of 4 covering the equipment, comprising one Senior Experimental Officer, who acts as Centre Manager and three Experimental Officers who run the equipment. External contact for usage is checked firstly through the academic director and then delegated to the appropriate person for action.

We have recently developed a professional on-line booking system. This automatically provides data in a number of important categories: microscope usage levels, automatic charging and reports to supervisors of the expenditure, individual user statistics etc. The system saves a great deal of staff time in policing the previous manual system and logging user data. This helps promote equipment sharing as external users can be given access to the booking system so that staff do not have additional administrative burden in allowing external users access. Charging is handled through our finance department.

Culture: How was the culture of sharing developed? Are research staff willing to travel to use the equipment? How do we propose to foster the required culture for effective sharing?

The culture of sharing equipment has been in place for at least a decade. It started through collaborative work using the microscopes, but primarily built up through unsolicited enquiries from within the University and users from other Universities. Over the years it became increasingly clear that such sharing would have to take place in order to balance the books as core departmental funding for the facility was reduced. Clear statements on the web site help in this respect, along with clear points of contact. It was a simple choice for us to be outward looking rather than inward looking. However, this has led to problems. Our client base has grown and this now puts pressure on some key equipment items, such that waiting times for access have increased, leading to user frustration. While this clearly shows where additional equipment is needed, it is a different matter to find the funding for the equipment and the additional space and staff time required.

Appendix 3.3
Case Study Core Genomic Facility

The Core Genomic Facility (CGF) is based within the Medical School and its main activity is the supply of a DNA sequencing service to researchers throughout the University. Three technical staff work within the facility (2.35 FTE). The manager is HEFCE funded (0.75 FTE with facility) and the other staff have fixed-term contracts (1.0 + 0.6 FTE). The main pieces of hardware utilised for DNA sequencing are a 3730 DNA Analyser (replacement value £193K) and a Biomek NX Robot (replacement value £70K). Facility staff have sole access to this equipment. Originally the Medical School supported its core facilities by providing HEFCE funded technical staff (2.0 FTE originally then 1.0 FTE post-VSS in the CGF) but over the past three years Medical School core facilities have been asked to pay back HEFCE staff salary costs to the faculty (33% in 2009, 66% in 2010 and 100% in 2011). The CGF has achieved this objective each year, in addition to paying 100% of its fixed-term contract staff salary costs. Prices are currently £2.95 per single sample with a reduction available for some high throughput batches (£160 for up to 94 samples). The CGF is expected to process approximately 40,000 samples this year.

Reputation

- Historically the CGF had poor a reputation, which the new manager (appointed 2004) proactively sought to remedy by introducing some quick fixes for data quality issues, speaking to existing and past users to find out what the other issues were (e.g. erratic data delivery, perceived lack of technical support for troubleshooting) then seeking to fix them, offering free trials etc
- Feedback from customers is now actively sought – both when customers are emailed to tell them data is available and via online feedback system (although this isn't used much as customers now tend to do this by email or face to face).

Staff

- Attitude – staff viewed the CGF as "their own business" – saw its success as their success (and vice versa) and took genuine pride in it
- Training very important – particularly in the early days when hardware was upgraded-knowledgeable staff able to troubleshoot researcher's issues as well as facility hardware issues
- Facility staff are onsite and accessible to researchers so can advise in the event of problems which is a big plus over external suppliers, also builds rapport / relationships
- The technician that was appointed just prior to upgrading major equipment (see below) had previously worked for one of the main commercial competitors. This gave customers (existing and potential) reassurance that the facility was providing an equivalent service to external commercial suppliers (but at a much lower cost).

