Pre-publication text

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Research Equipment Needs in UK Universities: a Snapshot Study

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THE UNIVERSITY of MANCHESTER

Foreword

The results of the UK Government's Spending Review 2000 will be announced later this summer. In our submission to the spending review ('Investing in Universities and Colleges for Global Success', CVCP, December 1999) we set out our vision of the goals and priorities for UK higher education for the next three years. We pointed to the strengths and rich diversity of UK universities, and outlined a framework by which they could fulfil their role in the economic, social and cultural life of the nation.

We drew particular attention to the need for additional Government investment to bridge the gap in research funding, especially for infrastructure and equipment, and to put research funding - greatly improved in the spending review of 1998 - on to a sustained basis.

This report from PREST on research equipment, part-funded by the Higher Education Finding Council for England, helps to identify the scale of the challenge. It outlines outstanding requirements across a broad sample of research-intensive university departments. It demonstrates that, even despite recent increases to research equipment and infrastructure funds (in applications for which on the whole these departments have fared well), there remain extensive unmet needs. UK universities cannot sustain their world-class research output without adequate resources. If our universities are to make the contribution that both they and Government would like to see to national well-being, then their research capacity will need further additional investment in the forthcoming spending review.

Together with a parallel report from SPRU at the University of Sussex on the impact of public investment in basic research on innovation and competitiveness, this report helps to make the case for additional investment in our research base, whose continued health is vital for national prosperity.

Professor Howard Newby
President, CVCP

Executive Summary

1. This study was commissioned by CVCP as a supplement to its submission to the UK Government's Spending Review 2000 and part funded by HEFCE. It takes a 'snapshot' of the present state of research equipment provision and needs in UK universities, by means of a limited follow up to the equipment survey carried out by PREST (Policy Research in Engineering, Science and Technology) and CASR (Centre for Applied Social Research), University of Manchester, in 1996.

2. Three main exercises were undertaken:

- Heads of department in the four most equipment intensive cost-centres (chemistry, physics, biosciences and mechanical, aeronautical and production engineering) in four research intensive universities were asked whether equipment priorities identified in 1996 had been acquired and the extent to which funding initiatives have addressed equipment needs;
- 30 individual equipment items described in 1996 were traced to ascertain whether they had remained in use, and if so with what capability and for what purpose.
- Applications to the Joint Infrastructure Fund (JIF) and the Joint Research Equipment Initiative (JREI) were analysed to assess the extent to which the equipment needs identified in 1996 have been satisfied.

3. Heads of department reported a largely unchanged situation in the overall technical capabilities of their research equipment. Improvements in equipment provision tended to be uneven, with individual groups benefiting from support from JIF or major charities but with no benefit for remaining provision.

4. Two-thirds of departments had critical experiments they were unable to perform due to lack of equipment. Several commented that their departments' research strategies were now being driven by the existing or prospective availability of equipment. As in previous surveys, the hardest gap to fill was that of 'middle order' equipment to provide the generic infrastructure of a 'well found' laboratory. With the exception of JIF, where the probability of success was low, it was hard to obtain funding for this type of resource.

5. Revisiting the lists of key priority items identified by each department in 1996, only two out of fourteen departments had managed to get all of these funded, four more had more than half funded, six had fewer than half funded and two had not received any of them. Of the 31 priority items where funding sources could be identified, 35% were obtained through normal Research Council granting mechanisms, 29% via Funding Council or university resources, 16% through JREI, 16% through charity or industry funding and only one item through JIF.

6. Our analysis of publicly available data on JREI awards suggests that this initiative has largely matched the priority types of equipment identified in 1996. Our research found that this funding is generally associated with specific research agendas rather than with generic equipment provision. Other

research suggests that the requirement for external co-sponsorship (often in the form of manufacturers' discounts) has kept success rates for applicants artificially high, so that lack of a large number of excess applications is not an indicator of lack of need for equipment.

