A working group on the provision of electron microscopy in the physical and engineering sciences (EMPESWG)

Final report

Executive summary

This report describes the outcomes of a process that aimed to review the current ecosystem for electron microscopy (EM) in the physical and engineering sciences, to project future needs, and to look at ways of improving coordination within the EM community to maximise the cost-effectiveness of the sector. The process started with a Town Hall meeting in 2009, followed by a more detailed study by a working group (WG), the outcomes of which were presented to the community in a further Town Hall meeting in April 2014, and feedback from which was incorporated into the writing of this final report from the WG.

The WG identified 4 key areas to focus on: (i) evaluation of the current ecosystem; (ii) coordination of access; (iii) coordination of training and (iv) identification of future technologies and projection of future needs.

Each area led to recommendations summarised here:

(i) The Current Ecosystem

This part of the report made use of evidence from surveys conducted of both EM laboratory leaders and also of users of EM facilities. The recommendations are:

- Enlarge the survey base (both for laboratory leaders and particularly the large breadth of EM users) and re-evaluate the current ecosystem at regular intervals;
- Set up a database for electron microscopy and related equipment, and staff expertise;
- Review the performance of previous EM user access schemes and make recommendations of best practice for future access schemes, for the benefit of the UK EM community.

(ii) Coordination of access

An important outcome of the ecosystem survey was that getting access to advanced instruments was a greater hindrance than the existence of the instruments themselves, demonstrating a need for improved coordination of access. The key recommendations are:

- The sharing of training resources to increase the expert user base
- The formation of a handbook of microscopy facilities

- The formation of a network for the sharing of best practice for training and equipment sharing
- The continuation of work to identify effective and practical ways of establishing a funding "centres of excellence" in key techniques, learning from previous experience with access schemes.
- The continuation of work to identify emerging techniques can most effectively be provided through a single National Centre and to develop effective models for developing sustainable national facilities.

These recommendations initially require the continuation of networking activities with costs estimated to be £100k over 3 years. Centres of excellence are estimated to require £200-300k over 3 years to operate. National facilities are about £5-10M over 5 years including capital investment.

(iii) Coordination of training

The principle recommendation is the formation a virtual, distributed EM training partnership across the UK. The roadmap to develop this would consist of two phases, the first essentially developing the embryonic network that would lay the foundations for a more ambitious distributed training centre with funding for cohorts of doctoral students.

An initial 18 month phase 1 is estimated at £180k with the second fully populated distributed training programme for cohorts of 20-30 CPD researchers/PhD students/technical staff trainees with a fully funded cost of ~£1M per cohort.

(iv) Emerging technologies and capabilities (Techwatch)

The outcomes of this section are (i) the recommendation of a mechanism for regular review of emerging technologies to identify key capabilities that the UK needs to have available to remain competitive and (ii) a review of current emerging technologies that the UK should consider investing in.

Unlike around a decade ago where aberration correction and monochromation were clearly identifiable technologies that were key to remaining competitive, there is currently a wider range of potential new technologies that could form targets for new investment. Along with renewal of the crucial base or "routine" instruments, many of which are reaching the end of their working lives, a total potential investment of £50M over the next 5 years can be identified.

The report has not identified specific funding streams for the various forms of investment proposed, and it is likely that the pattern of a wide range of funding sources be utilized will continue.

1.1 Background

Electron microscopy (EM) is an experimental technique that underpins a range of research across the sciences, enabling the characterisation and imaging of materials at the atomic level. By enabling better resolution and opening the technique to more challenging types of sample, advanced techniques increasingly enable a broad range of internationally leading research in the UK. To understand the needs of the EM community, EPSRC commissioned a working group led by Professor Peter Nellist (Oxford University) and Professor Rik Drummond-Brydson (Leeds University) to report on the current situation, and future requirements in terms of access to instruments, training, and future hardware needs.

The remit of the working group covered only electron microscopy and did not consider other atomic scale microscopies. Although tasked with looking at the requirements for physical sciences and engineering, by working with groups in the life sciences EM community it was possible to consider where mutually beneficial interactions could be made between the communities. The working group met 3 times in late 2013 and early 2014 and followed this up with a 'Town Hall' meeting in April 2014 where the broader community could comment.

Whilst a key motivation for EPSRC was to obtain a picture of the future capital requirements in this area, the issues of access mechanisms to instrumentation and training have emerged as pressing concerns and are also considered in this document.

The history behind the formation of the working is described briefly here: Following some informal discussion within the UK electron microscopy in the physical sciences community about coordinating capital investment and recurrent support for advanced EM facilities, a community meeting was held in 2009 to discuss whether there was any support for a "distributed facility" model. In such a model, regional centres would offer specific advanced capabilities available as a user facility. The report of the 2009 meeting in attached as Appendix A. The broad outcomes of that meeting were that there was general support for greater coordination of investment in advanced instrumentation, and that a working group be established to develop a model or models in more detail. There was general agreement that a pyramidal structure could be identified (Fig. 1) consisting of a layer that included the kinds of routine instruments that are found in most institutional EM facilities, a middle layer of possible regional or indeed national capabilities that acted as Centres of Excellence for a particular capability in EM, and a top layer that consisted of a very small number of national facilities providing instrumentation that would be hard to acquire and support in a single institution.

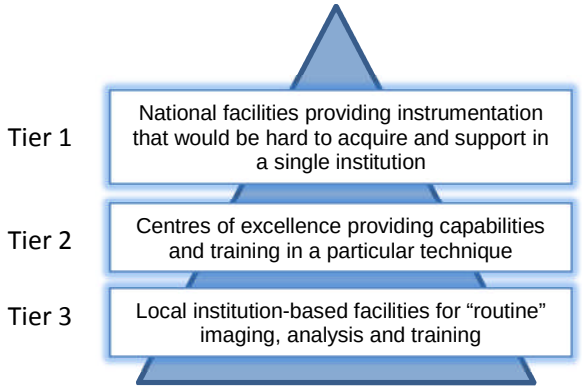


Figure 1. The pyramidal, or "layer cake" model of EM facility types

It was strongly noted that supporting all of these layers in terms of instrument renewal and accessibility of recurrent costs was crucial, and in particular the bottom level which was often not regarded as "exciting" as the other layers and not as easy to access funds for, despite its impact actually being great.

The formation of that working group was suspended during the bidding process for the EPSRC National Facility for Aberration-Corrected STEM (NFACSTEM) and the establishment of SuperSTEM as an EPSRC Mid-Range facility.

SuperSTEM became the NFACSTEM in 2011 through a bid from consortium of five universities (Leeds, Manchester, Liverpool, Oxford and Glasgow), and subsequently a further four universities (Warwick, York, Sheffield and Cambridge) indicated a desire to become partners to SuperSTEM allowing access through the SuperSTEM mechanism and providing capabilities not available at the principal Daresbury site. This can be regarded as the development of an embryonic distributed facility and showed the desire of a number of institutions to work in this kind of coordinated way.

In 2013, with the apparent desire for coordination in mind, the SuperSTEM management committee felt that they should lead the formation of the working group proposed in the 2009 community meeting. The EPSRC kindly provided funds to enable to costs of the working group to be met. The group was formed by asking SuperSTEM, the Electron Microscopy and Analysis Group (EMAG) of the Institute of Physics (IOP) and the Royal Microscopical Society (RMS) to nominate three working group members each. The nominated working group members (and their institutions) were:

Nominated by SuperSTEM

- Pete Nellist (Oxford)
- Quentin Ramasse (SuperSTEM)
- Jeremy Skepper (Cambridge)

Nominated by the RMS

- Rik Brydson (Leeds)
- Ed Boyes (York)

- Paul Brown (Nottingham)

Nominated by EMAG

- Ian MacLaren (Glasgow)
- Sarah Haigh (Manchester)
- Richard Baker (St Andrews)

Angus Kirkland (Oxford) was also co-opted to the WG because of his involvements with EM capabilities at the Diamond facility.

Rik Brydson and Pete Nellist co-chaired the WG.

Dan Emmerson of the EPSRC was able to attend all but the first meeting.

All those named above have been involved with the writing of this report.

1.2 The activities of the working group

The WG met for three face-to-face meetings and one teleconference. The WG also organised a further EM community meeting on 9 April 2014. The minutes from all these meetings are attached in Appendices D-G.

The working group met initially on 11 June 2013. It became clear that making progress would require a snapshot of the current "ecosystem" in electron microscopy in the UK. Two surveys were developed by the WG and administered by the RMS. One was targeted at those individuals leading EM facilities (both in the physical and life sciences) to capture the range of instrumentation available and how that instrumentation was used and supported. The second survey was distributed more widely through the EMAG and RMS mailing lists to users of EM facilities to gauge their current demand, levels of access and likely future demand.

The summaries of the survey data are presented in Appendices B and C.

It became clear during the survey process that the WG shared many similar aims to those of the BioImagingUK group (www.bioimaginguk.org). In subsequent WG meetings, representatives of the EM interest group of the BioImagingUK community attended, including Lucy Colllinson (CRUK), Jemima Burden (UCL), Raffaella Carzaniga (CRUK) and Paul Verkade (Bristol).

The second meeting of the WG was held on 12 September 2013. It reviewed the survey data, and agreed that there were four main themes on which to report:

1. The Current Ecosystem (Rik Brydson and Paul Brown)
2. Coordination of Access (Pete Nellist and Ian MacLaren)
3. Coordination of Training (Richard Baker and Sarah Haigh)

4. Identification of Emerging Technologies and Capabilities in EM (Ed Boyes, Angus Kirkland and Quentin Ramasse)

Initial proposals were developed by those listed in parentheses and reviewed at a third meeting on 24 January 2014. These were then presented to an EM Community Town Hall meeting on 9 April (2014). The outcomes of the discussion at that meeting were discussed in a final teleconference on 15 May 2014.

This report is therefore organised around the four areas listed above in the following sections.

2.1 The Current Ecosystem (Rik Brydson and Paul D Brown, with input from BioimagingUK)

The following represents a summary of two surveys administered by the RMS and EMAG in late 2013: one to laboratory leaders (40 responses) and one to general electron microscopy (EM) users (140 responses). Whilst admittedly being a snapshot and somewhat incomplete, these surveys did highlight the following points:

1. The current situation in terms of equipment and staffing has been arrived at in a rather ad-hoc way, via a variety of relatively uncoordinated funding streams (JIF, SRIF, RCUK, HEFCE, EU etc.). The UK is well provided for in many EM areas, but there are clear capability gaps. The age profile of equipment varies considerably, and it is recognised that much will need renewing in the next ~ 5-10 years. Many of the major research universities are now equipped with sub-Ångstrom resolution EM. Among these labs are the national facility for aberration corrected scanning transmission electron microscopy (SuperSTEM) based at Daresbury and the 5 centres that currently provide complementary high-end instrumentation as part of the SuperSTEM national service. SuperSTEM is run as a free at point of use 'mid-range facility' under a contract with EPSRC.

   The survey showed that capital for underpinning equipment is not the most serious short-term hindrance to access and this is borne out by applications EPSRC received to their 'Core Capability for Chemistry' call in 2013. Of £15M awarded across 4 core chemistry techniques, atomic level microscopy (including EM, scanning probe microscopy (SPM) and atomic force microscopy (AFM)) accounted for only **£800k**. On the other hand, applicants to that call were asked to outline their roadmaps for future requirements and atomic level microscopy made up **£13.4M** (£10.4M for EM) out of a total of £47M indicating a projected future need. This includes a number of notable potential investments including a £4.7M FEI TEM with EELS and STEM detector based at Leeds and coordinated through the N8 group of universities.

   Other recent funding opportunities (the 'great technologies' call and strategic equipment scheme) have awarded around **£12M** for atomic level microscopy, mostly EM, since 2012 and this covers the range from bench-top equipment to ~£1.9M analytical transmission electron microscopes (TEM).

2. The overall levels of (running) cost recovery for current EM facilities vary considerably. Significant capacity is available on these instruments, predominantly arising from insufficient staff support or a lack of trained users capable of independent working. Recovery of running costs, particularly for high end equipment, is a critical issue in order to maintain this

equipment in efficient operational condition and to provide dedicated long term support and expertise for users;

3. In terms of the current requirements of the user community, there is a demand for more "high-throughput" analytical TEM, cryoTEM, cryoSEM, aberration-corrected TEM and FIB/SEM, plus the occasional use of more specialised in situ SEM/TEM techniques (e.g. heating, environmental, tomography etc.) and EBSD. Where it was an issue, the availability of technical expertise and access costs appear to be the main problems restricting access, particularly for high-end techniques;

4. A wide range of specialised capabilities were suggested as being missing from the UK portfolio, including serial block face SEM (3view), dynamic TEM (D-TEM), sub-Å resolution variable energy TEM (SÅRVE-TEM), electron holography, electron tomography, low voltage SEM and TEM, He ion microscopy, LEEM, advanced FIB/SEM including cryoFIB/SEM, and analytical cryoTEM, plus specialised holders for in situ microscopies, along with appropriate sample preparation capabilities. Some (but not all) of these do appear to be accessible already within the UK, and perhaps the responses reflected problems with access costs, capacity, expertise or coordination;

5. Notably, with an increasing drive in the physical sciences to image and analyse soft materials, there are significant overlaps with the BioimagingUK EM Roadmap[1], particularly in the areas of analytical Electron Microscopy; cryo-FEGSEM, cryo-preparation and FIB/SEM, along with correlative Light and Electron Microscopy, and Electron Tomography. There are clear benefits for the UK in coordinating the two efforts.

An embryonic EM network had arisen as part of the creation of the EPSRC funded SuperSTEM Facility in 2001, the Electron Microscopy User Community Statement of need in 2009 and the subsequently awarded EPSRC mid-range AC-STEM facility. Furthermore, the initiation of both Materials and Nanoscience Equipment Access Facilities, funded since 2006/7, has provided a test-bed for potential EM user access schemes, however it is noted only two of these facilities were renewed.

The development of a Laboratory Leaders network could potentially address some of the problems of the present ad-hoc development of EM capability, and would assist in coordinating efforts to facilitate wider access to facilities, thereby making greater use of spare capacity on current infrastructure. In the physical sciences, there is clear demand for equipment access in terms of overall user-numbers, but obstacles include the requirements for dedicated staff / expertise for user support and training, access to funds for small instrument upgrades to maximise throughput, along with VAT issues in regard to the provision of research services.

Increasing demand in the physical (and geo-) sciences to work with biomaterials and biological samples suggests some degree of overlap and integration of facilities across the communities would be desirable. For the physical sciences, this will be beneficial in terms of sample preparation and low dose techniques, whilst for the biological sciences, increased use of chemical analysis techniques

[1] http://www.bioimaginguk.org/images/4/4b/EM_Roadmap_011012.pdf

would improve biochemical understanding of processes, to complement the study of biological ultrastructure. This represents a clear opportunity for the UK microscopy community as a whole.

Recommendations:

- Enlarge the survey base (both for laboratory leaders and particularly the large breadth of EM users) and re-evaluate the current ecosystem at regular intervals;
- Set up a database for electron microscopy and related equipment, and staff expertise;
- Review the performance of previous EM user access schemes and make recommendations of best practice for future access schemes, for the benefit of the UK EM community.

2.2 Coordination of access (Pete Nellist and Ian MacLaren)

The review of the current ecosystem has highlighted that significant capacity is available on the UK portfolio of EM instruments, but that also that there is unfulfilled demand for high-end techniques, with the main restrictions to access being the availability of technical expertise and the question of whether the researcher involved has funds to cover access costs to a facility. In this document these barriers are explored in further detail, and potential actions in the short, medium and long term are identified.

1. Availability of expertise

The working group identified that EM instrumentation is most effectively exploited when it is supported by dedicated and skilled support staff. Such support staff can ensure that the instrument is operating effectively, and perhaps more importantly can provide the necessary training to ensure that users can use the instrumentation more fully, perhaps becoming capable of out-of-hours access when the support staff are not available. The barriers to making such staff available are: (i) the availability of sufficiently long term funding to enable institutions to provide long term contracts for such staff and (ii) a clear career path for such staff in a university setting.

2. Sharing of instrumentation

It is clear from the survey of the current ecosystem that there exists a strong culture of maintaining facilities locally within an institution and for users to show a strong preference for making use of local facilities rather than accessing local facilities. The pyramid structure shown in Fig. 1, suggests that different levels of equipment have differing requirements for whether they should be available on an institutional, regional or national level. Nonetheless, the working group concludes that facilitating equipment sharing within EM is crucial.