Service level and customer charges

- Investment in upgrading to a 3730 (higher throughput DNA sequencing machine) and introducing robotics in 2005 decreased turnaround time and costs and further improved data quality which helped win back customers who had been outsourcing
- Manager was proactive in building upon this – with particular focus on continually improving standard processes to reduce costs (ultimately cut costs by 70% compared to 2004 level).
- Introduced lower charge rate for large batch size (up to 94 samples), which were more amenable to automated handling and thus required less labour. This helped to drive throughput up further which, given the high fixed costs involved in providing the service, enabled charges to

be kept low for all customers despite increasing costs of key consumables

- A further element in keeping costs down was the CGF joining together with two other local users of 3730s to buy large packs of polymer (a key consumable). This was in response to a massive 10-fold price increase in the price of smaller pack sizes late in 2005 and saves the facility approx £27K annually. The price rise was not passed on to the larger pack sizes but it is impractical for individual users to buy these alone due to shelf life.
- There are various external suppliers of DNA sequencing services, both commercially and at other Universities but the CGF was able to beat them on turnaround time (as well as on cost and accessibility to staff for troubleshooting etc) as the extra day taken to mail samples is highly significant given timescales involved (we quote 48 hrs but often supply data within 24 hrs).

Other factors

- Despite the fact that there are two identical sequencing machines locally (1 NHS, 1 UoS), neither offers similar services to the CGF so are not in direct competition. In fact, as well as collaborating for polymer purchase we help each other out in the event of one of the machines breaking down (run samples for each other) or if issues with consumable supply / performance etc so any service disruption is minimised.
- Cost of hardware is prohibitively expensive so individual labs are not likely to buy.

DNA sequencing throughput and revenue from sequencing

- Throughput has declined in the past two years from its peak in 2008/9, particularly in 2009/10 but this does not appear to be due to outsourcing of equivalent service according to checks on uBASE. Newer technologies (i.e. NextGen sequencing) are thought to be partially responsible.
- Proportional revenue increase this year is due to price rises in February 2011.

	2003/4	2004/5	2005/6	2006/7	2007/8	2008/9	2009/10	*2010/11
Samples	3,390	7,149	23,030	49,863	42,254	49,408	29,019	40,000
Revenue	£20,962	£19,923	£50,572	£84,493	£78,254	£79,424	£65,307	£90,000

*** Projected**

Issues with the current model

- Up until three years ago, the CGF made a healthy surplus each year which it hoped to accumulate and use for replacing / upgrading hardware in the future as well as investing in external training courses for staff etc. Since the faculty reversed its position on funding HEFCE staff for the core facilities, all such activity has ceased, the surplus has been eroded and with no reserves the CGF is going to face a massive challenge just to meet its commitments in the coming year. If the CGF had not had to pay back salary to the faculty it would have been in a strong position to provide the matched funding that is likely to be required for future major equipment purchases.

Appendix 3.4
Study Biology Light Microscope Facility

Light Microscope Facility – House in the Department of Biomedical Science, University of Sheffield

Background

The University of Sheffield Light Microscopy Facility (LMF) is an interdepartmental, multi-user facility that underpins research in Biomedical Science (BMS), Molecular Biology and Biotechnology (MBB), Animal and Plant Sciences (APS) and the Faculty of Medicine, Dentistry & health. Currently, there are 27 groups who are regular users and 18 occasional users.

Equipment

The facility was originally established in 2006 through funding from a Wellcome Trust Equipment grant and the University of Sheffield, which funded two new microscopes (a confocal and a wide-field), maintenance contracts, relocation of three existing microscopes, refurbishment of space, network storage and the employment of a dedicated Grade 8 scientific experimental officer (SEO). Subsequent growth with additional funding means that the facility now includes 3 standard confocals, a spinning disk confocal, a TIRF/confocal, two wide-field, an Aperio and one live-cell imaging microscope. The high content microscope for the RNAi Facility is located in the LMF and is supported by the SEO. The RNAi Facility shares the LMF network storage facility. A bid is currently being prepared for a state-of-the art super-resolution microscope, which resolves structures that are smaller than the resolution of light.