7. The success rate of 21% in the first two rounds of JIF and the total of £821.6 million of highly rated unfunded proposals demonstrates the large remaining infrastructure deficit, which includes equipment. This figure is even more remarkable given the very high costs of making an application to the initiative.

8. Heads of department, while welcoming both JREI and JIF, pointed out that proposals both initiatives had to be closely tailored to the existing research profile of the institution and that both were therefore were poorly suited for moving into new areas of research. They also agreed that the value from these investments is not being maximised because of the growing deterioration in generic research equipment and infrastructure.

9. The equipment item survey demonstrated that equipment has remained in use for longer periods than expected by its users in 1996 but there has been a general shift in the type of usage from dedicated research functions to general research and from 'general research' to 'research and teaching'. A similar evolution has taken place in technical quality and working condition, with a significant shift from the top categories to merely adequate.

Conclusions

10. The study has found that the substantial efforts made to improve the provision of equipment in UK universities have led to some improvement in the situation since the 1996 survey. Nonetheless, there are still important issues which remain to be addressed, most notably that of the 'well-found laboratory' and the related issue of teaching equipment. The extremely selective nature of JIF and the funding rules for JREI have created an uneven landscape in which there are outcrops of high quality provision, but where equally high quality work, even in the same departments, remains heavily constrained.

11. It should be stressed that this study has focused upon institutions that have benefited most from selectivity and it is highly likely that the general situation is somewhat worse. On the positive side, there is some evidence that the reorganisation of equipment into better managed facilities and suites makes the provision more efficient and cost-effective, though this tends to be happening within institutions rather than between them. This finding bears out the original recommendations of the 1996 report and the earlier study on sharing which showed that additional management costs are incurred for shared equipment.

12. Three key sets of factors support the argument that there remains a need for further substantial action on the research equipment front. First, the 1996 survey predicted that 60% of the total equipment stock of 1996 would be out of leading-edge research use by now. This has been confirmed by the update, in effect if not literally. Many of these items may still be in use, but they are

no longer used at the leading edge, and are in transition towards mixed use or teaching use. These data have been used by others to calculate a remaining gap of the order of £600 million. The more complex picture painted by the update snapshot suggests that continuing funding problems mean that departments are often forced to patch up and keep going items which they had expected to be out of use by now. The key funding issue now is generic research equipment and the battered concept of the well-found laboratory.

13. Second, the update shows that, for our sample of four cost centres in four institutions, many of the priority items listed in 1996 still have not been obtained, and further that severe funding constraints are continuing to determine research priorities and research directions. Project funding and the unpredictable patterns of success in peer reviewed competition for funds prevent a strategic approach being taken towards equipment provision.

14. Third, the extent of the over-subscription of JIF by proposals rated 'excellent' (even in the face of the large cost of proposal relative to the low chances of success) is testimony to the urgent need of many departments. JIF grants for new or refurbished buildings have presented the only way in which significant funds can be directed towards the more generic (as well as the highly-specialised) research infrastructure needs of university departments. JREI funding, while welcomed by the community, is restricted by the condition for matching funding. The availability of such funding is unlikely to extend much beyond the present levels.

15. A final caveat is that this study has provided only a snapshot of the present state of equipment provision and needs. The timescale for the research was determined by that of the Government's current spending review, necessitating a highly selective approach to the challenge of updating our 1996 results. A proper appraisal of the situation can only be made on the basis of a full equipment survey following the previously established PREST/CASR methodology. Several interesting trends beyond the scope of this short study remain to be investigated, including:

- the significance of the rapidly growing capital intensiveness of the life sciences;
- whether the emergence of new organisational forms of research such as interdisciplinary schools provides a more effective environment for the management of equipment;
- what consequences arise from a growing dependence of universities upon access to industrial equipment; and
- whether increased selectivity in research funding has consequences for the organisation of teaching of final year students and postgraduates.

16. Having noted the problems of this study, it is worth stressing that, at least for the departmental update, the sample, though small, is heavily biased in favour of highly RAE-rated departments. Most of the departments included in our 'snapshot' survey can be supposed to be amongst those most able to attract funding for research equipment, and the approach selected here might therefore be expected to under-estimate the problems of the sector as a whole.