The town-hall meeting endorsed this view in general, but there are specific questions that need to be resolved: (i) The use of access schemes has been promoted by the EPSRC previously, and the success of such schemes can be regarded as rather variable when it is noted that of 13 EPSRC access schemes funded ~6 years ago – 4 reapplied for renewal and two were funded (though we are not aware that a specific call was made for renewal). (ii) The question of whether access schemes

should be free-at-point-of-access or based on a ticket scheme is not resolved. (iii) There is a clear need to ensure that available instrumentation is well publicised and that there is a clear catalogue of facilities and capabilities. (iv) There needs to be clear accountability of the facilities to the EPSRC and the wider community, regardless of the answer to question (ii). (iv) The capabilities in which access is provided in this way should be identified by the potential measurable impact of the access and alignment with national research priorities, and that the scientific outcomes, such as publications, conference presentations, and other research impacts are monitored.

Short term actions

1. The shared training resources referred to in the Training part of this report will have the effect of sharing the expertise of support staff where they exist and increasing the expert user base.

2. The formation of a handbook of microscopy facilities is underway, and there is a working group containing members of the BioImagingUK initiative and this EPSRC funded working group to finalise the formatting and operation of such a catalogue. Broadly, the aim is to have a web-based system that can be searched and updated easily. The Royal Microscopical Society have expressed an interest in hosting such a system.

Medium term actions

1. The sharing of best practice for training and equipment sharing and management was identified as being a priority. The BioImagingUK initiative has already identified the need for community-led development of strategy to identify funding priorities in the life sciences, and we propose the extension of this to include the physical sciences. The aim is to provide continuity to the process started by the EPSRC Working Group, through the formation of a network of those who lead electron microscopy-focused research facilities or research groups. Such a network would provide a mechanism for the sharing of best practice and the report generated by network meetings will provide a strategic coherent statement for funders and applicants to align their future calls and applications to defined priorities for the UK scientific community. This continuity would also allow some of the open questions not resolved by the current working group to be further considered. This would require funding to cover travel and meeting expenses.

The BBSRC issued a specific call for proposals for such networking activities with a budget of £100k, and we propose that this is matched in the physical sciences.

Longer term actions

1. Centres of Excellence

Envisaged here is a funding scheme to which an institution or consortium of institutions can make bids to enable trans-institution access to institution based equipment. Such a centre should concentrate on specific, but established, advanced techniques within electron microscopy, for instance tomography or in-situ studies. Such an approach would provide a longer term funding base to enable the retention of key support staff and would facilitate the full exploitation of capital investment in EM capabilities. An estimate of the cost is £200-300k over 3 years per centre, with 4-5 centres possible.

Work is required to identify the most effective way funding such centres. It is clear that they should not simply be a repeat of previous access schemes, with minimal accountability to the EPSRC or the wider community. Importantly, the question of free-at-point-of-access versus ticketed schemes must be resolved. It was considered essential by both the working group and the town meeting that the method of access such centres must be simple and not involve a time-consuming application that would otherwise form a further barrier to cross-institution access.

This issue is faced in other disciplines and by other research councils, and we recommend that it is further considered through discussions between the BioImagingUK initiative, members of the Physical Science EM community and the relevant research councils.

2. National Centres

The Centres of Excellence described above would not preclude the formation of further National Centres (e.g. through the EPSRC mid-range facilities mechanism). Similar to the existing SuperSTEM facility (EPSRC National Facility for Aberration-Corrected STEM), such National Centres could provide a vehicle for providing cutting-edge capabilities to the UK that would be hard to establish in a university setting or with the support of just one university.

Clearly, one role of the Technology Watch activity described in Section 2.4 is to identify capabilities and technologies that would be suitable for forming Centres of Excellence or National Facilities. The requirement for excellent sample preparation facilities was also identified as an area that individual institutions were finding difficult to renew their capabilities and to support with adequate staffing etc. User accessible sample preparation facilities could be associated with Centres of Excellence or National Centres for application specific sample preparation, or indeed form its own Centre of Excellence.

2.3 Coordination of training (Richard Baker and Sarah Haigh)

Community consultation has demonstrated that one of the key factors preventing the UK's existing world-leading electron microscope (EM) instrumentation being fully utilised is the limited availability of high level technical and applications expertise. We believe that unless this is addressed we risk losing our position as one of the strongest countries for EM research and failing to maximise the potential impact of current and future EM infrastructure for the benefit of UK research and business.

To combat this shortage we propose a virtual, distributed EM Training Partnership (EMTP) be established with support from RCUK. The main aims of this network would be to:

1. Improve awareness of the capabilities of EM to solve research problems for a wide range of application areas in UK research and business.

2. Expand the number of researchers with high-level EM expertise in the UK through provision of high-quality, comprehensive and widely-recognised Continuous Professional Development (CPD) and PhD training courses.

3. Increase collaboration and equipment sharing within the UK by involving and connecting the whole UK EM community.

4. Provide cost and time savings to the community together with academic excellence by providing a accessing to educational and learning resources produced across the country.

5. Provide a single point of contact by which to ensure effective representation of EM to external organisations, with the aim of attracting continued UK and international funding.

As a starting point, the focus of this proposed training is directed towards applications in engineering and physical sciences. However, in the future partial overlap or complete merging of this training structure with that described by BioimagingUK may be beneficial.

Roadmap for Training

We propose that the EM Training Partnership could be established in a two-step process, the first phase being achievable in the short term with limited initial investment. The initial goal of phase 1will be to identify and design the necessary structure and content, together with terms of membership and access arrangements for the EMTP. If successful this would result in an application for further funding to establish and expand the EMTP over the medium and long term.

Short Term – Phase 1

1. A Training Working Group (TWG) would be set up to comprise of ~10 people. The group would include: representatives from academia and industry who currently provide EM training; end users (including a technical staff member and recent graduate) and an expert in on-line training. Meetings will be held every 6 months for two years.

2. The working group will develop a detailed course structure for the EMTP through consultation with interested parties in both industry and academia. An EM-focused virtual learning environment (VLE) will be established and populated with details of EM equipment and resources across the UK, links to on-line EM training resources, relevant webinars and existing course notes where these are already available. If funding is not continued beyond phase 1 this would still provide valuable resource for the UK community. However, it is anticipated that there will be considerable gaps in content and at this stage the principle aim is to identify the topics, required skills and key learning outcomes for the training courses.

3. During this process the working group will liaise with current providers of nationally accessed training courses (such as the EM suppliers, SuperSTEM Laboratory and the Royal Microscopy Society) to identify whether the existing courses could be integrated or adapted to address the needs of the EM network.

4. In parallel with the above the TWG will identify and approach universities and companies who might be interested in being involved in the network in order to access or provide particular resources or training course. Through consultation with these interested parties a range of possible funding models and levels of ‘buy-in’/ engagement will be proposed to ensure wide spread take up of the EMTP.

5. To help encourage engagement throughout the community, limited pump-prime funding is also requested to allow a limited number of visits and proof-of-principle experiments (up to £2k per

project) to encourage involvement in the EMTP from companies and universities without significant EM experience. Suitable projects will be selected and overseen by the working group.

6. The final part of this initial phase will be to construct and submit bid for further funding to establish the EMTP.

The major cost for phase 1 is requested to cover an 18 month post for a recent graduate to support the working group, help create and populate the VLE and liaise with potential interested parties. Total cost is estimated as £180k which includes £150k for staff time, administrative and technical support to set up on-line resources, £20k for pump-prime visits and £10k for travel/refreshments at biannual working group meetings.

Medium/Long Term – Phase 2

The final shape of the EM Training Partnership will be identified during phase 1 but is likely to aim to train cohorts of 20-30 CPD researchers/PhD students/technical staff per year over five years at a cost of ~£1m per cohort (assuming 50% support from RCUK). Participants would be distributed over the country so training would be mainly via online courses, residential visits and mini projects. Before starting the VLE would be fully populated in order to create a high quality and internationally recognised, freely accessible EM learning resource which would be further enhanced by students during their studies.

Possible elements of the EMTP Structure include:

VLE content. (i) Core lecture courses (slides/video) on the main aspects of EM, including supporting theory, with online submission and assessment of student work. (ii) A reference section including student literature reviews, technical notes, instrument details, sample preparation techniques, analysis methods, 'tricks of the trade' etc. Multimedia and student submissions encouraged. (iii) Links to useful EM tools such as relevant software, and external sites to augment training. (iv) A programme of webinars. (v) An online forum to facilitate enquiry-based learning group assignments and for exchange of ideas, results, Q&A sessions, etc.

Residential courses, workshops and conferences. Two, week-long residential courses during the first year (modelled on highly successful RMS and SuperSTEM courses) and an annual student conference event with workshops on emerging topics, specific techniques, specialisms. Long-standing EMAG and RMS events will be incorporated into the programme.

Training Centres: Regional training centres will provide regular hands-on EM training, concentrating on the fundamentals, within reasonable travelling distance for the participants. National Training Centres will provide high-level, specialist residential short courses.

Research Visits and Miniprojects. Funding will be available to support ~10 week CPD and PhD visits to other EMTP members.

2.4 Identification of Emerging Technologies and Capabilities in EM - Techwatch (Ed Boyes, Angus Kirkland and Quentin Ramasse)

Techwatch Overview and Remit

1. To provide a technical structure for the field, both scientifically and organisationally

2. To introduce mechanisms for Techwatch initiation, continuation and review; ensuring that all community members have the opportunity to contribute; with discussion meetings at MMC and electronically on a continuing basis

3. To propose first generation target areas of interest, a mechanism for adding to them and continuing review of initiatives at every stage

4. To identify necessary enabling support actions; including staffing and infrastructure development needs

The challenge is to identify key developments with a clear scientific value, economic and societal impacts, alignment with national priorities and a clear route to capability generation. Consideration will need to be given to access support requirements, including personnel, and to both capital and operating costs on a sustainable basis.

A pyramid of capabilities, similar to the Bioimaging model, is envisaged:

A. Major user facilities with multiple instruments, supporting infrastructure, operator and scientific staffing, and expectation of long term support

B. Centres of excellence with application specific capabilities, support for external users, staffing and maintenance contributed to centrally

C. Widely distributed local facilities

The Techwatch should support each 'level' but focus on A + B; with elements defined on the basis of uniqueness, nationally and especially internationally, feasibility, cost effectiveness, accessibility and above all scientific and wider impact. Realignment of existing resources to meet current use needs should be considered.

Unlike about a decade ago where aberration correction and monochromation were key technical developments that needed to be established in the UK and motivated the formation of a Level A facility in the form of SuperSTEM, it is not now possible to identify a clear two or three leading candidates for further level A facilities. Nonetheless, possible First Round Targets at A and B Levels, without priority order. Indicative, approximate costs are indicated where appropriate and these are reflected in the table below and these total around **£50M** over the next 5 years.

a. Next Generation In-Situ microscopy, with reactive environments, hot stages and for custom stage developments on a modern platform adding operational flexibility and high capability electron spectroscopy. **£5M**

- UK development and application strength with strong support in UK industry focused nanoparticle catalysis research and over time incorporating several of the following capabilities

b. Pulsed Sources both in the fs regime for diffraction and possibly spectroscopy, and in the µs-ms regimes for imaging and diffraction. **£10M**

- basic studies at electronic transition frequencies and to control and snap-shot electron exposures in a wide range of applications

c. Surface Microscopy, LEEM, PEEM, SPLEEM and ultrahigh resolution SEM (see also a). **£5M**

- adding the underlying nanostructural component to surfaces other than extended single crystals

- including a UHV microscope for surface studies; type to be determined, and possibly more generally

d. Anaerobic specimen preparation and transfer systems, possibly the development of standards with X-ray beam lines and loadlock specimen cleaning capabilities **£3M**

- to improve the infrastructure and relevance of the study of reactive systems or ones (most of them) subject to contamination from exposure outside the microscope system. Should probably form part of all microscopes in the future. Vacuum suitcases (inverse space shuttles) to become common.

e. Wet cells for living systems; organic, inorganic and combinations, including with life science applications

f. Magnetic analyses

- UK strength, basis of magnetic data storage, microwave devices and national and international industry related

g. Vortex and spin polarised microscopy

- added component of magnetic systems analysis

h. New fast electron detectors enabling sub-ms to µs recording

- higher sensitivity and reduced dose access to shorter time resolved recordings to increase relevance of experiments and to support minimally invasive methods

i. Low voltage instrumentation with high performance (STEM at ≤30kV, SEM at ≤1kV) (see also j). **i + j: £6.5M**

- to improve the signal to damage ratio in e-beam analyses by getting below the threshold or otherwise by greatly reducing the cross-sections for damage and to greatly improve the surface sensitivity of bulk specimen analyses

j. Improved vacuum systems generally (see also d)

- basic infrastructure to preserve samples

k. Quantitative diffraction based analysis

- with great potential for 3D structural information, reduced dose and short timescale analyses

l. Application specific stage and control developments

- facilitating application specific operations with targeted experiments, especially for dynamic studies and for minimally invasive studies

These potential developments can be summarised in the following table. As previously mentioned, there is not a current clear consensus around the facilities that should form new Tier 1 and Tier 2 capabilities, but possibilities are listed here. Investment in renewal of the existing instrument and capability base must be an important priority currently, given the age profile of the current equipment base identified in Section 2.1.

			Future requirements		
		The Eco-system today	**Core Chem B[1]**	**Medium term (5 yrs)**	**General Technical Developments**
Tier 1	SuperSTEM, Daresbury	3 x AC STEM with hi-res EELS		Pulsed source **£10M**	standards with X-ray beam lines Fast electron detectors for *in situ* EM
Tier 2	High-End Regional EM[3]	AC ETEM; ESTEM; AC STEM; Double AC (S)TEM x 4; Probe corrected STEM x 7	Surface EM **£4.7M** Other **£4.5M**	$2^{nd}/3^{rd}$ Gen in situ EM **£5M** Low voltage & UHV TEM/SEM **£5M / £1.5M**	Ultra high vacuum Magnetic analyses Quantitative diffraction based analysis Vortex beams/spin polarised EM Wet cells Anaerobic specimen preparation and transfer
Tier 3	Widely distributed departmental facilities	Basic level SEM, TEM	**£1.4M**	Upgrades for existing equipment **£15M** Specimen preparation **£3M**	Application specific stage/control developments (also for tier 1/2)
Totals			**£10.6M**	**£39.5M**	

[1] Requests made in the institutional roadmaps from the "Core Chemistry" Call in 2012.

Additional Comments:

The Techwatch process should support core capabilities without unnecessarily restricting individual scientific initiatives.

Resources should be made available to support developments in specimen preparation, both generally for the highest quality microscopy and specifically for device and interface studies, and to benefit from advances which may be made elsewhere. This is an identified bottleneck in microscopy applications at this time, needing urgent attention and investment. This will be the subject of on-going discussions and actions by a sub-set of the EMWG committee as part of the proposed on-going Techwatch review.

There will be a Techwatch survey and review bi-needs to be surveyed periodically with a frequency tbd, but reasonably annually, or as requested by community initiatives, and with a discussion the list to be reviewed at each MMC and EMAG meeting annually by the continuing EMWG committee on the basis of need, feasibility, priority and timeliness.

Priorities will depend to a significant extent on funding possibilities for both capital and also importantly for operational and personnel costs on established application domain science projects; while also providing for exceptional new science.

3. Conclusions

The overarching conclusion from the WG and the discussions at the Town Hall meetings is that there is an appetite in the community to work in a coordination way regarding the allocation of both capital and recurrent research support in electron microscopy. This appetite is driven by the increased challenges of supporting advanced instrumentation and in maximising its impact both Each of the sections above contains recommendations that range from actions that can be accomplished immediately with minimal cost to those that would require substantial investments. In some cases, such as those involving how access schemes should operate, there remains work to do to.

The intention of this report is now to provide a basis for discussions with funding agencies regarding the resources that can be made available, and how they should be targeted. In some cases, it might be necessary to form targeted further working groups to develop specific plans, for example in the areas of training or access schemes.