Finance

The current financial model is similar to that proposed by the Task & Finish Group and it was recently reviewed with some modifications by Joanne Ward, the Finance Officer for the Faculty of Science (a statement can be provided if necessary). The SEO is underwritten by the department to provide stability for a skilled manager. The facility is essential for research and the host department will provide any necessary subsidies. When the LMF was established the charges were very low compared to other Institutions in the UK. Currently we charge £16 per hour for confocal and wide-field microscopes for the first 500 hours and £8 thereafter. Users from outside the Faculty of Science are charged a higher rate of £30 per hour. The charges are now set to meet the costs of maintenance contracts, a contribution to the salary of the SEO, consumables including network storage, software licenses, replacement parts and any additional equipment that enhances the Facility. The SEO position was funded by the Wellcome Trust equipment grant for the first five years and subsequently by the University of Sheffield with a contribution from the LMF, which is anticipated to increase yearly. All users routinely request £25 per hour on grants to cover these additional costs. Where groups are temporarily without grants, their charges are waived.

Management

The LMF has a management committee consisting of Professors Liz Smythe, David Strutt, Kathryn Ayscough and the departmental manager Mark Ellse. This committee makes long-term policy decisions and initiates new grant applications. The LMF is managed on a daily basis by Darren Robinson who trains new users, ensures that the microscopes are in full working order, liaises with suppliers, organizes the charges and implements new software packages. He meets with Liz Smythe and Mark Ellse every two weeks to discuss ongoing issues.

Outputs:

Publications: Studies that have benefited directly from the Facility have been published in high impact journals (Nature Cell Biology, Nature Neuroscience, Nature Chemistry, J Cell Biology, Current Biology and PNAS among others).

Training: All of the PhD students and postdocs within the Biologies have the opportunity to avail of state-of-the-art microscopy facilities including image analysis. Some undergraduates are also trained if this is relevant to their specific research project.

Recruitment: The availability of high quality microscopy facilitates the recruitment of first class academic staff.

Access:

All departmental facilities are listed at http://www.sheffield.ac.uk/bms/about/facilities
The LMF is at http://www.sheffield.ac.uk/bms/about/facilities/lmf

The context of workstrand 3:

1. Charging models: All charges are advertised openly per hour and applicants for funding are advised on how to complete their URMS forms. VAT is not usually charged (refer to Joanne Ward – Faculty of Science Finance Officer)
2. Access: The website is open with a direct contact for the LMF manager, who is responsible for advising all users. The webpage content is shown in the appendix below. All information downstream of this is open to those allocated a password. A single webpage with tabbed functions allows users to manage bookings, time and support. See the second page of the appendix below.
3. Legal: We follow departmental regulations as they apply to all labs and principles of Good Laboratory Practice. Damage and injury is covered by the departmental and university policies.
4. Technical: Support and training are offered as required but all users must demonstrate competence before they can use equipment independently.
5. Administrative: The facility manager is responsible for day to day activity, data management and charges. They are backed up by the management committee and by the Faculty Finance team.
6. Culture: The culture in the department is collegiate and the funding applications for the machines inevitably involve numerous users. The advantages of well managed machines, technical support for all users and shared experience provide obvious benefits even for the most reluctant members of the community. The booking system is entirely equitable as it is open and driven by the users and the availability of the equipment.

Note:

Facility managers must be technically skilled. Management skills alone are in adequate.

Costing does not include space charges as they are already allocated through departments and it does not include equipment depreciation as this is covered through grant applications and TUOS contributions at the point of purchase. Inclusion of these charges would in many cases make charges prohibitively high.

Light Microscopy Facility

The Light Microscope Facility (LMF) is a joint unit of the Department of Biomedical Science and Department of Molecular Biology and Biotechnology located in room B2 228 of the Alfred Denny Building.

The microscopes currently in the LMF are:

- Two laser-scanning confocals. Leica SP1 and Zeiss LSM 510 with Meta head, heated incubation chamber and CO2 supply.
- Delta Vision RT deconvolution wide-field (non-confocal) system, also with a heated chamber and CO2, and a quantifiable laser unit for FRAP and FRET.
- Optigrid (optical sectioning) system on an Olympus fluorescence microscope with Volocity image capture and processing software.
- A wide-field inverted Leica live-cell system with a heated chamber and CO2 supply controlled by Volocity. Additionally, an upright Olympus FV-1000 confocal, in Firth Court D29, BMS, and a DeltaVision in Firth Court E32, MBB, are also managed by the LMF and bookable.