1.1 Introduction

Adequate supply of high quality equipment remains critical for university researchers to reach and maintain positions at the leading edge of many areas of research, especially in science and engineering. Research in many areas of science is increasingly capital intensive. This has been driven by rising sophistication in the levels of measurement and performance demanded, by automation of previously labour-intensive activities in order to hasten the pace of discovery, and by the opportunities opened up by advances in the technology which underpins equipment.

This study was commissioned by the Committee of Vice-Chancellors and Principals, with the support of Higher Education Funding Council for England, to supplement submissions to the UK Government's Spending Review 2000. It seeks to assess the present status and needs for equipment by means of a 'snapshot' survey, which follows up a much larger national survey carried out in 1996.

In that year, PREST (Policy Research in Engineering, Science and Technology) and CASR (Centre for Applied Social Research), both at the University of Manchester, published the results of a study of research equipment provision in UK universities, commissioned by CVCP and the English, Welsh and Scottish Funding Councils. That study was based on two major surveys of UK higher education institutions:

- a comprehensive survey of heads of 973 departments of science, medicine and engineering in ninety-one institutions, and
- a detailed survey of the stock and state of equipment items in a sample of four cost centres (chemistry, physics, biosciences and mechanical, aeronautical and production engineering) in seven universities.

The 1996 study found that

- 79% of departments were unable to perform critical experiments in some areas of research because of a lack of funding for equipment; and
- that 17% of equipment used for research had only a poor (or very poor) capability, and that up to 60% of the stock had a remaining useful life of five years or less.

Based on the survey responses, the estimated cost of the 'priority items' needed to bring universities up to date to perform the research for which they expected to be funded over the next five years was put in 1996 at £474 million. In particular, the increased proportion of expenditure from project-specific funds was found to have created imbalances in the system, with a lack of support for 'generic' items and for maintenance and spares. The report concluded that productivity gains could be made by moving away from a model of funding equipment based on piecemeal assembly via a series of project proposals towards one of equipping a 'well-found' and well-managed research facility.

Finally, the study made clear that this move could not be accomplished via a single, one-off injection of resources into the system, noting:

- the time before leading edge items become obsolete;
- the upward pressure upon funding caused by the continually increasing sophistication of equipment in most fields; and
- the large proportion of research equipment passing out of use each year.

These all meant that steady and continuous support for research equipment provision was required.

1.2 Context of the Study

Elected with a large majority in the House of Commons, the Labour Government that came to power in May 1997 inherited a crisis in university research. Concerns about imbalances in the dual support system, which had been growing for some time, had become acute with the publication in 1996 of the PREST/CASR Research Equipment Survey. Others produced similar estimates of the 'research funding gap' and Sir Ron Dearing's National Committee of Inquiry into Higher Education, which had been set up to deal with the whole question of higher education funding by the previous Conservative Government, highlighted equipment as a central problem. By the time that Dearing reported, a new initiative – the Joint Research Equipment Initiative – had already been launched by the Office of Science and Technology and the higher education funding councils in an attempt to address the issue.

The cumulative effect of this scrutiny was acceptance that the way the research funding system operated encouraged the conduct of more research in universities than could be supported by the resources available. Among the range of recommendations it made concerning the future of higher education and its funding, the Dearing Committee urged that research council grants should meet the full indirect costs of research, preferably through the provision of extra resources, but alternatively via a transfer of resources from the research budgets of the funding councils, or even through a reduction in the overall volume of research conducted. The structural imbalances that resulted from the long-term neglect of university research funding, exemplified by the unsustainable 'research gap' highlighted by Dearing, were clearly in urgent need of redress.