The enthusiasm of the learned societies such as the Royal Microscopical Societies and the IOP through the EMAG group are noted and their support has been and will continue to be utilized. This is already happening in some cases, for example through the RMS support for the catalogue of microscopy facilities.

Appendix A: Report on 2009 town hall meeting

UK ELECTRON MICROSCOPY COMMUNITY MEETING

4 NOVEMBER 2009

Organised by Electron Microscopy and Analysis Group of the Institute of Physics

NOTES FROM MEETING AND OUTCOMES

The following notes summarise the presentations in their chronological order. After each presentation there was substantial discussion. The main points raised are collected and summarised here.

Morning session

1. Review of current EM Facilities in UK and also Future Needs - Pete Nellist (PDN)

PDN attempted to define advanced facilities by focussing on recent developments in electron microscopy for materials science, in particular the development of the spherical aberration corrector. It is now believed that there are 8 aberration-corrected instruments in the UK. There will inevitably be a wide variety of opinions over what should be considered for future advanced facilities. The following highlights some of the possibilities.

The use of aberration-correctors for STEM instruments raises the need for advanced EELS and EDX spectroscopy instrumentation, monochromators, and further developments in high-brightness guns. The use of aberration correctors for HRTEM and EFTEM highlights the need for monochromators, chromatic aberration correction and faster, more efficient detectors.

There are developments in controlling the specimen environment in-situ, such as providing gases, liquids, temperature control, providing sufficient space for the high tilts necessary for tomography, field-free imaging. A particular future possibility is the transfer of samples between different characterisation facilities while maintaining a desired environment or temperature.

There has been some recent developments in dynamical TEM, in which ultra-fast laser pulses are used to provide very short electron beam pulses used for investigating dynamical processes. Currently there is no UK activity in this area, and it is challenging because of the range of expertise required.

A difficulty with providing user facilities separated from an academic research environment is that it restricts possibilities for technique development work, a field in which the UK has been historically strong.

Other types of facility highlight were those for specimen preparation, control of accelerating voltage and dose, LEEM, SEM, FIB, He ion.

2. Historical and Background Context of this Meeting – Andrew Bleloch (ALB)

ALB described how the idea for this meeting had grown out of a recent consultation by the SuperSTEM group in order to establish an Expression of Need for the EPSRC review of mid-scale facilities. Informal meetings held at Imperial College in April, and at the EMAG AGM Sheffield had resulted in the idea of a UK community meeting to explore ways in which the acquisition of advanced microscopy facilities could be organised in a coordinated way rather than the current approach of individual institutions competing for resources.

ALB went on to outline some of the necessary steps to achieve such an outcome, including defining a road-map of desired facilities, defining the grounds on which institutions should seek to cooperate, and on which competitive approaches are still desirable.

Comments from the floor included:

- That it is crucial to include the physical and life-science communities. Indeed this could be a vehicle for cooperative working between EMAG and the RMS.
- There was some discussion over what support might be available for small facilities. It was discussed that NHS microscopy units were vulnerable because of the lack of young personnel being trained to take over from existing staff.
- The need for integration of training into the facilities was highlighted.
- It was pointed out that such facilities may create opportunities for cross-disciplinary research.
- The difficulty of technological development in user facilities was again highlighted.

3. Pros and Cons of Possible Models for a Distributed Facility

Three volunteers agreed to present potential models for a distributed facility. It was highlighted that these individual did not necessarily subscribe to these models. In each case the bullet points from their presentations are presented followed by a summary of the following discussion.

(a) Keep the status quo (Dave McComb - DMcC)

DMcC presented the following pros and cons for not changing the current situation:

Pros

- Many well-established and internationally leading/competitive research groups developed using existing funding models
- Excellent infrastructure
  - Many aberration corrected instruments
  - Accessible to non-expert groups
  - Funded access schemes available
- Considerable knowledge base in research officers/instrument scientists
- Well-funded research groups
  - Research council, charities, RDA/TSB
- Reasonable national distribution
- Good coverage fields/techniques/disciplines
- Large scale collaborative proposals when appropriate (SuperSTEM)
- Survival of the fittest!

Cons

- Funding challenges
  - Aging equipment profiles
  - State-of-the-art equipment (£££££)
  - Routine equipment hard to fund (FEC & CIF)

  - Need many grants to cover service contracts
  - Access schemes are inadequate
    - Poorly funded
    - Some only accessible to the “in-crowd”

- Research officers/instrument scientists on “soft money”
  - Continuity of knowledge
  - Career development prospects limited

- Difficult and time consuming to set up major infrastructure projects (SuperSTEM)

The following discussion highlighted the following:

- There was concern expressed about the possible regional distribution of facilities, and the role that might be played by regional development agencies.
- It was suggested that the potential for investigating EU funds be investigated, which led on to a discussion of problems with the ESTEEM and EPSRC access schemes.
- The difficulty of instrument development research was highlighted in light of the changing funding landscape, and there was a suggestion that one centre might be dedicated to development work.

(b) A distributed facility over a number of centres with different potential funding models (Rik Brydson - RMDB)

Why the need?

- EM equipment is labour and expertise intensive
- Recently significant developments have been realised - e.g. FIB sample prep, tomographic techniques (TEM and SEM), aberration correction
- EM is a/the key tool in (Bio)Nanoscience and Technology
- UK is still a major player in EM internationally
- Capital costs are rising for a basic machine (particularly TEM) - although cheap compared to synchrotron science
- RCUK needs to maximise research benefits to research-led institutions

Possible model:

- ***Model aims to maximise international competitiveness in EM whilst providing best facilities for UK researchers in general.***
- Creation of up to (say) 10 centres (reviewed every 4/5 years by external panel) based on existing groups with track record
- Each centre offers (say) 2 specialisms (e.g. based around either an EM technique, materials expertise, sample prep. or property measurement etc.)
- SuperSTEM (EPSRC) and Imaging Solutions Centre (STFC) could be part of the model.
- Funding for dedicated staff to host external visitors for a significant proportion of the time (say 33%) (inc. travel/ accommodation and consumable costs)
- Applications reviewed by internal panel with external reps.

- Equipment funding - bids screened by an external panel and then submitted to EPSRC (bid for proportion of some nominally ring fenced funding)

Pros:

- Avoids aberration corrected chaos !
- Provides highest quality service to UK researchers
- Embeds facilities in a true research and training environment (Universities)
- Basic EM infrastructure remains in place throughout many institutions (funded by fEC), specialist facilities topped up by rolling grant facility income but these are available to all.
- Retains expertise and offers training opportunities
- Promotes collaborative research on a formal basis
- Fits neatly into current EPSRC for Access to Materials/ Nanoscience equipment facilities (*currently EM is offered by facilities at Oxford, Imperial, Leeds, Nottingham, St Andrews, Manchester Metropolitan, QMW, UCL (FIB), Bath (EBL)*).
  Also some fit to SuperSTEM facility (access here has been over complex in the past).

- Could include EPSRC, NERC, STFC (and even perhaps BBSRC) in the scheme

Cons:

- Could be viewed as a private club (in or out)
- May stifle innovation if having to provide an external service
- Would need community to self regulate through serious external review (could bring in formal international review panel).
- Would need Universities to sign up to this and to commit significant fEC funds and staff as part of the deal.
- May decrease individual University consultancy income if successful (possible industrial arm to the model ?)
- Singles out EM as a special case (albeit being a successful and coherent community to date).
- Involves significant Research Council funding – larger than a medium scale facility (probably more of the order of 20-30 million every recurrent 5 year period)
- Would need Research Councils to agree joint commitment
- Relatively novel and untested model (Australia ?)

The following discussion highlighted:

- As an example of a distributed scheme, it was suggested to examine the Australian model carefully.
- Aberration correctors will become standard on instruments, so the need for facilities to provide them is not clear.
- It is important to have a fully formed process to handle user applications and support their experiments. Experienced local administration and scientific support is crucial.
- A suggestion was made that leasing may reduce the problem of finding large capital sums.
- A potential danger of the approach was the potential to inhibit the possibility of universities being able to obtain funds for equipment.
- The difficulty of administering resource and fee transfer was highlighted, and that the distributed approach tended to negate the community and compactness of research groups.

(c) A Single (or possibly Dual ?) National Centre for UK EM (Angus Kirkland - AIK)

Some Possible Starting Assumptions

1. That the UK wishes to continue to invest in high performance Electron Microscopes for both Physical and Biological Sciences.

2. That the capital costs of the next generation of instruments exceeds that available to individual Universities and there will be limited numbers of these instruments.

3. That infrastructure and maintenance costs will approximately scale with instrument

costs and that few Universities have suitable sites.

4. That there is a limited pool of skilled research scientists and technical staff

to support these instruments.

5. That individual Universities (or groups) are unable to fully populate instrument time with their own projects.

6. That there exists a synergy with other large scale facilities which should be exploited.

7. That running costs will exceed realistic grant based recovery for individual Universities.

Advantages of a National Centre(s)

- Optimised environment suitable for housing the next generation instruments.
- Provision of full time staff to maintain / operate the instruments (career opportunities).
- Initial capital budget is competitive compared to other large scale facilities.
- Provision of highly specialised facilities that cannot be justified within a single University.
- Access by all groups on merit / need – no local ownership.
- Proximity to other large scale facilities - synergies.
- Maximisation of instrument use through access by a larger research community.
- International profile and National cohesion / collaboration.
- Ongoing costs passed to local groups on the basis of time used.

Disadvantages of a National Centre(s)

- Carefully planned management and infrastructure required to maintain neutrality.
- Access and Location; Hosting of visiting scientists.
- Configuration of the instrument pool requires careful thought.
- Allocation of time and costs - ? Peer reviewed ticket system.
- Incorporation of “instrument / technique development” in a user facility.
- Need to maintain links to traditional academic activities within Universities.
- Risk of creating a high visibility “white elephant”
- Confidentiality and Data protection.

Other factors:

Major Research Facilities

1. Compile, maintain and publicise an inventory of facilities nationwide or at least regionally along with mechanisms for access and high utilisation levels.

2. Create mechanisms/incentives to consolidate major materials preparation and characterisation facilities in central laboratory space to serve the broad university materials community.

From EPSRC Materials International Review, 2008.

Other thoughts:

A National centre would require a paradigm shift in our local operational models, but one that is successfully used within other communities and at SuperSTEM.

2. A National centre would NOT mean the end of University EM equipment which remains essential for initial experiments and to “feed” the National centre.

3. The National centre model (infrastructure, site, equipment, funding access…) works equally well for a small number of differentiated National centres.

The following discussion highlighted:

- The problem of university neutrality when it was likely that the local university would strongly support or influence the facility.
- The question of how many centres might be required, and whether it could be distinguished from a distributed facility.
- It was noted that often a fast access was required if a specific sample had the possibility of answering an important question. It was noted that the bureaucracy needed to be right to make this happen.

5. Presentation of Plans for the Imaging Solutions Centre at Harwell (Mike Johnson, STFC)

The presentation contained the following information:

ISC will bring together :

- Imaging Scientists (links to Research Complex, UK Universities)
- STFC's large scale facilities – ISIS, Diamond, CLF
- New lab-scale imaging techniques
- Visualisation & data interpretation software
- Imaging R&D - technique development
- Leading Detector Technology (link to Detector Centre)
- Computational Modelling (link to Hartree Centre)

What will the ISC look like ?

A. New building at RAL – possibly with specialist environment
B. New Imaging Equipment
C. Core STFC support staff (15 – 20)
D. Resident Scientific teams (30 – 50)

The ISC Consultation Process

- Four ISC Consultation panels created January 2009
- Chaired by:

Prof. Maggie Dallman (Imperial)	Life Sciences
Prof. Philip Withers (Manchester)	Materials
Prof. Lefkos Middleton (Imperial)	Medicine
Prof. Dave Stuart (Oxford)	Electron microscopy

Potential Instrumentation for the ISC

- Imaging Software and computer hardware
- Electron Microscopy for Life Scientists
- Electron Microscopy for Physical Scientists
- Super Resolution Optical Microscopy for life Scientists
- Lab-based X-ray tomography
- High Specification scan-probe microscopy

The ISC Creation Process

- ISC Consultation meeting July 2008
- ISC PM Board (Senior STFC staff , first meeting October 2008)
- ISC Advisory Panel (External Advisors)
- ISC Consultation Panels
- ISC Consultation Web pages
- ISC London Meeting (March 2009)
- ISC-Industry interaction (August – December 2009)
- ISC Business Plan (Nov. 09 – Feb. 2010)

Summary of ISC

- Entirely New entity on the RAL/Harwell campus
- Needed by Industry and Academe
- World-class facilities & solutions
- Links to Diamond + ISIS + CLF expertise
- Societal impact: energy, environment, life sciences & medicine
- Excellent Campus synergies

Similar information can be found at the website http://www.scitech.ac.uk/ResFac/Gateway/ISC.aspx.

6. Discussion of the EPSRC review of Mid Range facilities (Natalie Stear – EPSRC)

The EPSRC has recently conducted a review of Mid Range facilities in order to place the funding for such facilities on a similar footing. The first stage of this process was an invitation for the submission of Statements of Need to identify the facilities that should be included. With regard to electron microscopy, the following were noted:

- Statements of Need (SoNs) were received for aberration-corrected STEM, and other EM facilities.
- Aberration-corrected STEM has been identified to be taken forward in Phase 2 (see http://www.epsrc.ac.uk/ResearchFunding/FacilitiesAndServices/outcome.htm for complete list) under the heading of "Materials Characterisation Facility" which may include other materials characterisation methods that were proposed by SoNs that were felt by the original panel to be complimentary to the aberration-corrected STEM.
- An advisory group will be formed to decide the form of the tender for the "Materials Characterisation Facility".
- The outcome from this group will likely be presented for discussion by the community at a town hall meeting, probably in the spring or summer 2010. This is yet to be agreed by the advisory group.

The discussion following this presentation noted:

- That some coordination between the EPSRC and STFC efforts in electron microscopy is desirable. A possible vehicle for this is via RCUK.

7. Summary of meeting (Andrew Bleloch – ALB)

ALB summarised the meeting with the following bullet points:

Background

- UK has a strong history in EM
- EM is key enabling technology for nano age.
  - Not investing in EM is not an option

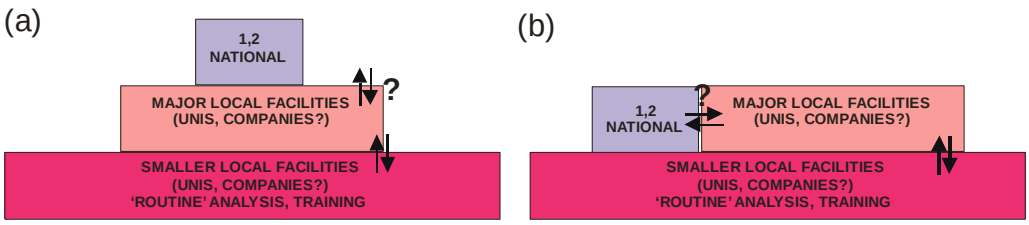
- International competitiveness

Summary of morning session

- Context for this meeting
- Discussion of models
  - Responsive mode funding of competing university facilities
  - Distributed network of advanced facilities
    - Ring-fenced funding
  - National centre(s)
- Others?

Presentation of a 'Layer Cake' model (Richard Baker – RTB, EMAG Chair)

After the formal presentations and considerable interesting discussion, RTB suggested a further model to the meeting which would combine several aspects of those models already presented. The motivation for this was to try to persuade the EM users and the funding bodies to consider the whole electron microscopy community, and its various activities, as a whole. This holistic approach may have the benefits of increasing the efficiency and effectiveness with which finite resources – financial, human and technical - were employed overall.



During the day, funding proposals for two large electron microscopy centres, the pre-existing SuperSTEM facility and the proposed ISC at Harwell, were discussed. The benefits of such national facilities for the provision of very high-end expertise and equipment were highlighted. It was also hoped that these facilities would be heavily involved in the development of improved and new EM

techniques (e.g. 4-D EM). These facilities form the top layer in part (a) of the Figure. The next layer represents major local facilities, and may correspond for example to university- and company-based EM centres with aberration-corrected TEM instruments. Again, these centres have the capability to offer very high-end analysis facilities and expertise. Much of this is, and will be, directed at research led by scientists of the individual research centre in question. A major consideration here is the rising cost of state-of-the-art instrumentation and of the operation and maintenance of these instruments. It had been stated that these are rising out of reach of many university departments, or even of universities themselves. There is motivation therefore to pool, and reduce, costs and resources and improve efficiencies by (1) allowing freer and more frequent access to outside scientists of these major local facilities and (2) planning instrument purchases and developing centre capabilities so that they become complementary rather than competing. The ease and equity of access arrangements to these national and major local facilities were also considered to be of great importance to avoid a 'them' and 'us' culture within the EM community.