All these microscopes in the LMF are booked electronically via any internet-enabled computer. This database can be found at: http://bookingdatabasepc.shef.ac.uk/

Connecting to the networked data storage

Data generated in the LMF are stored and remotely backed up via dedicated servers. For a step-by-step guide on how to connect to the networked data storage, refer to the PowerPoint (RH Downloads box). Use the drive whose hostname is lmfdata2.shef.ac.uk.

A fridge, wet-bench and dry-area within the facility assists specimen preparation. An hourly charge is levied for using these microscopes in order to recover essential charges. You are welcome to discuss your experimental and imaging requirements to maximise the results obtainable from our equipment.

Support is available on use of the facility and on image acquisition and processing. This ranges from microscopy training, e.g. for postgraduates new to the field, through advice on project collaboration, to consultation on the design and purchase of new equipment by individuals and groups. A dedicated mailing list informs users of developments within the LMF.

For further information, including charges, please contact the LMF manager Dr Darren Robinson. Ext 24682.

Welcome to the BMS-MBB Light Microscopy Facility

My Information | Equipment | Assistants | Administration | Reporting | Logout

Equipment Assistants Access Problems Configuration

Category: Microscopes [Change]

Setup Equipment

Name	Internal Cost	External Cost	Click to Modify
1. Leica SP1 confocal	16.00	30.00	Edit Schedule Stats Block Make available
2. Zeiss LSM 510 confocal	16.00	30.00	Edit Schedule Stats Block Make available
3. Olympus FV-1000 confocal	16.00	30.00	Edit Schedule Stats Block Make available
4. LMF DeltaVision DV-1	16.00	30.00	Edit Schedule Stats Block Make available
5. MBB DeltaVision DV-2	16.00	30.00	Edit Schedule Stats Block Make available
6. Olympus BX 61 Optigrid fluorescence	6.00	30.00	Edit Schedule Stats Block Make available
7. Leica DMIRBE Live Cell timelapse	5.00	30.00	Edit Schedule Stats Block Make available
8. Perkin Elmer UltraView spinning disc	16.00	30.00	Edit Schedule Stats Block Make available
Analysis PC (B2 227)	0.00	0.00	Edit Schedule Stats Block Make available

Add new Equipment...

Workstrand 4:
Opportunities for optimising use of medium scale facilities

Lead: Professor Tom McLeish – Durham University

4 Medium-Scale Facilities

4.1 Definition

Medium-Scale Facilities (MSFs) are typically larger, more specialised or more expensive than would be sustained by the research programme of a single university, yet do not attract the attention and resource of major national facilities (such as synchrotrons or neutron sources). As such they are easy to overlook, even to miss altogether, in national strategies for research planning and funding. However, they are increasingly vital to the success of national research communities. Because they require an active strategy to realise and support effectively, they also become differentiators of quality: national research communities that achieve successful support of MSFs will outperform those that do not in research fields whose cutting edge is defined by them.

EPSRC defines a mid-scale facility as: *one which provides resources that are of limited availability to UK researchers for one of several reasons including:*

- *The relative cost of the kit*
- *Dedicated kit in every University is not needed*
- *Particular expertise is needed to operate the kit or interpret the results or*
- *Progress is enhanced by sharing information or software.*

We would add from the work of this project that an MSF may also arise from the context of technique development: though in principle not prohibitive in terms of cost or operation, the presence of cutting-edge technique-development linked to local expertise may also define an MSF. In the context of this N8 project MSFs tend to fall into the second and third categories of shared access defined in section 1.3:

- 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;
- Central national or regional facilities which provide controlled access or research services.

The challenge is to conceive, support and sustain such facilities. The knowledge that will support the facility, both scientifically and of the instrumental technique, is located within critical mass of researchers at a University. For this reason, and for reasons of scale, situating them within that university is the right way to support them, rather than at a national laboratory. However, connectivity, access and communication within the wider research community are in that case all the more important to optimise. This begins with the Research Councils in appropriate funding mechanisms, often involves long-term partnerships with manufactures and requires careful management of user communities.