The response of the Government, following its first 'comprehensive review' of spending priorities announced in 1998, was to focus attention on university research. A new £600 million Joint Infrastructure Fund was established (in partnership with the Wellcome Trust) to provide a one-off injection (over three years) of resources to address the most pressing research equipment needs of UK universities, and additional funding was also found for the research budget more broadly. In 1999, the Higher Education Funding Council for England (HEFCE) contributed a further £150 million to JIF, bringing the total fund to £750 million. Together with the new investment there came a new attitude towards research, with a greater recognition of the economic and social role of university research in an increasingly knowledge-based society. In a parallel study to this one, CVCP (with HEFCE support) has commissioned work from SPRU (Science Policy Research Unit) at Sussex University to assess the impact of basic investment in university research on innovation and the economy.

The adequacy of equipment provision remains a priority policy issue. One aspect of the debate is the adequacy of equipment in UK universities to meet the needs of industry in the knowledge economy. In a recent PREST report[1], SmithKline Beecham

[1] Cox D, Georghiou L and Salazar A, Links to the Science Base of the Information Technology and Biotechnology Industries, Report to ESRC for the Director-General Research Councils, February 2000

reported that UK universities were not providing graduates with adequate practical training in advanced techniques. This has two consequences:

- restrictions on industrial placement students, because of the additional training that the company had to give them; and
- a tendency in the past three years to recruit chemistry graduates from continental Europe rather than the UK as a result of their superior practical training.

There are thus two principal questions that this study has sought to answer:

- How have the Government's new vision and additional funding affected the university research equipment needs identified in 1996?
- Have initiatives such as JIF and JREI been able to fill the research equipment gap, or do problems remain?

The present report revisits the results of the 1996 research equipment survey, taking a 'snapshot' from which to explore the extent to which equipment funding issues still remain, and the extent to which subsequent initiatives have improved the situation.

Because of the acceleration of the Government's timetable for the spending review, it was necessary to base this snapshot on only a limited sample of (research-intensive) science and engineering departments from those surveyed in 1996. The 'snapshot' survey was complemented by analyses of other current evidence on universities' unmet research equipment needs.

1.3 Approach

This study is based upon three main sources of evidence:

- Interviewing heads of departments in the four most equipment-intensive cost-centres at four strongly research active institutions, to ascertain:
    - whether equipment priorities identified in 1996 had been acquired;
    - the extent to which funding initiatives have addressed equipment needs; and
    - equipment issues more generally.

- Analysis of applications to the Joint Infrastructure Fund and of publicly available information about Joint Research Equipment Initiative awards, to assess the extent to which equipment needs have been satisfied; and

- A survey of those responsible for 30 individual equipment items which had been described in 1996, to ascertain whether they had remained in use, and if so with what capability and for what purpose.

2 Department survey 'snapshot' update

To recap, the PREST/CASR departmental survey found in 1996 that 79% of departments were unable to perform critical experiments in some areas of research because of a lack of funding for equipment. Based on departmental responses, the cost of the 'priority items' needed to bring universities up to date to perform the research for which they expected to be funded over the next five years was estimated at £474 million. Departments noted then that the increased proportion of expenditure from project-specific funds had created imbalances in the system, with a lack of support for 'generic' items and for maintenance and spares. Based on the results of the department survey, the study concluded that productivity gains could be made by moving away from a model of funding equipment from piecemeal assembly via a series of project proposals towards one of equipping a 'well-found' and well-managed research facility. This, the study made clear, could not be accomplished via a single, one-off injection of resources into the system, but rather required steady and continuous support for research equipment provision.

2.1 Approach

As part of the 'snapshot' we revisited fourteen departments, selected from four cost centres:

- physics,
- chemistry,
- biosciences, and
- mechanical, aeronautical and production engineering

These departments were located at four research-active institutions:

- one Oxbridge institution,
- one University of London college,
- one 'civic' university, and
- one 'campus' university.

Seven of these departments or units were 5* or 5 rated in the 1996 Research Assessment Exercise. Three more were 4 rated. The remaining four were rated 3a or below. The sample is therefore heavily biased in favour of highly-rated departments.