It is possible that major local facilities – and access to them - will develop under this model to the extent that they become roughly equivalent to the 'national' facilities. A situation illustrated in part (b) of the figure.

The lower and largest layer of the structure represents less expensive, 'lower-end' microscopy facilities which are available in a large number of university and commercial locations. Under the current funding regime, facilities which are simply very useful but which do not in themselves show great innovation or adventure are very difficult to obtain, especially in the price range of even modest EM facilities. However, they are an essential part of the overall EM structure (and of science, medicine and engineering in the UK). This is where thousands of hours of mainly 'routine' but necessary research is performed. It would be a false economy to underfund this layer of the structure in order to fund the upper layers, since this kind of routine work would then be forced onto the more expensive high-end facilities, representing a disproportionate consumption of resources.(The phrase 'routine' here is unfair since a great deal of highly innovative work is performed on instruments which do not represent the current state-of-the-art.) Equally, the number of trained EM scientists was cited as a serious and growing problem and particular emphasis was given to medical research. This layer of our structure provides the large majority of the training for the EM community as a whole. This training is necessary for the activities within this layer itself but also acts as the entry level to those layers above.

In order for these separate layers to form a real whole together, there must be very significant exchange and communication between them. First of all, changes (positive and negative) in the availability of resources at any one centre may cause it to rise or fall between layers. Much more importantly is the exchange of information and mutual access to facilities. The exchange of information between centres in the same layer but also between layers is vital for the planning of an overall structure that is truly complementary and efficient. This efficiency will not be attained unless there is equitable, timely, organised and uncomplicated access by workers at any centre (or none) to facilities they need for their work. For such communication, planning and effective access, the whole cake needs to be considered together. Therefore, we must engage the whole EM community and the relevant funding bodies, at a high level, in a careful and deliberate action to safeguard and build upon the excellent resources we have in the UK for EM by considering them as a whole.

8. Next steps

It was generally agreed that it will be necessary to engage with funding agencies to explore ways in which a coordinated UK strategy for UK could be supported. It was agreed that a working party should be constituted, working closely with the Royal Microscopical Society with suitable representatives from the life sciences and physical sciences electron microscopy communities, to develop a specific model proposal that could then be put to a future community meeting. The EMAG committee have asked Prof Rik Brydson to convene this working party.

Appendix B: Results of laboratory leaders survey

The survey was conducted in the summer of 2013. Laboratories with a significant number of electron microscope instruments across the physical and life sciences were identified by Rik Brydson and Pete Nellist, and contacts at those laboratories were invited to make submissions.

There were 40 responses, with 19 of those being identified as coming from laboratories with a principal focus on life sciences and 21 from laboratories with a principal focus on physical sciences.

The results from each question asked are as follows:

1. **How many electron microscope columns do you operate in each of the following categories (including TEM, SEM and FIB instruments)?**

The numbers below are the total number of instruments reported by all respondents.

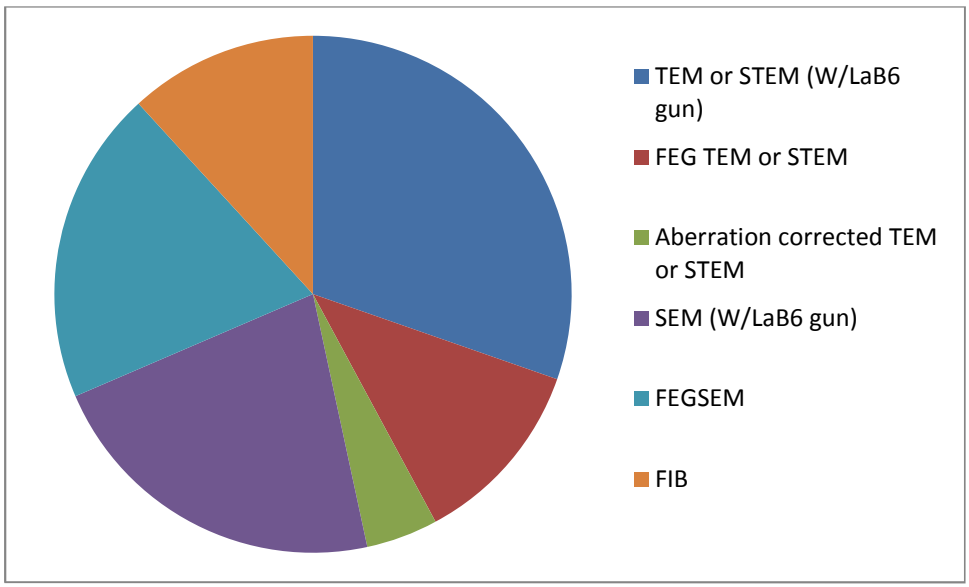
TEM or STEM (W/LaB6 gun): 54

Aberration corrected TEM or STEM: 8

SEM (W/LaB6 gun): 39

FEGSEM: 35

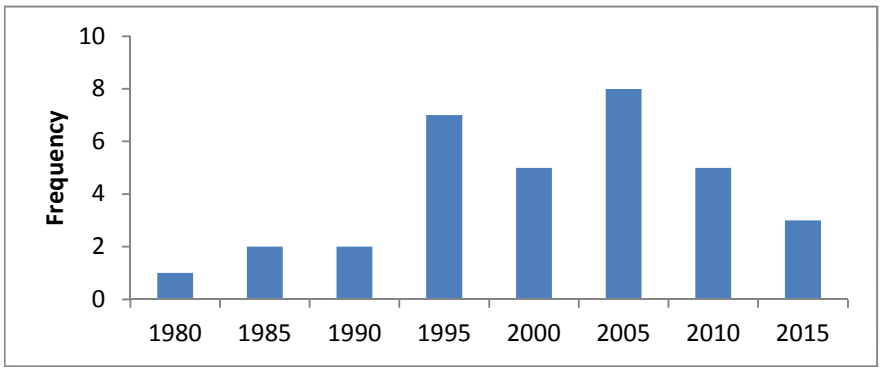
FIB: 21



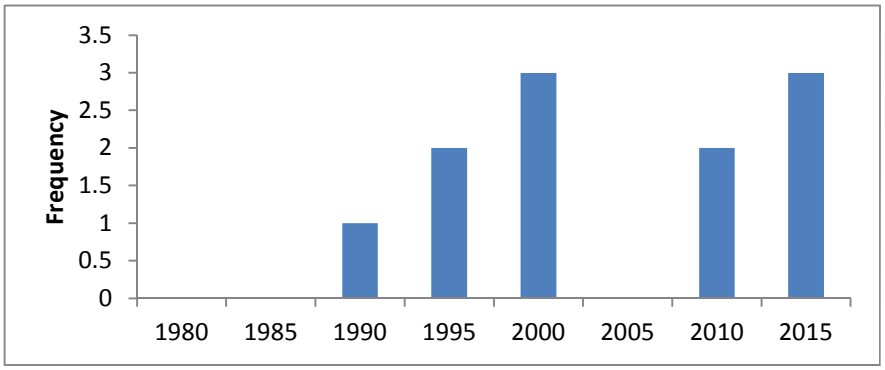
2. How old is each column?

Not all respondents gave the delivery dates of their instruments, but the data from those that did is shown below. Each bar refers to delivery in the 5 years preceding the year given.

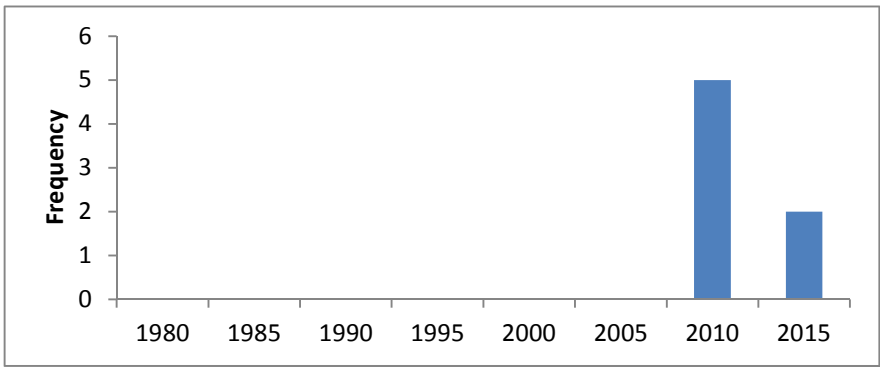
TEM or STEM (W/LaB6 gun)



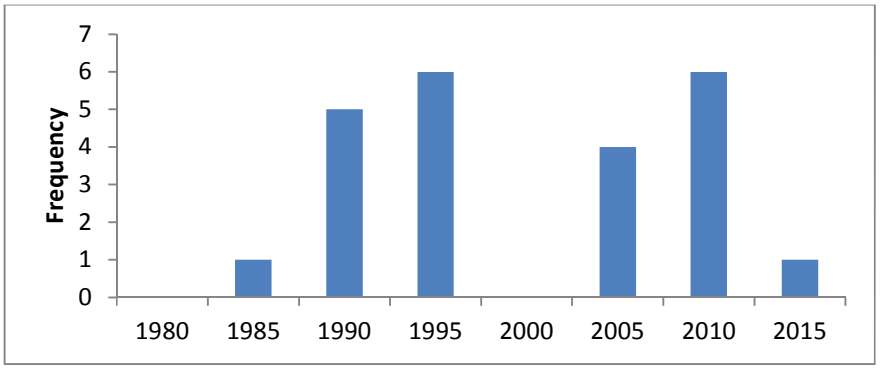
FEG TEM or STEM



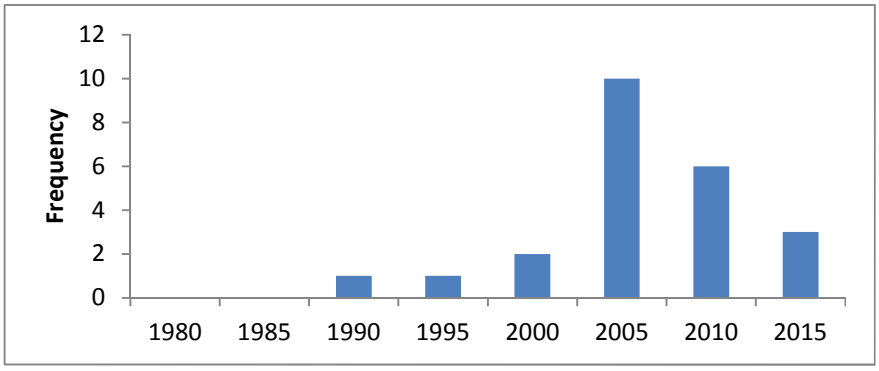
Aberrration corrected TEM or STEM



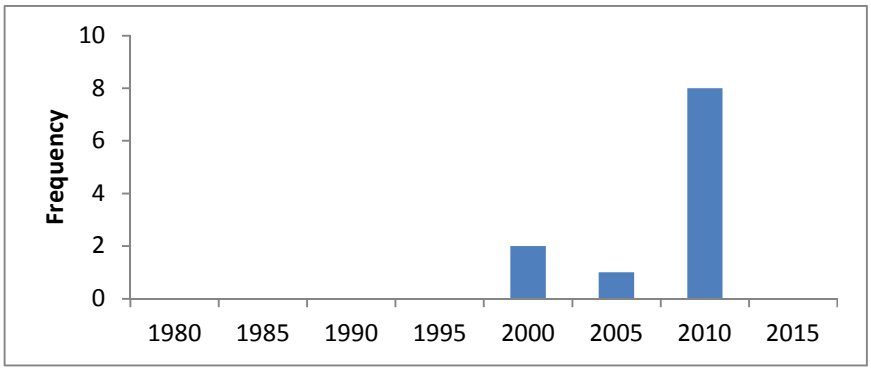
SEM (W/LaB6 gun)



FEGSEM



FIB



3. Do any of the columns in the following categories offer analytical (spectroscopy) capabilities?

The percentage shows the fraction of the respondents indicating that they have that category of instrument that also have analytical capabilities on that category of instrument.

TEM of STEM (W/LaB6 gun): 18 (56%)

FEG TEM or STEM: 12 (80%)

Aberration corrected TEM or STEM: 8 (100%)

SEM (W/LaB6 gun): 18 (78%)

FEGSEM: 20 (74%)

FIB: 10 (71%)

4. **How was the equipment funded? [approximate proportion of Research Council, University, Charity, EU or RDF, industry, other]**

The individual responses are shown below:

RCUK, EU, etc
MRC
60% EPSRC, 20% Industry, 20% RDF
EPSRC/HEFCE
University 80% REF 20%
CRUK 75% MRC/ BBSRC/ EPSRC 25%
100 % HEFCE, (SRIF)
30% RCUK; 60% University; 10% Industry
University investment
80% Research Council 20% University
Wellcome Trust, University and charity
EPSRC, Department and University
Regional Development funds and ERDF
70% Wellcome, 30% RCUK
3 HEFCE 1 University
100% Wellcome - TEM 100% EU - FEG-ESEM
University
RCUK, Wellcome Trust, Commercial
SRIF, CIF 80% EPSRC 20%
Not known
EPSRC (100%, EM430), industry (JEOL 2010)
both 100% university funded
EPSRC for the FEGTEM, 1 TEM and 1 W SEM ERDF (EU) for FIB, FEGSEM Department for 2x FEGSEM
SRIF for Aberration corrected TEM/STEM
Most recent items: University/SRIF. Not sure of older items
SRIF, RCUK (1990's), NHS Trust - part funding
TEM Wellcome SEM unknown, probably University
TEM - SRIF FIB - SRIF AC-STEM - SUPA (70% University / 30% Scottish Funding Council)
90% SRIF/JREI 10% University
RC: 2 Uni: 1 HEFCE: 1 RDF:3 Industry: 1 EU: 2
100% university
SRIF
50% University and 50% Research Council
University capital
University = 58% EU/ERDF = 42%
EPSRC - TEM CIF - FEGSEM
FEGTEM and dual-beam FIB-SEM: EPSRC
aberration corrected cFEG-STEM: ~80% SHRIF, 18% EPSRC, 2% ERDF
>90% Wellcome Trust, remainder from University funds
University
20% EPSRC Not sure of others.

Of these responses, 17 (44%) mentioned part Research Council funding, 20 (51%) mentioned part or full university funding, 5 (13%) mentioned regional development funds, 7 (18%) mentioned part charity funding and 9 (23) mentioned SRIF funding.

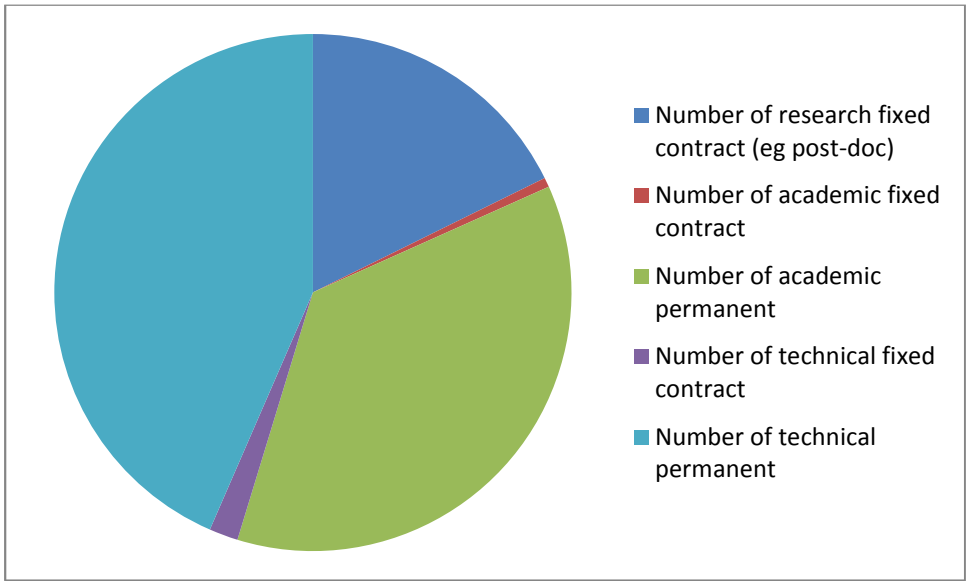
5. **Do you offer specimen preparation as a service to internal or external users?**

30 respondents (75%) said that they did offer specimen preparation.