This workstrand has examined a number of examples, both existing and planned, within this category, identifying issues that should steer strategy for exploiting MSFs to best effect at both national and consortium scales.

4.2 What are the characteristics of Medium-Scale Facilities?

In many respects, MSFs as defined here exist on a continuum with the larger facilities highlighted in earlier workstrands. But they bring a consistent set of additional challenges that not all shared facilities do. Building on the EPSRC definition we have identified clear characteristics of MSFs:

- Typically one or two only at national level
- Centred on t a university with a tradition of relevant research and development expertise.

- Require formal access arrangements and funding models,
- Typically sustain a wide user-base from academia and in some cases industry,
- Require dedicated staff to run, maintain and develop,
- May contribute to the uniqueness of UK research capability,
- Enable research that otherwise would not feature in UK landscape,
- User-base may extend internationally,
- May link strategically to large-scale facilities in development strategy,
- May sustain a link to one or more equipment manufacturers in accelerating incorporation of developments into more routine equipment.

4.2.1 Examples

Facilities already discussed in this report that fall into this category are: The York Biosciences Facility (Table 4 of the synthesis report), the Tier-2 High Performance Computing facility and the proposed N8 shared high-frequency NMR facility (case studies on pages 22 and 23). These have featured in recent submissions to the RCUK capital infrastructure consultation.[1]

A further long-standing example is furnished by the Sheffield-based III-V semiconductor growth facility http://www.epsrciii-vcentre.com/Home.aspx. It catalyses an entire national research field, and retains international profile by continuous development. More recently, EPSRC have invested in a state-of-the-art electron beam lithography facility, centred at Leeds, which is a hub for regional activity (http://www.engineering.leeds.ac.uk/faculty/news/2010/yorkshire-gets-4million-electron-lithography-facility.shtml).

The potential of MSFs to link strategically to large scale facilities and equipment manufacturers is also illustrated by the Durham X-ray crystallography facility for extreme sample environments CoEDS (see box).

1 Ref RCUK consultation

CoEDS – Centre of Excellence for Diffraction Science at Durham

Durham chemistry department has developed over 20 years a unique facility for crystallography in extreme environments. The suite of instruments includes:

- XIPHOS: A unique single crystal X-ray diffractometer optimized for *ultra-low temperature* diffraction experiments using a 3-stage closed cycle cryo-refrigerator with a temperature range 2 – 290K.
- XIPHOS II: A unique single crystal X-ray diffractometer with Ag X-ray microsource and advanced optics, optimized for *high pressure* experiments using diamond anvil cells (DACs), range 0.5 – >100kbar.
- Bruker Proteum: High intensity, focused Cu X-ray source, single crystal diffractometer, optimized for biological, *very small (<50µm3)* crystals and absolute configuration studies, temperature range 30 – 400K.
- Bruker D8: Advanced powder X-ray diffractometer, optimized for a *wide temperature range* 16 – 1500K, high resolution structural characterizations and novel experiments.

A major industrial partner, Bruker, co-funds the facility in exchange for access to the IP in the development of their technology.

Software and hardware developed at CoEDS is transferred to other national facilities at Southampton and Diamond. Areas of science enabled include the over-arching *Functional Molecular Materials* sector, for example Organic Superconductors, Porous Magnets, Single Molecule and Single Chain Magnets, Non-linear Compressibility , Spin Crossover materials, Metal Formates, MOFs, Hydrogen Storage Organic Frameworks, Negative Thermal Expansion, Functional Inorganic and Hybrid materials.

A wider-access model is now under development with a proposed three-way contribution to investment in the facility from: (i) the host university, (ii) the major industrial partner, and (iii) EPSRC. An identified capital cost of the facility is the continuing support of researchers who contribute to the technical development of the facility and to its access provision.