Heads of department were contacted with a printout of their department's five equipment priorities from 1996, and asked whether these priority needs – which had been deemed essential for the future research programmes of those departments – have been met in the intervening period. Heads were also asked to comment on the extent to which funding initiatives, such as the Joint Research Equipment Initiative (JREI) and the Joint Infrastructure Fund (JIF), have addressed the equipment needs of their departments, and more generally on equipment issues as they impinge on the department's national and international research standing. In all, fourteen heads of department responded, in many cases having informally polled their constituent research groups.

2.2 Findings

2.2.1 The technical capabilities of departmental research equipment

The majority of departments reported no improvement (seven) or some deterioration (four) in the technical capabilities of their research equipment provision since the 1996 survey. Three departments reported an overall improved position. In two departments the distribution across the different categories of capability had changed significantly for the better (usually because of some major JIF or charity investment in the department). In several other cases the proportion of both 'very good' and 'poor' or 'very poor' equipment rose at the expense of the middle headings; that is, some equipment provision had improved but some deteriorated. The scale of the sample was such that it is impossible to determine whether there are any significant differences according to institution type and cost centre.

Where 'snapshot' respondents provided figures, these are reproduced below.

Redbrick University – Chemistry

	1996	**Today**
Very good	20%	40%
Good	20%	20%
Adequate	20%	20%
Poor	10%	10%
Very poor	30%	10%
Under construction	-	-

Civic University – Chemistry

	1996	**Today**
Very good	80%	80%
Good	10%	10%
Adequate	10%	10%
Poor	-	-
Very poor	-	-
Under construction	-	-

Oxbridge University – Inorganic Chemistry

	1996	**Today**
Very good	30%	60%
Good	15%	7.5%
Adequate	30%	15%
Poor	10%	5%
Very poor	10%	5%
Under construction	5%	2.5%

Civic University – Biochemistry

	1996	**Today**
Very good	37%	25%
Good	43%	35%
Adequate	13%	30%
Poor	7%	10%
Very poor	-	-
Under construction	-	-

Oxbridge University – Zoology

	1996	**Today**
Very good	30%	40%
Good	40%	13%
Adequate	15%	25%
Poor	10%	21%
Very poor	5%	1%
Under construction	-	-

University of London College – Physics

	1996	**Today**
Very good	50%	30%
Good	10%	20%
Adequate	20%	30%
Poor	15%	20%
Very poor	0%	-
Under construction	5%	-

2.2.2 The department's ability to perform research

As in 1996, departments were asked whether there were any areas of research in which they were unable to perform (or were delayed in performing) critical experiments due to lack of equipment. As in 1996, our 'snapshot' update found that the majority of departments (nine out of fourteen, or 64% - as opposed to 79% in the original survey) reported limitations of this sort, with some of the others reporting that they 'make do' as best they can. In fact, it was pointed out by several respondents that:

> the availability of existing equipment, or the likelihood of winning funds to invest in new equipment, is the principal factor behind strategic decisions about whether or not to follow a particular line of research within a department.

This is an issue for large and successful departments as much as any – since success implies both new researchers and new research directions. Continuing success as an internationally competitive department requires continuous investment and will require additional investment in middle-order equipment, the generic 'infrastructure' of a department – or what used to be called the 'well-found' laboratory. Such items may not be prohibitively expensive individually, but to invest on them in the scale needed to equip (or re-equip) a new or growing research group calls for significant resources. It is these sorts of resources that our 'snapshot' survey suggests departments have by far the greatest difficulty in funding through existing mechanisms.

Some of these needs could be met through a successful JIF bid for new build or significant refurbishment - but such bids, however excellent, have a very low probability of success (21%). To give one example, a civic university chemistry department needs to replace up to half of its fume hoods with modern ones, and must make further provision for expansion at the same time. This will require up to 100 research quality fume hoods, which cost roughly £20K each. To some extent these costs would have been mitigated had that department's JIF bid for a new building been successful, in which case the necessary pipe-work could have been put in place.