6. **How many academic and technical staff are associated with supporting the equipment?**

The number below are the total FTE reported by all respondents:

Number of research fixed contract (eg post-doc)	29.4
Number of academic fixed contract	1
Number of academic permanent	60.5
Number of technical fixed contract	3
Number of technical permanent	72.2



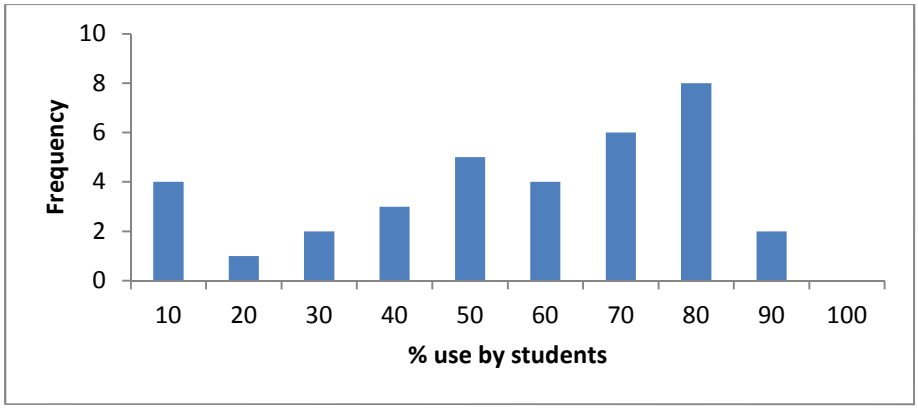
7. **How many users make use of your facility annually?**

The numbers below are the total reported by all respondents:

How many users make use of your facility annually? Number of internal users	1950
Number of external users	670

8. What percentage of the use of your facility is students?

In the histogram below, the bars refer to the decile up to the percentage given.



9. Is access to your instruments charged?

Yes 78%

No 15%

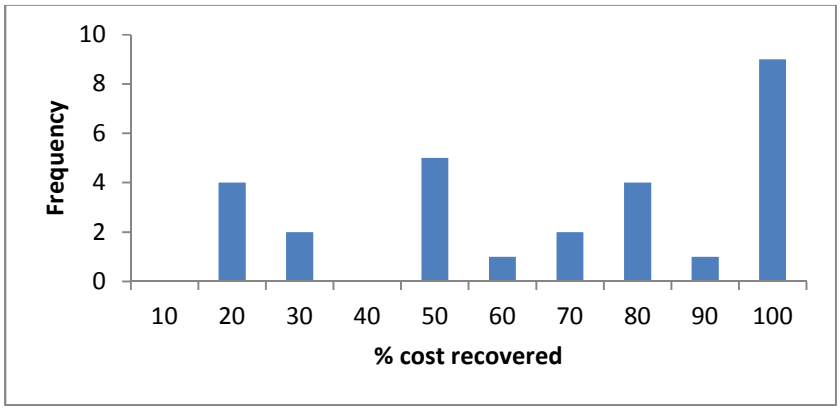
10. Who pays for access for students (eg group leader, department)?

Of those that responded, the responses were:

Group leader 20 (63%), Dept/faculty/institution 12 (37%)

11. What is your level of cost recovery?

In the histogram below, the bars refer to the decile up to the percentage given.



More detailed comments:
100% - service contracts / running costs
we recover the maintenance contract
60% of running costs including salary

About 65% of used time can be billed and costs recovered. However, we usually run things so that 100% of our costs are covered by our billing structure.
The college pay for upkeep and consumables
100% for FIB-SEM & FEGTEM; 20% for aberration corr. cFEG-STEM
100% of service contracts

12. What limits the capacity of your instruments?

Trained users 33% of respondents

Staff support 55% of respondents

Availability of instruments 55% of respondents

Other (please specify)
Downtime of old instruments waiting for repair.
We have spare capacity - approx 30% of available time is unused.
Downtime owing to the age of our microscopes.
Issues to do with out of hours working.
Up-to-date capabilities.
Downtime and service.
Support staff and safety cover are issues limiting access, as is the unwillingness of many modern users to work 'unsocial' hours.
Maintenance contracts not covered by department or faculty.
Service agreements with manufacturers re. work under cat 3 biological containment level.

13. What EM capabilities are currently missing from the UK portfolio?

Low voltage, sub-angstrom TEM.

FIB/SEM for biological volume EM 3View for biological volume EM 200kV FEG TEM for biological room temperature tomography.

In life sciences, open access to Serial Block Face SEM and FIBSEM.

Analytical cryoTEM Dynamic TEM,

Access to expertise and instruments for 3D EM.

3view systems.

ChemiSTEM for catalysis research..

3View demand is greater than available capacity

HIM

In chamber serial sectioning for bioImaging Sensitive CL systems for bioimaging

National facilities like SuperSTEM, but to include Cs corrected TEM, top end FIB.

EMs do not become redundant but they do become obsolete in the research environment - that is to keep research at the cutting edge up-to-date instrument capability needed

Investment in high end specimen preparation has not kept pace with investment in high end TEM and STEM instruments - some problems are more limited by our ability to make the specimen than our ability to analyse a representative thin specimen.
Advanced FIB - He/Ne Ion, Plasma FIB Advanced SEM - many recent advances in detector technology and beam deceleration.
.
Only very specialised ones e.g. dynamic TEM.

3-View.

Direct correlative LM/EM units eg iCorr Trained staff.

Ultra-high resolution low voltage SEM for physical sciences and industrial technology Surface science microscopy Capacity for special set ups generally - too many general purpose instruments, probably in part due to way things are currently organised as dispersed unco-ordinated facilities.

EDS FIB.

atomic resolution EDX mapping; cFEG-SEM; TEM-CL.

High end cryoEM for CryoEM single particle and tomography (National Facility funding letter pending), cryoFIB/SEM for lamella preparation for cryoTEM tomo, FIB/SEM for blockface imaging of cryo specimens, FIB/SEM for blockface imaging of plastic sections.

DTEM.

15. Any additional comments

We have some very old microscopes, very high demand, which underpins key research, but finding the money for replacements is difficult!

Capital funding for routine instruments with up-to-date operation and analysis capability is difficult to obtain - it is not always about high end instruments at the national facility level.

We are limited by the capabilities of our machines, e.g. no edx, only 100kV TEM therefore not high enough resolution for some of our users needs.

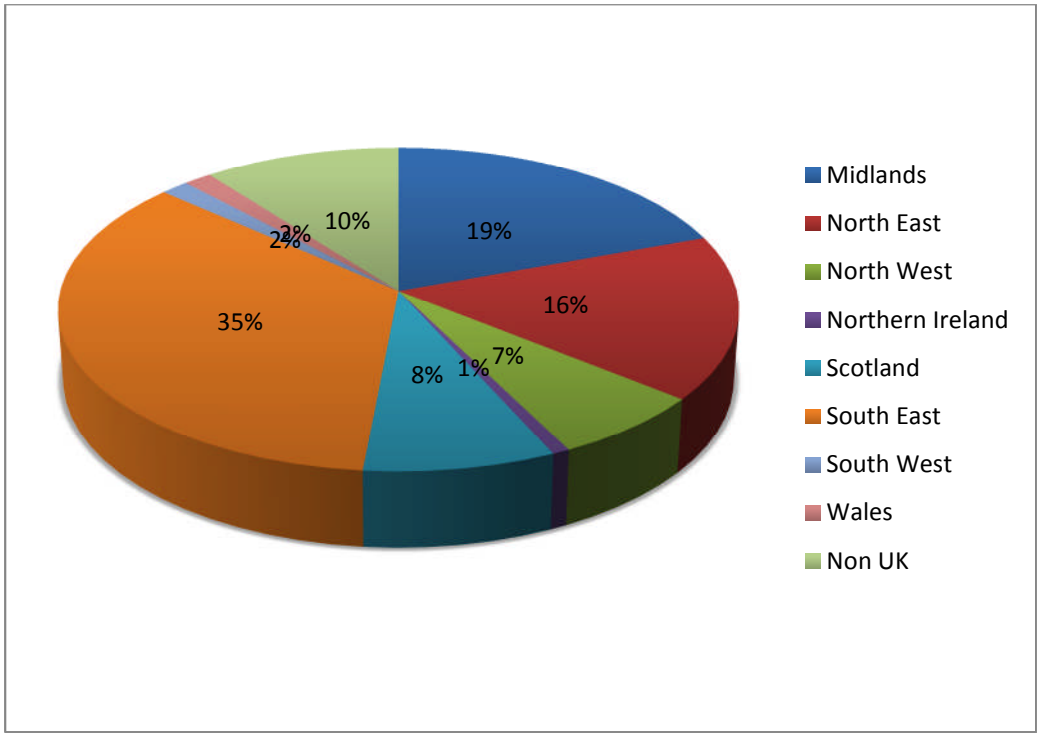
Access to TEM facilities in the UK is reasonable.

Due to retirement etc in the biological sciences there is a lack of younger EM officers both in university and hospital labs who can take EM forward into 21st century.

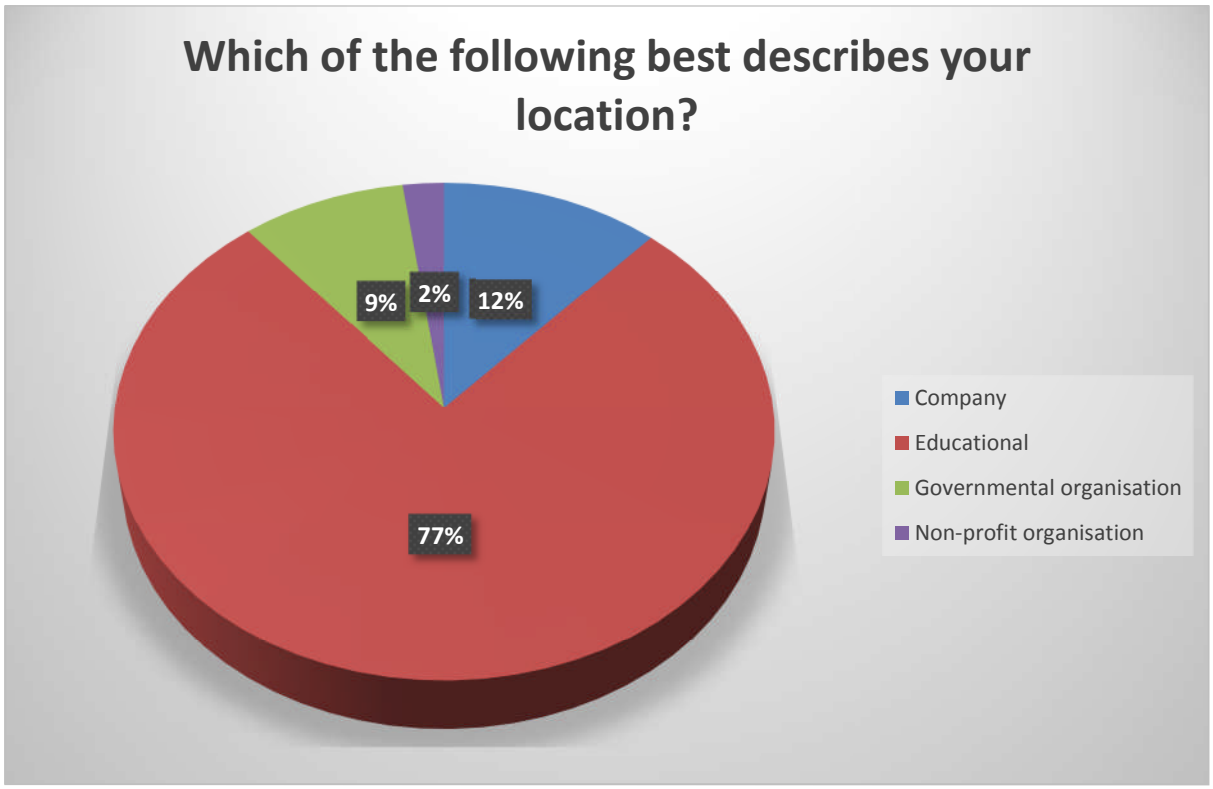
If some labs get EPSRC or EU/ERDF funding to offer external users access for free, then this will put those forced to charge for access out of business.