4.2.2 Significance

MSFs have a clear strategic role to play within a national research landscape. They may represent internationally leading research, and contribute to its sustainability. The potential added value that the networking of MSFs provides marks them out as requiring special consideration from the point of view of support mechanisms and access arrangements. They not only bring a unique facility within reach of several academic groups which individually could not support it, but also may open up rapid knowledge exchange with industry, including economic growth, through their support of an "open innovation" mode of equipment development (see exemplar box above). They may support experiments and hardware development at major facilities and constitute foci of international collaboration.

4.3 Success Criteria

The set of criteria identified in workstrand one on attitudes and working practices and in workstrand three on successful business models apply a *fortiori* to MSFs. Examples are: responsible use, willingness to share, a clear mechanism for prioritising calls on the facility, and a sustainable but flexible financial model. All are essential to the successful implementation of an MSF.

Some additional features arise from the special criteria of MSFs:

4.3.1 Peer Review

Although not necessarily on the scale of a national facility, MSFs may, as we have seen, share the quality of uniqueness of, e.g. a synchrotron source at the national level. Some may therefore require a form of "light touch" peer review to optimise the selection of proposed experiments. This adds a burden of labour and transparency to the core academic collaboration which supports the facility.

4.3.2 Support Facilities

Like some national facilities, MSFs may require access to other, supporting facilities to optimise the efficiency of their use. For example, it is sometimes possible to avoid failed experiments by running candidate samples for high-quality characterisation on a unique and oversubscribed MSF by screening in a lower-grade facility (e.g. high field NMR), which could be sited at a local institutions.

4.3.3 Early Career Access

Special care needs to be taken with Early Career Researchers, who may not have access to research grant funding at the same level as more experienced researchers. This may also apply to first-time users: in both cases it is important to keep the facility open to new users since these will contribute to the health of its science programme, avoiding stagnation. Careful consideration for the funding model for this access will be needed (as illustrated by the discussion of charging models in work strand 3).

4.3.4 Pump-Priming Phase

The nature of MSFs may extend the timeframe within which the business case for the facility operates. If research council funding is necessary to support the facility, it should be clear if this is likely to be the case throughout its lifespan or if an initial period of support will bridge to a model based on a sustainable charging model. In many cases there will be considerable benefits to the local university of hosting a cutting-edge MSF. In consequence part of the financial model might include a contribution from QR-funding from the host institution.

4.3.5 Support Personnel

MSFs need dedicated support personnel to deliver maintenance, access support and development. Although these may be supported from research grants in an *ad hoc* manner, it is better practice to see the human component as an integral part of the capital infrastructure (as in the facilities funding model supported by STFC in the context of national facilities development.

4.3.6 Review

The role that MSFs can play within the research culture of a significant national network of research groups implies that a structure of quinquennial review, or similar, is advised. Supporting a national portfolio of MSFs is vital, but needs to be strategically focussed.

4.3.7 Regionality

There is a balance to strike between the geographical "density" of MSFs and their specialism/size of relevant research community. In some cases it is appropriate for there to be one of a kind within the UK (e.g. III-V facility), in some cases a small number (e.g. Tier 2 HPC). An integrated strategy will identify the appropriate localities and numbers in each case.

4.3.8 International Scale Networking

Efficiencies of scale may additionally be won by networking MSFs into international research collaborations or infrastructure pools. In the case of the UK these are most likely to be found within EU research networks. An example of good practice here is the European Soft Matter Infrastructure project (ESMI), spawned from the Network of Excellence SoftComp (www.esmi-fp7.net/).

4.4 Conclusion

The health of a leading and research-intensive nation such as the UK relies on its capital infrastructure. Within that, MSFs play a key role in differentiating, resourcing strategic research, stimulating economic growth and new fundamental research, and networking the research community.

In the current funding climate MSFs offer great opportunities for very effective and efficient investment, and we cannot afford to stop resourcing this vital element of our research support. Partnerships with industry in both roles of user and manufacturer will be important.

Strategic thinking about placement of MSFs, especially those within HEIs is important. Adequate support for development, access and maintenance is essential.

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.