In another case, an Oxbridge zoology department has been held back in its physiological ecology research by the need to replace greenhouses used to support their locust-breeding programme. Some of the research groups within this department have benefited greatly from large investments by the research charities and from JIF and JREI. However, the effect has been uneven across the different research areas, with not all areas being equally attractive to external funding bodies.

In still another case, the inorganic chemistry laboratory of an Oxbridge institution has moved into (and quickly become established as a world leader in) nanotechnology research. However, they are hampered significantly by the lack of sufficient high-resolution transmission electron microscope provision. The department was successful in a joint JIF bid for an extremely high-grade TEM (transmission electron microscopy) facility with another department, but their allocation of time on this equipment is limited, and would be more efficiently used if they had their own lower-grade provision (costing around £300K) for preparatory and day-to-day work.

This latter point – the need to maximise the utility of the highest value equipment (of the sort provided through JREI and JIF) by funding the broader provision of lower-cost equivalents for preparatory work (items less likely to be supported by JIF or JREI) – was made by several respondents.

2.3 1996 Departmental Research Equipment Priorities

In the 1996 survey, departments were asked to list their key research equipment priorities. These priorities were the basis of the study's estimate that £474 million would need to be invested over the following five years in order to meet the existing research equipment priorities of departments. Our 'snapshot' update asked about the extent to which these priorities have been met, and the sources of funding involved where funds have been forthcoming. The 'snapshot' showed that, of our 14 departments (across four universities), only two had had all of their key priority items funded in the intervening period. Four more had had most (50% or more) of their key priority items funded, while a further six had had less than 50% of their priorities funded. However, two departments reported that none of the priority items that they had identified in 1996 had been successfully funded in the intervening period.

The size of our sample, and the short time available for this 'snapshot' survey must be borne in mind here. It is possible that department heads may not have full recollection of all equipment purchases over a period of five or so years. In some cases there was uncertainty because changes in departmental boundaries meant that the research need identified in 1996 no longer fell within that department, or because the items listed were included in current proposals on which decisions were awaited. In some cases changed research priorities removed the need to invest in a particular item of equipment, again suggesting that priorities are influenced by the availability of equipment as much as the reverse. For these reasons, the above account may *under*-estimate the extent to which departments have been able to meet their needs.

Conversely, however, some of the successful departments found that the scale or specification of equipment included in their 1996 priority list proved to be insufficient to meet their growing needs. In many ways departments are 'chasing a moving target', especially successful departments. In a similar vein, many of the priorities involved 'suites' of similar or identical instruments, which in some cases were only partly funded. For these reasons then, the account above may over-estimate the extent to which departments had been successful in meeting their 1996 research equipment priorities.

2.4 Funding sources for priority items obtained

For the thirty-one successfully funded items for which funding sources could be positively identified by the respondent, eleven (around 35%) were obtained through normal research council grant mechanisms. Nine more (29%) were obtained via funding council, university or department resources, while five (16%) were supported via JREI. Five more (16%) were funded wholly by charities or industry, whilst just one (around 3% of the total) was obtained through JIF.

2.5 Current research equipment priorities

Some respondents felt unable to give precise estimates of current research equipment priorities in the short time-span in which the 'snapshot' study was conducted, and in one case a department stated that it had no already-identified priority needs. In all, some 26 priority items were identified by ten departments. Four chemistry departments together identified 14 priority items costing a total of £3,460K. Three

biosciences departments identified six priority items, costing in total some £735K. Two engineering departments identified four items in all, totalling £440K. One physics department identified two item priorities, worth £160K in total. The average priority item costs for these cost-centres were as follows: for chemistry, approximately £247K; for biosciences, approximately £123K; for engineering departments, approximately £110K; and for physics, £80K. The small size of our 'snapshot' sample unfortunately makes these figures of little more than illustrative use.