Appendix C: Results of EM user survey

(a) Geography

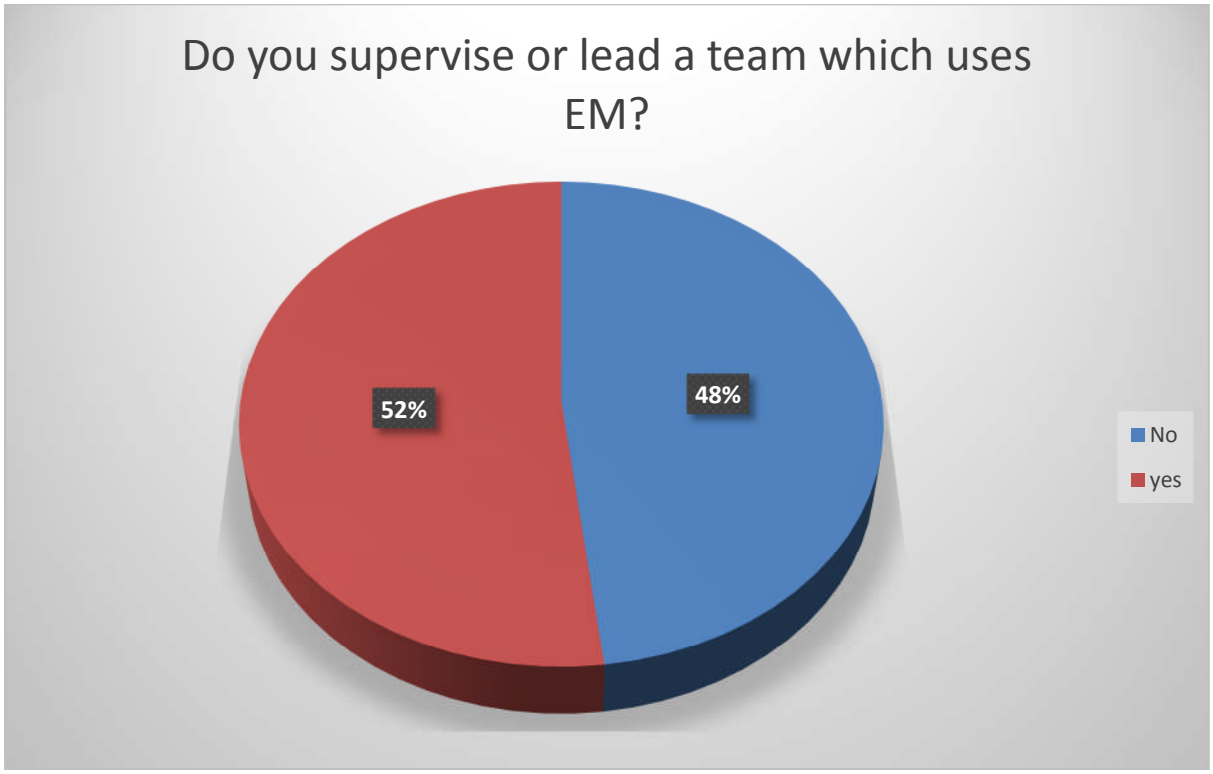


(b) Affiliation

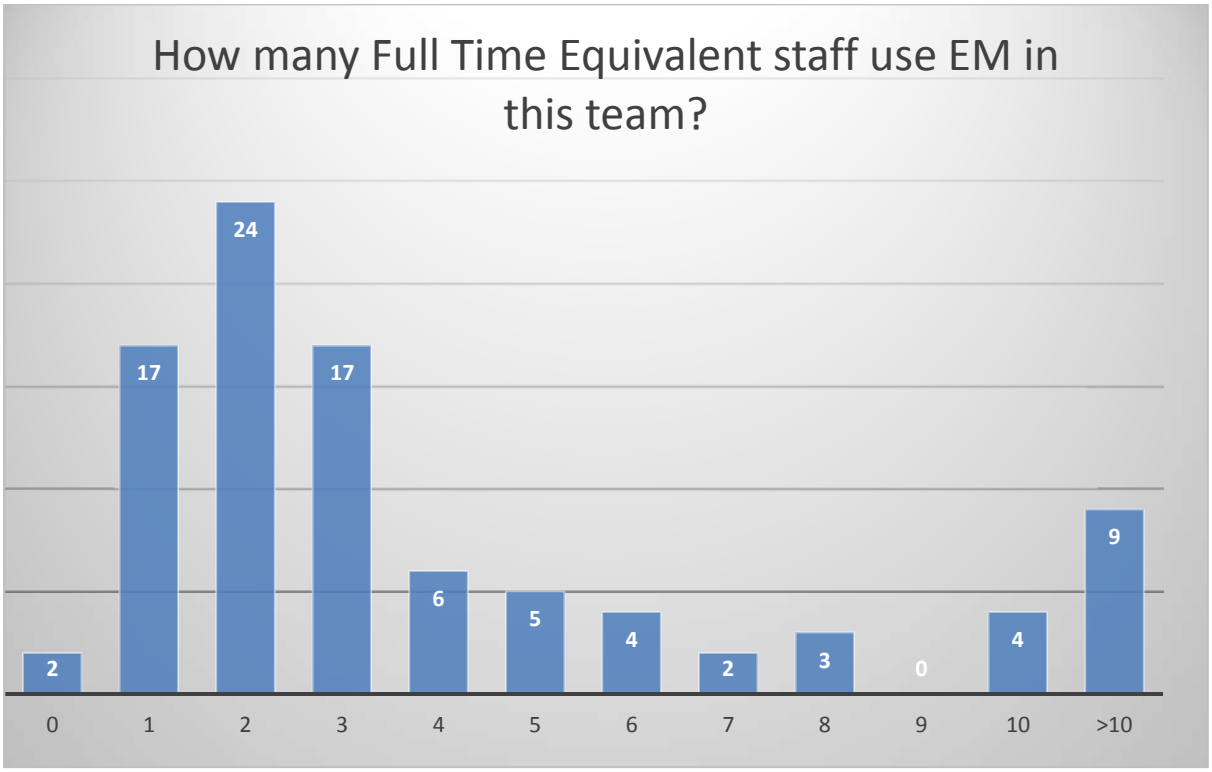


(c) Professional position

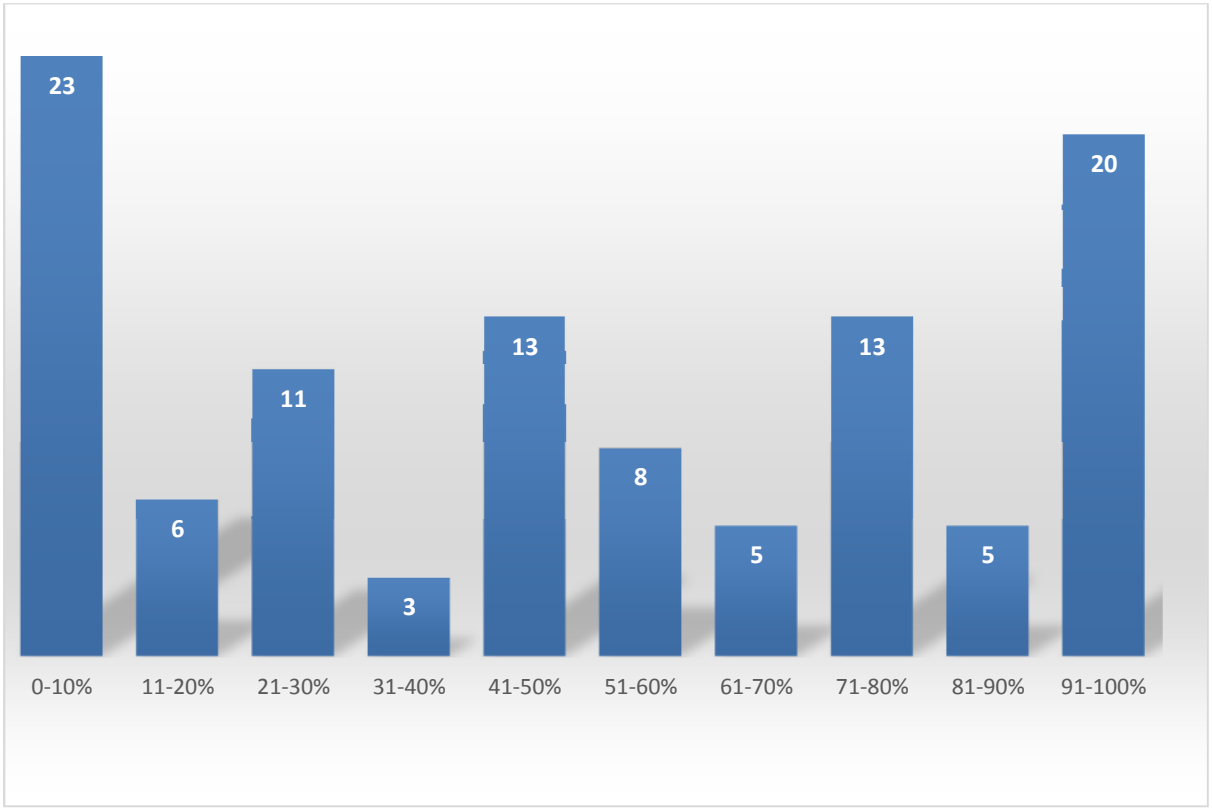
(d) Team leadership



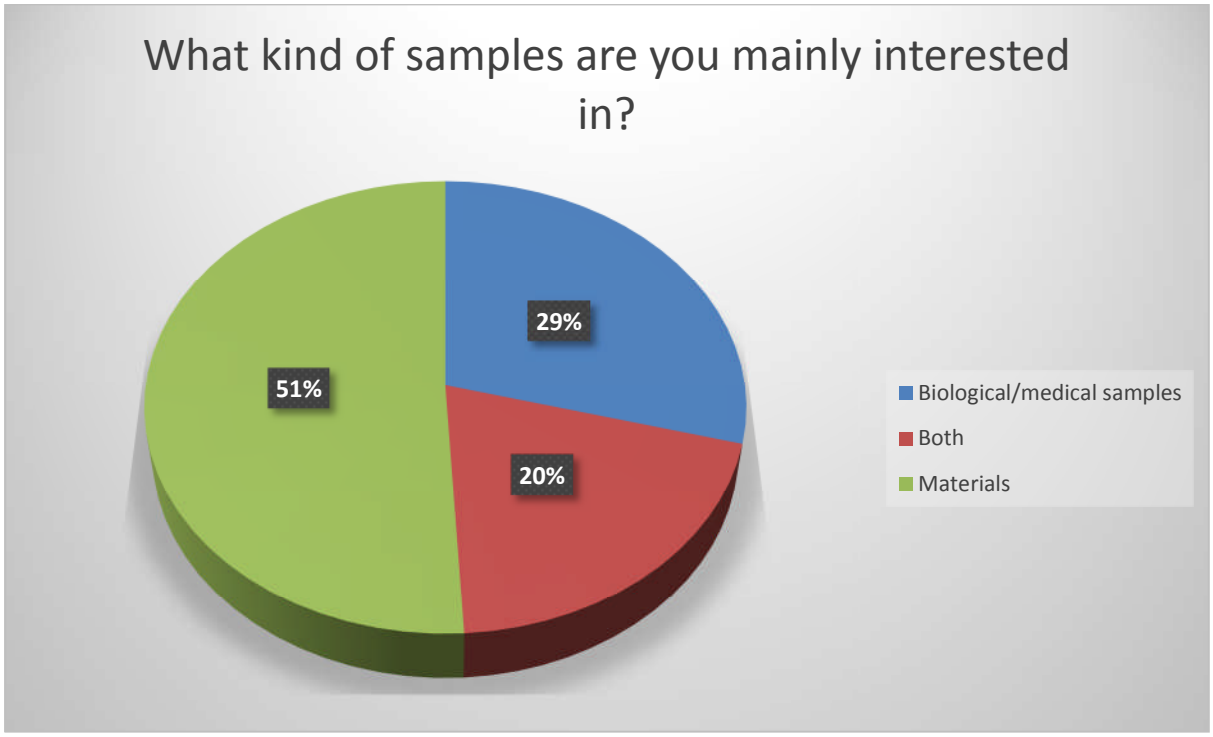
(e) Size of team



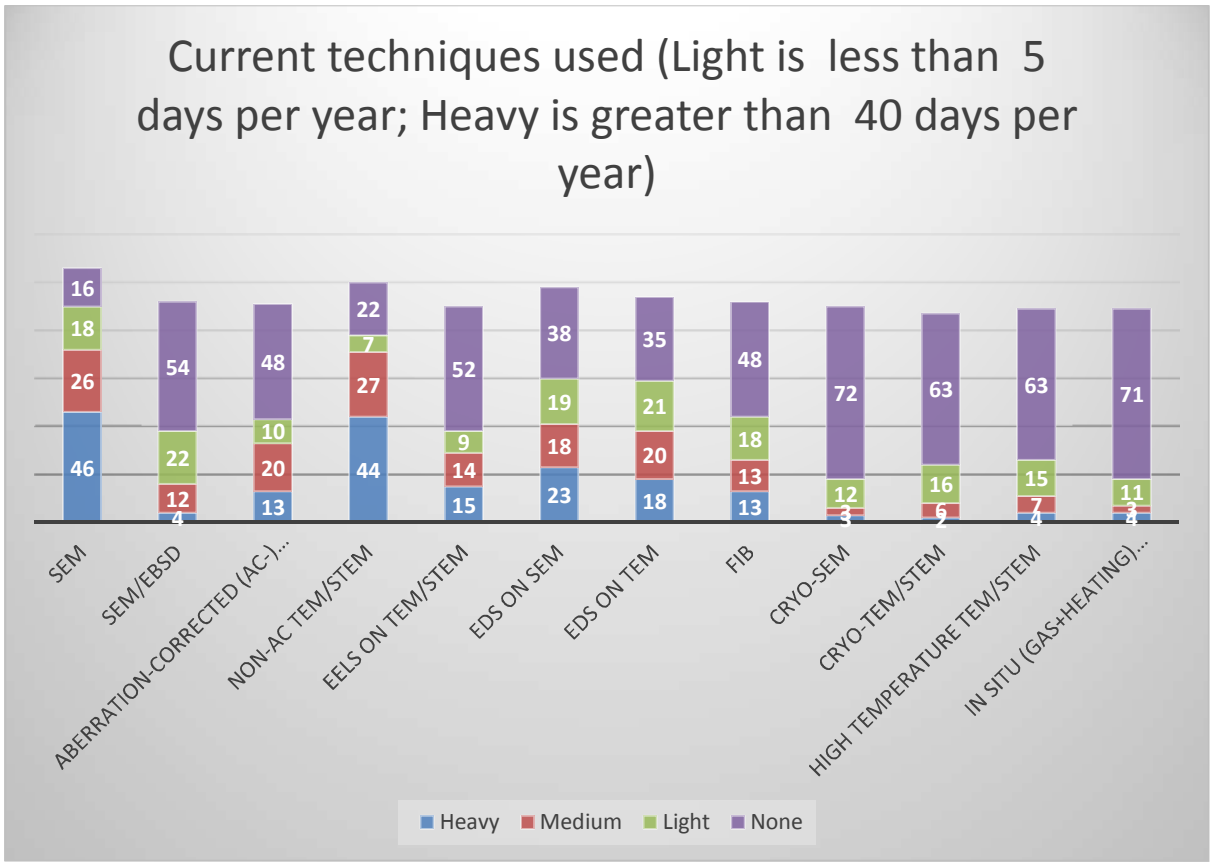
(f) Fraction of time spent on EM work



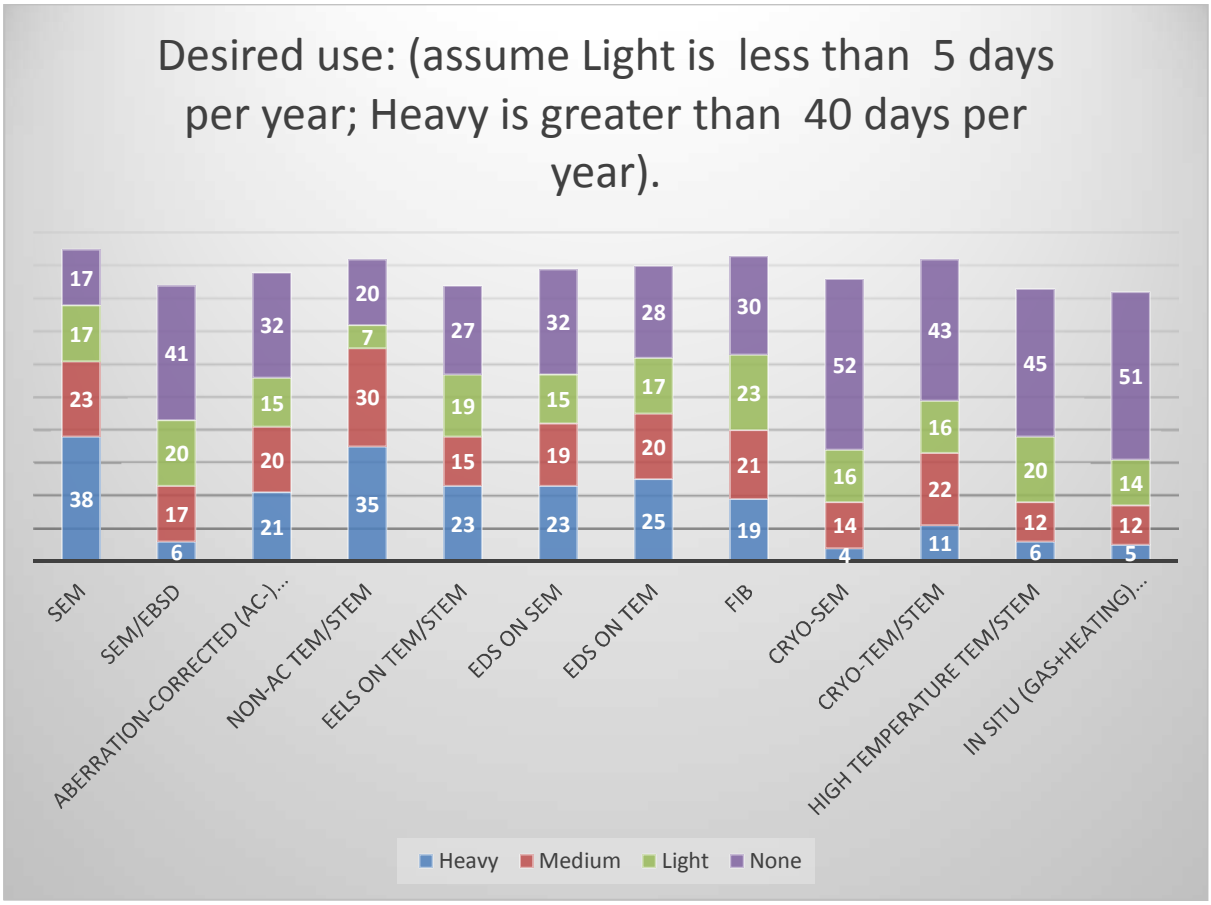
(g) Type of samples



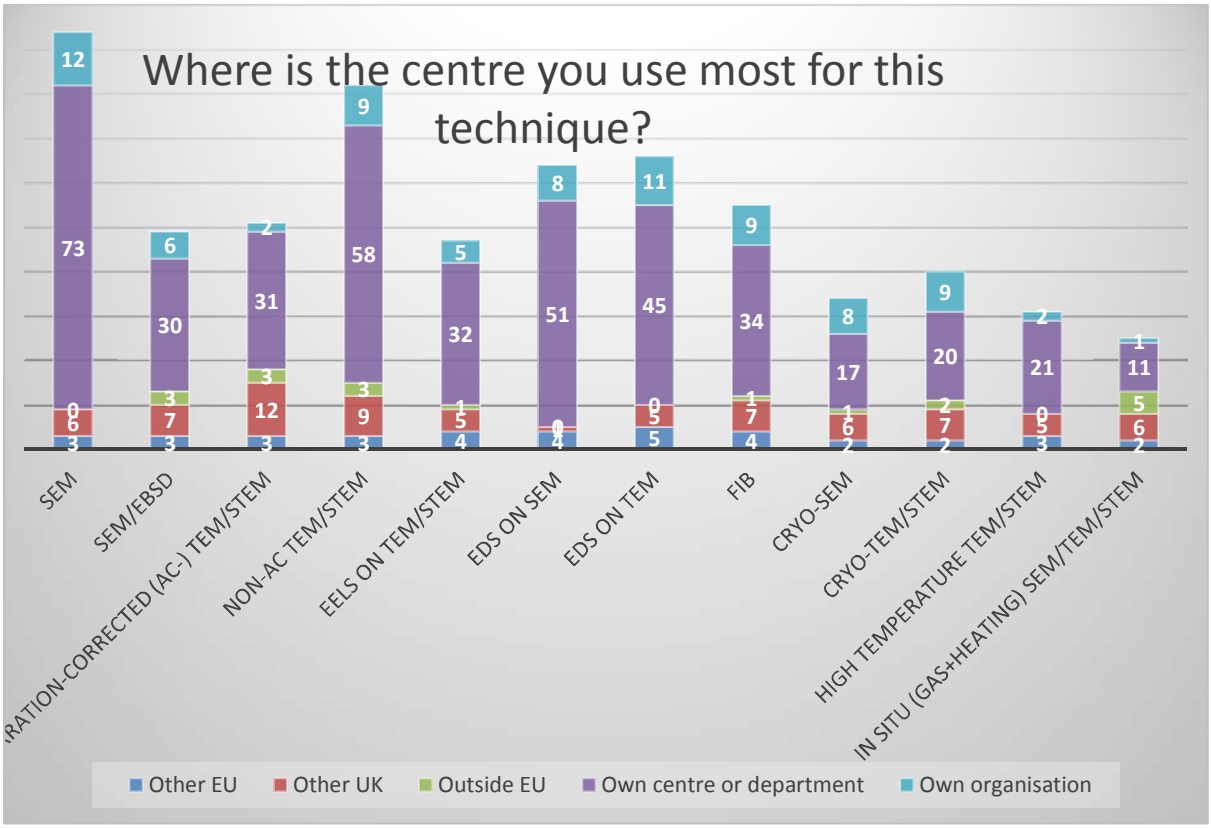
(h) Current technique usage



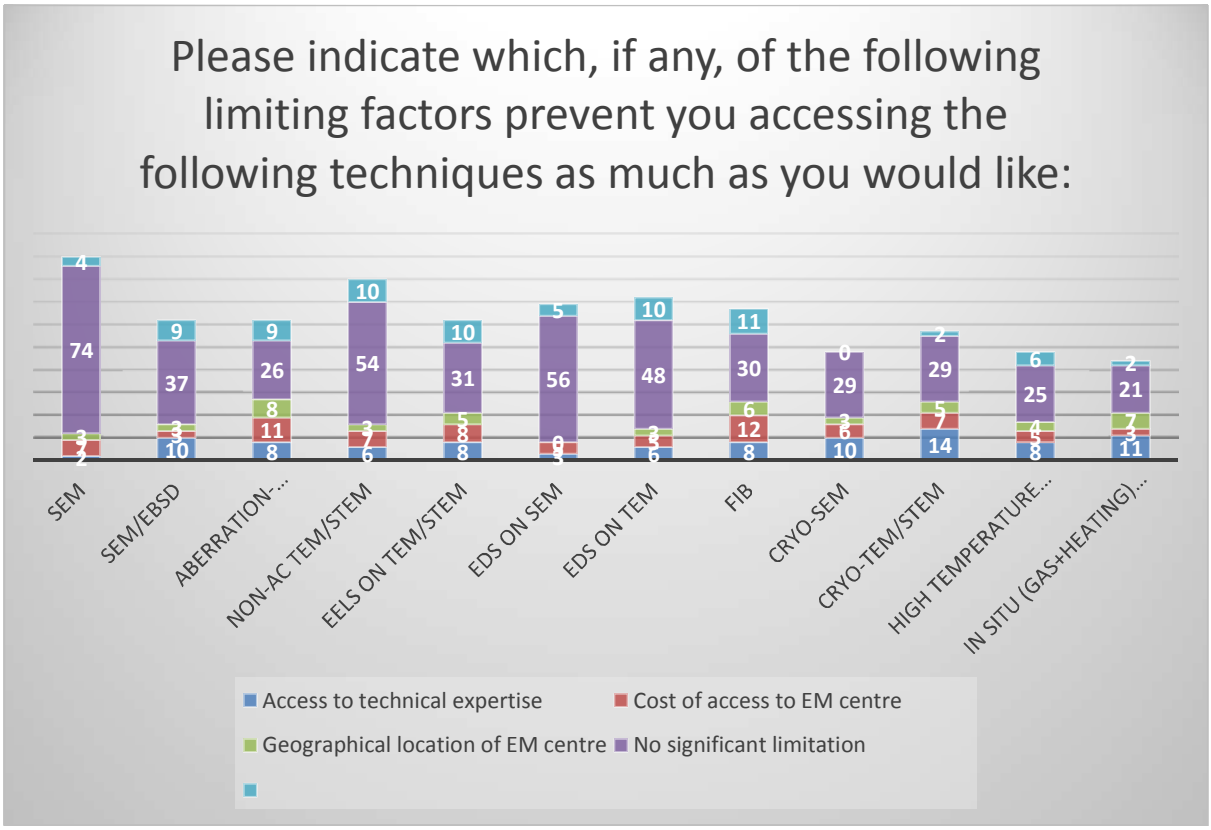
(i) Desired access



(j) Location of instruments used



(k) Access limiting factors



(l) Missing facilities

Aberration corrected ETEM / ESTEM Vey high frame rate direct electron detection	1
AC-LEEM	1
All seems available, it would be excellent to have a "bank" of in situ TEM holders for experiments (to optimise usage...often these are expensive to purchase and maintain, but are only usec	1
Better quality new generation FIB preparation Focussed argon beam preparation / sample optimisation (e.g. nanomill)	1
Dynamic TEM Analytical CryoTEM	1
Electron Holography	1
EPSRC-type Lorentz Microscopy Facility	1
Heavy ion in situ ion irradiation (in situ gas heating should also include ion irradiation considering the vast expertise within the UK in this area, and the facility of a similar type at the Univer	1
Helium ion microscopy (is available but not enough maybe)	1
High efficiency STEM EDX i.e. ChemiSTEM	1
High Voltage (1 MeV +) TEM	1
In situ microscopy with an ion beam irradiating sample, similar to IVEM-TANDEM (higher energies than currently available)	1
Liquid S/TEM for biological applications	1
Low Voltage Aberration Corrected TEM/STEM	1
low-kV HREM and HR-STEM	1
More CLEM	1
Nanomill	1
SARVE-TEM	1
Shottky FEG-SEM with EBSD, forescatter, TKD, colour CL, EDS for Earth and Planetary Science applications	1
Ultrahigh resolution low voltage (1nm at 1kV) SEM/EDS with at least in-situ heating and preferably also other capabilities.	1
None	13

Appendix D: Minutes of the First meeting of working group – 11th June 2013, IoP London

Co-chairs: Pete Nellist (PDN) and Rik Brydson (RDB)

Present: Ramasse, Maclaren, Brown, Skepper, Boyes, Kirkland, Haigh, Baker, Brydson, Nellist

Apologies: Tracy Hanlon EPSRC

Expenses: Katherine Hartwell to circulate Oxford Expense forms

Numbers refer to Agenda Items

1. Review of report from 2009 community meeting and review of working group terms of reference

PDN reviewed the background to the Working group (WG) which arose out of the community meeting in 2009 which itself grew out of the mid-range facility review, followed by discussions at the 2009 EMAG AGM. This WG is under the auspices of SuperSTEM, RMS and EMAG. It has been recently driven by SuperSTEM as part of the National Facility Roadmap requested by EPSRC. It was noted that NMR have also conducted a similar review recently**. PDN agreed to contact EPSRC to see if we could learn anything from this review process.**

The EM community meeting was held in November 2009 and essentially discussed three models:

A. The status quo: essentially what we are currently seeing with the current EPSRC Capital Call. This meeting is not directly connected with the call, but that it is relevant to the EPSRC for future funding possibilities.
B. A distributed facility over a number of centres. Think of them as individual beamlines with different capabilities.
C. A single national facility.

Arising these separate models Baker (RB) introduced a Layer "cake" model combining elements of all three models. This model was well received but further action was suspended by the mid range facilities review. It is the purpose of this WG to formulate this combined model and take this forward.

Key aspects of this latter model include: provision of appropriate capability from advanced capability, specialisms and workhorse instrumentation, and the potential for movement between the layers, training of operators and also users, technique development and appropriate preparation and screening of specimens.

WG Objectives. PDN then outlined the Objectives for the WG which were submitted to EPSRC. These are outlined in a separate document. These general objectives and terms of reference were approved by the WG

Current Landscape. The current situation at SuperSTEM was outlined. Kirkland (AK) then outlined the model used at Diamond beamlines: 3 permanent staff per beamline – a Principal Scientist and 2 Support Scientist (with established promotional structure) with 15% of uptime devoted to beamline development (often in collaboration with Users). One option here with a distributed EM facility model would be to get University buy in for the creation of permanent Research officer posts to mimic this structure (RCUK funding could provide guaranteed income over say a 5 year period allowing Universities to plan). Diamond also has a proportion of the time available for non-UK access aiding collaboration and high quality output – perhaps similar ideas could be included in the EM model.

AK also then discussed recent developments at Harwell which could be included in the Distributed EM facility model if capacity is available. These developments are driven by Diamond and are associated with a the I14 beamline (X-ray nanoprobe) consisting of a National Centre for CryoEM (2 machines funded by Welcome/MRC) and two more machines in the same building oriented more for the Physical Sciences and driven by Oxford (High resolution imaging TEM) and Industry (tba). Free at point of use access would be through a Diamond beamline model and facility is planned for opening in 2015.

The WG also discussed the fact that we should further investigate the structure of the EuroBioimaging Network (life Sciences principally super-resolution LM). We should also ensure the plans are integrated with the ESTEEM2 network (Oxford and Cambridge being nodes).

2. Initial discussion on possible models for a distributed facility .

Initial discussion on the Distributed Facility (layer cake) model concluded

- Support for underpinning technology is key element when thinking about support for higher level capabilities.

- SEM, TEM, FIB and Specimen Preparation (particularly technique development in Spec Prep) should all be included

- Life Sciences should be included

- Supporting Running costs and Equipment Renewal are two key issues for equipment.