3 Equipment Funding Initiatives

3.1 Joint Research Equipment Initiative (JREI)

The Joint Research Equipment Initiative was launched in February 1996. The initiative, run by the research councils and higher education funding councils on behalf of the Office of Science and Technology, requires that proposals attract additional external financial support for equipment to enable the applicants to conduct 'high-quality research'. Bidders must request at least £12,500 from the JREI, and applications where the additional external support is greater than 50% of the total cost are particularly encouraged.

There are two competitions within JREI:

- Competition A funds bids for research equipment up to the value of £150,000 (JREI contribution), and is funded and run through the research councils.
- Competition B funds bids for research equipment over £150,000 (JREI contribution), and is funded by the HEFCs through the research councils.

Each competition is open to only to researchers in UK higher education institutions, and all applications are peer reviewed. Bids for whole research facilities are ineligible. Some equipment of a 'generic' nature can be bid for, but JREI is specifically not intended to support the 'well found laboratory'. Institutions are allowed to 'top-up' the external sponsorship, provided that they can show that the money used for this purpose has not been obtained through either the research or the funding councils. Equipment running costs are only eligible for inclusion under Competition B.

The funds available through JREI have increased by nearly a quarter from 1996 to 1999, and over those four years the initiative has channelled £131 million of public money into research equipment in higher education institutions. Slightly less than £100 million of this has been distributed (just over 300 grants) via Competition B, while the remainder has been spent on nearly 600 smaller grants under Competition A. During this time the emphasis has changed, with the funds allocated to Competition A almost doubling, whilst those allocated to Competition B have grown by around 18%. The average size of award too has increased over the period – from £53,149 to £68,970 for Competition A, and from £301,839 to £348,128 for Competition B. In 1999 proposal success rates were 72% for Competition A and 58% for Competition B. It is unclear to what extent the funds disbursed through JREI represent new, additional cash for research equipment, and to what extent they are 'top-sliced' from existing budgets.

Publicly available information about JREI grants suggests that the sorts of items being supported by the initiative, certainly under the funding councils' Competition B, are very much the sorts of items most commonly identified in the PREST/CASR 1996 Survey as priorities. These include items such as mass spectrometers and NMR machines, imaging and computational equipment. Those 1996 priority items not or seldom funded through JREI in 1998, such as centrifuges and scintillation counters, tend to be comparatively less expensive items.

	1996 survey frequency	1998 HEFCE/DENI JREI*
Mass spectrometer	147	6
Centrifuge	125	1
Imaging equipment	116	4
Liquid chromatograph	115	0
NMR	76	10
Confocal microscopy	71	1
Scintillation counter	50	0
Scanning electron microscopy	50	1
Electron microscopy	47	3
Computational equipment	46	10

* excludes Research Council, SHEFC and HEFCW JREI figures

Respondents felt that JREI funding is more forthcoming for proposals containing specific research agendas and priorities, rather than those intended to meet more generic equipment needs. This tendency may be reinforced by the peer review of the scientific case for proposals, since the scientific case is often effectively a specific programme of research. Some respondents also noted the likelihood of incurring additional costs as a result of a successful JREI application, costs which can sometimes be considerable and which generally have to be covered by the department or institution.

There is a tension between the idea of encouraging the shared use of research equipment, and the tendency of initiatives such as JREI to support the procurement of equipment intended for specific research programmes and purposes. Our research, and that of others, suggests that much sharing does occur, but usually only at the departmental or institutional level.

The requirement for external ‘sponsoring’ funds has caused a great deal of concern in higher education, with successful and unsuccessful applicants alike reporting that they experienced problems in securing such a commitment. There is currently no way of estimating the extent to which difficulties in attracting such sponsorship have restricted the number of applications made, though it can be supposed that this effect has kept the JREI success rates artificially high when compared with those of JIF. JREI has attracted substantial sponsorship funding from external bodies, but respondents noted that this often comes in the form of a supplier discount rather than a real financial contribution from industry. Thus, while the requirement for external funds has reduced the cost to the public purse of investing in research equipment, it is debatable whether this can be considered as truly leveraging industrial support. Anecdotal evidence suggests that non-supplier support is only likely in situations where there are already strong, pre-existing links – and even then industrial support is always given for specific reasons, and with specific strings attached. Industrial support is least likely to be forthcoming for the generic, supporting equipment, which JREI is already weighted against.