- Staff and Staff expertise is also a very key aspect of inclusion. Capacity (Bandwidth) is often staff related/limited – remote access for users has not really matured yet to circumvent this problem.

- Training needs to be considered to ensure we have the next generation of Microscopy operators and scientsist/engineers. Perhaps there is need for a Distributed DTC in this area as part of the model. Training comes at the underpinning level of the layer structure and upwards.

- Inclusion/Admission into the model needs some level of minimum commitment from Universities

(e.g staff posts and/or capital contribution). Universities can invest in underpinning structure to move into an upper level.

- Need to think about providing capability for users which is currently missing in UK – for example Pulsed source TEM, Specimen preparation for top level microscopy, LEEM, In-situ TEM/SEM, Diffractive imaging STEM. However identification of missing capability needs to be user-driven.

- Need to balance benefits of neutral sites versus University sites. It was thought that new developments (e.g. DTEM) should be on neutral sites if they are better environments. Whereas University sites sometimes better for collaborative based research ethos.

- for any model we propose we need to demonstrate DEMAND and improved OUTPUT and IMPACT by reorganisation of existing (or increased) levels of funding. We need to get RCUK, Universities and Regional University Alliances all on board.

3. Definitions of boundaries for classification of EM capabilities [1.5 hour]

Some limited discussion of this topic was undertaken, however generally it was felt that we needed to do some data gathering before any definitions were made.

Possible boundaries for classification within the layer model might be:

- Capital cost/maintenance cost for certain capabilities, e.g aberration correction, monochromation

- Technique Specialisms (Specimen Prep, Tomography, In-situ etc.....)

- Sample Specialisms (Soft matter, Thin films, Magnetics etc…)

4. Methodology and assignment of tasks for acquiring data evidence of the demand for advanced EM capabilities and for identifying gaps in the UK infrastructure [1.5 hour]

Potentially data gathering could be a large job – it was agreed to ask EPSRC for a sum (<£10k) to see if we could fund 1/2 graduate students to work for 3 months over the summer. **PDN to contact Susan Morell at EPSRC.**

WG needs to organise two questionnaires to gather data possibly via RMS (**PDN to consult with them):**

1. One targeting EM Facility Managers/ Lead Academics

This would aim to generate an EM database of current equipment profile and staff provision. Only really interested in those who have bandwidth for external access and may need additional support to sweat these assets. Need to also ensure we capture what proportion of current users are not fully funded (e.g PhD students).

WG produced draft questionnaire at the meeting which will be written up in a final version by PDN and circulated to WG for final agreement. This will be sent to targeted members in each University institution (see old attendee list of Town meeting) to ensure coordinated and limited responses. However the fact that this has gone out will be made public via RMS and EMAG via

email/newsletters. In principle responses should made collective and be essentially anonymous when send to RCUK. **TIMELINE: send out in July with 2 week deadline for end of July.**

Responses should be relative easy to summarise and potential additional capacity/bandwidth could be estimated based on standard access models.

2. Another subsequent questionnaire targeting users – **this will be drafted by Baker after consulting original questionnaire in 2009 for original statement of need**. This will be circulated to WG for modification/approval and ultimately circulated to users via RMS and EMAG.

Users can identify their needs including missing capability and missing availability.

Another key thing is to gather data on IMPACT.

- Identify where EM plays a role against RCUK thematic areas and priority areas. DoE have highlighted this in US. **RDB to have an initial go at this.**

- Need to also understand where we need to go in 5/10 years time to address upcoming areas.

- undertake some literature searched for number of journals papers with keyword (e.g. EM) in title or abstract. Compare figures with other techniques (e.g. NMR, Synchrotron…)

- Identify RCUK large grants (Programme/Platform) which have significant EM components from Grants on the Web. **(RDB to investigate this)**

- provide some narrative data examples of where EM has made impact in Industry. **AK to summarise 3-5 Illustrative Case Studies in discussion with Industry partners (Maclaren to talk with Mhairi Gass as well)**

5. Agenda for further meetings

Next meeting **Thursday September 12** in London where we should work up a distributed facility model and a roadmap.

6. AOB

Some discussion of the House of Lords document **– ALL send comments to Ian Maclaren**

By next week and make sure we mention this process.

Also brief mention of RMS House of Commons event on July 9th.

Appendix E: Second meeting of working group – minutes 12 September 2013

Venue: IOP London

Co-chairs: Rik Brydson (RMDB) and Pete Nellist (PDN)

Present: Richard Baker (RTB), Paul Brown (PB), Angus Kirkland (AIK), Ian MacLaren (IM), Sarah Haigh (SH), Ed Boyes (EB) (apologies from Quentin Ramasse) – Physical Science EM Working Group

Jemima Burden (JB), Lucy Collinson (LC), Paul Verkade (PV)– Co-opted from BioImagingUK

Daniel Emmerson (DE) - EPSRC

7. **Minutes of the last meeting**

The minutes were accepted.

8. **Review of the remit of the committee**

PDN briefly reviewed the terms of reference and objectives of the group.

The review of NMR facilities had been circulated, and Daniel Emerson noted that the EPSRC had posted a summary and funding roadmap with a 7-year timescale on their website at http://www.epsrc.ac.uk/SiteCollectionDocuments/Publications/reports/NMRDraftRoadmap.pdf.

DE noted that the EPSRC have data on funding for large instruments, and pointed out that the EPSRC wish to equipment to enable new science in addition to underpinning existing research activities.

9. **Bioimaging Initiative**

PV gave a presentation on the development of the BioImagingUK initiative, in particular describing how it resulted from the EuroBioImaging EU initiative, but encompasses all EM within the biological research area in the UK.

A meeting held about one year ago resulted in a roadmap document with three tiers consisting of 1-2 National Centres, 4-5 Centres of Excellence, and routine facilities as the third layer. It was noted that supporting the routine instruments was most important, and that staffing these effectively was a key issue.

The proposed National Centres were:

- High-resolution TEM for structural biology.
- Volume SEM (3view and FIBSEM)

The proposed Centres of Excellence were:

- Cellular electron tomography

- Correlative light and electron microscopy
- Analytical microscopy
- Cryo FEGSEM

There was discussion about the degree to which facilities could be shared between the bio and physical sciences. It was noted that skills that could usefully be shared exist in both areas, for example in imaging processing or analytical capabilities, and there is potential for increased dialogue.

RMDB raised the question of sharing of specimen preparation facilities. It was agreed that this is about associating these methods with centres of excellence. Full workflow facilities are required at each site, so all centres of excellence would have to be underpinned by all of these skills.

SH raised the question of integration of training into the proposed facilities and centres. It was agreed that the integration of training was important.

In discussing the funding model for National Facilities and Centres, it was agreed that equipment should be funded with support costs for 2-3 years, and after that through access charges. Access charges should include operating costs but not depreciation. Peer review is required to control access.

10. Discussion of how physical and bioimaging constituencies can work together

Action: A proposal was made that a half day workshop be held on the Monday afternoon before MMC14 in Manchester [The RMS office are currently checking lecture theatre availability.]. A focus of the meeting could be on methods for sample preparation, microscopy techniques and data analysis. Highlighting example case studies of applications between physical and bio EM would be useful.

Joint training courses may be a future activity.

It was agreed to ensure that future BioImagingUK meetings are advertised to the Physical Sciences Working Group.

11. Review of the EM Lab Leader Survey

PDN presented an analysis of the Lab Leader survey. It was agreed that it would be useful to extract the data arising from the physical and bio responses separately and that obvious omissions in the laboratories that responded would be invited to respond, in particular some earth science centres may be missing. [**Action: PDN**].

A dip in the delivery of new equipment was noted in the mid-2000s, possibly associated with the ending of the infrastructure funds (eg SRIF).

The possibility of a nationally agreed purchasing framework was discussed, and whether such a strategy would leverage better value for money. There was some discussion about whether the Research Councils could get involved with purchasing, or how the institutions could be encouraged to agree on national purchasing frameworks.

It was suggested that the degree of cost recovery should be broken down by instrument type [**Action: PDN**]

It was noted that the majority of staff supporting a facility worked on permanent contracts, highlighting the need for a Reseach Support Scientist type of roles with a clear career structure.

In discussing the mechanisms for supporting National Facilities and Centres of Excellence, it was noted that some respondents were concerned about facilities with free access pricing those with access costs out of the market. DE reported that the EPSRC were looking closely at sustainability of facilities.

12. Review of the EM User Survey

RMDB presented a summary of the more general user survey. Some concern was raised about how widely the survey had been distributed. It was suggested that groups that could circulate the survey were RSC (special interest group), IOP (groups), SEMT (society for electron microscopy technology) (Dave McCarthy), EMU, CryoMicroscopy group. BioImaging UK mailing list. [**Action: RMDB**]

It was noted that the vast majority of work was performed at the users home institution. IM suggested that travel to other facilities may be an issue for those on limited travel.

13. Definition of a new outline model for a distributed facility

14. Roadmap for the EM community and funding agencies towards the new model

The above two items were taken together.

It was agreed that, unlike in the Bio EM world, in Physical sciences there was no clear consensus on what techniques should form National Facilities and Centres of Excellence. It was agreed that the current emphasis should be on bringing together the capacity at the major facilities and the demand. The BioImagingUK initiative had already started work on collating a “handbook” of facilities, and it was agreed that the RMS be approached to support a “hub” through which access to advanced EM facilities could be facilitated. Research Council support may be needed to fund this.

There was some discussion about how developed the “hub” could be in controlling access, for example whether it provided peer review, or whether that was the role of the receiving institution. EB described how some facilities prefer to work as a clear collaborator rather than a service provider. It was suggested that access to facilities be available on JeS, much as the Mid-Range facilities currently are.

It was agreed that a mechanism for a “technology watch” should be established so that future developments that could form a National Facility or Centre of Excellence be identified early, in much the same way as the development of aberration-correction led to the formation of SuperSTEM.

It was agreed that the next step is to develop three documents:

(i) A summary of the current EM ecosystem in the UK across physical and bio EM [**Action RMDB and PB]**.
(ii) A description of how an “EM Hub” would work [**Action: PDN and IM**] including a description of a coordinated training model [**Action: RTB and SH**].
(iii) A proposal for a “technology watch” mechanism [**Action: EB and AIK**].

It was agreed to circulate the initial drafts of these by the end of November.

15. Agenda for further meetings.

It was agreed that the working group meet on 24 January 2014 to finalise the documents for circulation to the EM community.

A town meeting will then be held on 9 April 2014 to present the plans to the community.

16. AOB.

Appendix F: Third meeting of working group – minutes 24 January 2014

Venue: IOP London

Co-chairs: Rik Brydson (RMDB) and Pete Nellist (PDN)

Present: Richard Baker (RTB), Paul Brown (PB), Angus Kirkland (AIK), Ian MacLaren (IM), Sarah Haigh (SH), Ed Boyes (EB), Quentin Ramasse (QMR), Jeremy Skepper (JS) – Physical Science EM Working Group

Lucy Collinson (LC), Raffaella Carzaniga (RC)– Apologies from Jemima Burden (JB), Paul Verkade (PV) and Jason Swedlow- Co-opted from BioImagingUK

Daniel Emmerson (DE) - EPSRC

1. **Minutes of the last meeting**
   The minutes were accepted – note MMC2015 should read MMC2014 in section 4.

2. **Update on surveys and analysis and further developments**
   No further progress had been made on additional analysis or updating the lab leaders survey (PDN) or the User survey (RB) (see outstanding actions in Minutes of September 2013 meeting).

   PDN agreed to circulate a list of the labs that had responded to the lab leaders survey to the group so that omissions (in particular Earth Science labs) could be identified [**Action PDN**].

   A Joint Physical and Bioimaging Workshop at MMC2014 was now being planned and a timeslot and venue booked via RMS. There was discussion of whether Light microscopy, Scanning Probe, Image Analysis anfd Image Processing a nd Sample Prep should be represented (from Physical Sciences perspective).

   LC outlined the latest developments in the BioimagingUK initiative which covers both light and electron microscopy. The group was about to submit a £100k proposal for a 3 year Biomaging UK network to BBSRC which would involve user surveys, meetings to define strategic technology, training events, developing metrics for career progression and workshops to get the network started and its brief agreed within the community. The group thought this may form a template for a similar EPSRC funded initiative involving the Physical Sciences . DE agreed to make contact with appropriate BBSRC staff to see if a joint EPSRC/BBSRC initiative may be feasible.

   LC and AIK informed the group that in terms of the Electron Microscopy priorities the MRC/Wellcome had funded two high spec CryoTEMS for single particle analysis which will be sited at Harwell as a National Facility and accessed via Diamond.
   In terms of high volume SEM a number of Gatan 3 view systems had recently been funded so this appeared to be developing into a distributed network of capabilities.

DE tabled a recent analysis of data extracted from EPSRC grant funding, Recent calls (such as Chemistry Equipment calls) and recent capital equipment involving "Atomic resolution microscopy" – both EM and SPM. The data needed to be checked **[ACTION DE]** however it did present an opportunity to extract some headline levels of funding required for an Electron Microscopy Roadmap for the Physical Sciences. Clearly this had to be in terms of Replacement Equipment; Upgrades to existing kit and Staff Positions.
The group thought it would be useful to would be useful to look in detail at the NMR Roadmap which quoted figures such as Running Costs per Laboratory.
DE encouraged the group to include some financial indications in any final document. One option discussed was cost for each level in the layer cake model (National Centres, Centres of Excellence, Regional or Local Facilities) – both Capital and Staff.

3. **Discussion of documents**

The four draft documents had been circulated prior to the meeting: (i) A summary of the current EM ecosystem in the UK across physical and bio EM [**RMDB and PB]**; (ii) A description of how an "EM Hub" would work [**PDN and IM**] including a description of a coordinated training model [**RTB and SH**]; (iii) A proposal for a "technology watch" mechanism [**QMR, EB and AIK**].

Current Ecosystem. It was acknowledged that the current ecosystem was only a snapshot and could be somewhat incomplete. It was agreed that once checked the EPSRC analysis presented by DE could be worked into the draft. However the main points that needed to be drawn out were
1) the current situation in terms of equipment and staffing had been arrived at in a rather ad-hoc way; 2) the current requirements and needs of the community in relation to what is available; 3) the presence of any embryonic network; 4) the potential capacity, potential uptake of a wider UK network including the rate-limiting steps.

It was agreed that the development of a Lab Leaders network would somewhat address the problem of the ad-hoc development of the EM capability, and would assist in coordinating efforts to facilitate wider access of facilities thereby making greater use of the spare capacity on the current infrastructure.

The group also discussed the way that new user hands-on training and the funding of facility support can impede the full use of capacity.

Techwatch.

A number of areas had been highlighted and there was discussion as to how these might fit into the layer cake model (National Centres, Centres of Excellence, Regional/Local Facilities). It was agreed that the group needed to formally define the different levels in the model – i.e what a Centre of Excellence exactly means. It was suggested that equipment capital cost could be used to distinguish layers, and that these should be identified. It was also pointed out that the size of the UK suggested that Centres of Excellence should not be regarded as

regional, rather that they should be centres that provided access to equipment, training and data processing support in a single centre.
It was proposed to incorporate the Techwatch as an annual review at say the MMC congress in Manchester and also incorporate LM and SPM as well as EM.

Access Hub.
The document proposed a range of hub activities. The simplest was a directory of facilities (plus maybe capacity) at local Universities. It was agreed this could be hosted by the RMS and could form part of an initial EPSRC network proposal. It was noted that small upgrades to equipment may provide additional capacity for external users at this level.

The second level was Centre of Excellence in a particular Method or Technique. Here it was envisaged a proportion of access at a lab (or a set of labs) should be guaranteed as free at point of use. Applications for use could be decided locally and potentially vetoed (at University level) but all would be overseen by a Steering Committee possibly derived from the SuperSTEM architecture. Again upgrades to equipment may provide additional capacity for external users at this level, but that this funding mechanism should be decoupled from major infrastructure bids.
There was some discussion of VAT issues – particularly VAT on Research Services which would potentially divert funding away from Science. One way round this at Centre of Excellence level might be for a grant to fund or part fund staff who then have to offer free access to approved users. Here it would be important to provide indicative numbers for funding a Centre over say a 5 year period and how much access this would provide for users). The group recognised that such centres may take business away from Microscopy units which rely on income to cover running costs.

Training
The document suggested a formal CDT bid for a distributed training network. It was thought that some of the initial infrastructure could be set up as part of an initial Network proposal. However it was thought that perhaps a CDT application might be too late in light of the recent CDT funding round. One option discussed was that a Centre of Excellence bid would have to commit a certain number of studentships (derived from University CDTs or DTGs) plus training material. There seemed to be support for joint "microscopy" studentships across institutions to promote collaboration and sharing of teaching resources

4. **EM community town meeting**
It was agreed to ask the RMS to organise the Town Meeting on 9th April (find a venue and do email advertising). It was thought that potentially the meeting could attract up to 70 people and that the UK Bioimaging Committee should be invited.
It was agreed to distil each of the 4 documents down to a one page summary of the key statements **[BY END OF FEBRUARY]** which could be mailed out to the community and presented by each of the authors at the Town Meeting **[ACTION ALL]**. After receiving initial feedback from the community, the group could potentially meet again in May (May 16 2014 was identified).

5. **Cross-disciplinary EM meeting at MMC14 (Monday 30 June 2014]**
   It was agreed that this could be coordinated by EB and LC **[ACTION EB and LC]**. The group suggested an 11 am start with small (15min?) science talks from researchers involved in cross-over PS/LS research: e.g. Andy Brown, Andy Bushby, Roland Kroeger, Alex Porter, Lewis Pizarro and Toby Starborg. Gatan could be approached for sponsorship. The way forward including the proposed network proposals could also be discussed and a joint bid across Physical and Life Sciences to RCUK finalised following community input. This would then be followed up by a visit to Swindon to talk with EPSRC and BBSRC.

6. **Further actions of WG.**
   Revise current documents and present at Town meeting on 9 April. Possible meeting on May 16. Finalise joint Network bid to EPSRC following the July meeting.

Appendix G: Fourth meeting of working group (by teleconference) – minutes 15 May 2014

Co-chairs: Rik Brydson (RMDB) and Pete Nellist (PDN)

Present: Richard Baker (RTB), Ian MacLaren (IM), Sarah Haigh (SH), Ed Boyes (EB)

Daniel Emmerson (DE) - EPSRC

1. **Minutes of the last meeting and matters arising**

RMDB and PDN would review the list of the lab leaders targeted for survey to see if any obvious ones had been missed. **Action PDN and RMDB**

2. **Follow-up and outcomes from April 9 Town Hall meeting**

There were not additional comments regarding the Town Hall meeting report previously circulated by RMDB.

There was further discussion on the themes raised at the Town Hall meeting:

Access
There had been positive response to the proposal for increased sharing of equipment access and training. The exact mechanisms by which these could be accomplished were not resolved, and it would be important to keep in mind issues faced by previous access schemes. DE reported that of the 13 EPSRC access schemes funded ~6 years ago – 4 reapplied for renewal and two were funded. The need for light-touch schemes for requesting access was also noted

Training
In the area of training, it was suggested that VLE and pooled training was well received and should be activated . Additional hands-on short courses could be made available, perhaps through the RMS. RTB suggested shared PhD supervisors across institutions. It was agreed to seek links to existing CDTs where possible. PhD numbers need more discussion and there should be a CPD aspect to the training. EB noted the need for long term staff employment to enable effective training of new researchers.

It was agreed that centres for access should also offer training. Training could occur at sites that are not necessarily offering a national specialism but are prepared to offer preliminary training. Much can be done electronically.

Techwatch
It was agreed that the purpose of the list of new technologies in the Techwatch document was to flag the sort of thing that may be coming down the pipe. EB noted that it was key to identify what would be the possible applications and outputs from a particular new technology, and identifying

the alignment to RCUK and national priorities. How distinct would the technology be on the international page?

It was also important to identify the mechanism for reviewing the technology priorities through the use of surveys and occasional discussion meetings.

3. **Final report of working group**

It was agreed that a final report be produced that should be regarded as the output from the working group.

The authors of each of the documents presented to the Town Hall meeting should expand their document to ~2 pages in length focusing on providing actions that can be taken in that area in the short, medium and long term. Short term related to actions that could be implemented immediately, medium would require modest funding and long term would guide major new investment.

It was agreed to produce drafts of these documents by 6 June **Action all**. PDN then offered to merge the documents into a report with a narrative to form a stand-alone document in time for the interdisciplinary meeting on 30 June. **Action PDN.**

DE agreed to produce an EPSRC response, and drafts of the WG sections should be sent to him as early as possible. **Action DE.**

4. **Further actions and the Capital Consultation**

A cross disciplinary meeting has been scheduled for the Monday immediately prior to the start of mmc2014 (30 June). The broad aims of this meeting are to discuss both cross-disciplinary scientific ideas but also strategic themes to seek alignment between the BioImagingUK activities and those in the physical sciences. It was hoped that representatives of both the BBSRC and EPSRC would attend.

The recently released Capital Consultation was discussed. It was felt that there should be response from the microscopy community, in particular highlighting the need for capital spend in the underpinning technologies (eg specimen preparation equipment and entry-level instruments) and not just higher-value, higher-profile projects. It was agreed that a single response from as a large a constituency as possible would carry more weight. PDN agreed to contact Jason Swedlow regarding any BioImagingUK plans to response. [Note added post meeting – Jason Swedlow reports that the BioImagingUK group are considering a response and will discuss at a meeting on 11 June, and is interested in the idea of some form of coordinated response].

Action all: Read Capital Consultation Document at the following link, and forward ideas for a response to RMDB and PDN by 6 June for collation into an initial response.
https://bisgovuk.citizenspace.com/digital/consultation-on-proposals-for-long-term-capital-in/consultation/intro/view