3.2 Joint Infrastructure Fund (JIF)

JIF was established, in partnership with the Wellcome Trust, to provide over three years a one-off injection of resources intended to address the most pressing research infrastructure needs of UK universities. In 1999, the Higher Education Funding Council for England (HEFCE) contributed a further £150 million to JIF, bringing the total fund up to £750 million. Targeted at the biological, physical, engineering and social sciences, JIF provides funding for buildings, major equipment and other elements of infrastructure (such as research libraries). Staff to run or manage equipment may be requested for up to a maximum of three years, after which their posts must be taken over by the host institution. Running costs may be included, but not costs related specifically to research projects.

All applications submitted under the 'biological science' heading are processed by the Wellcome Trust, while other areas are handled by the research councils - EPSRC, ESRC, NERC and PPARC. Funds are not earmarked for particular research areas, or for particular calls within the three-year initiative. However, the £300 million Wellcome Trust contribution may only be spent within the biomedical sciences, while the £150 million provided by HEFCE must be spent in English universities. JIF proposals are reviewed by international advisory boards and final decisions are made by an executive committee which includes the Director General of the Research Councils, the Director of the Wellcome Trust, and representatives from the Trust, HM Treasury, the Research Councils and HEFCE. The minimum size of bid is £750,000, and all bids are not only reviewed on the basis of their scientific merit but also scrutinised closely for their viability with regard to building issues, technical equipment issues, legal matters, etc. Thus, applications require the generation of a great deal of information by the prospective recipient.

Since its inception, JIF has been heavily over-subscribed. The first two rounds of the five-round initiative received over 390 applications, totalling approximately £2.2 billion. A total of £470 million (well over half of the total) has already been allocated to 82 successful projects in 37 institutions. The success rate is around 21%. This has meant that only a small proportion of highly-rated proposals have been funded. £271.6 million worth of 'alpha-plus' rated proposals were left unfunded in the two rounds together with a further £478.3 million worth of 'alpha' rated proposals. Moreover, cuts of £71.8 million were imposed on the successfully funded projects.

This suggests a total funding shortfall of £821.6 million for proposals for investment into research equipment and infrastructure in British universities – proposals that were all highly rated for their scientific merit by an international peer review process. This residuum from the first two rounds alone is greater than the value of the fund in total. New applications for round 3, the results of which have just been announced, totalled £770 million, while the funds remaining to be disbursed in rounds 3-5 were just £280 million. The announcement of the round 3 grants has raised the total value of unfunded alpha-plus proposals to £456.6m. Projecting forward using the same ratio over the remaining two rounds the initiative as a whole will have rejected some £570.8m worth of alpha-plus bids.

3.3 The impacts of JREI and JIF

Many of the departments included in the 'snapshot' update had received (sometimes significant) JREI awards, often jointly with other departments. Funding council JREI support for the four institutions as a whole (over the period 1996-1998) are shown in the table below. Virtually all 'snapshot' departments had applied to JREI at some stage since the 1996 survey was conducted. However, although many have been comparatively successful in winning JREI support, some departments expressed concern that it is impossible to fulfil the requirement to get at least some 'sponsoring' funding from industry or other external sources for some areas of basic research. Several respondents felt that this was accentuating the extent to which equipment issues are changing the research agenda of departments by dictating which lines of work can and cannot be pursued.

Funding Council JREI* awards to the four institutions 1996-1998

Oxbridge University	15 grants totalling £7,621,741 (average grant £508,116)
London College	15 grants totalling £4,897,017 (average grant £326,468
Civic University	9 grants totalling £2,282,396 (average grant £253,600)
'Campus' University	1 grant totalling £193,185

* including joint HEFCE/Wellcome Joint Research Equipment Initiative but excludes JREI awards made by the Research Councils

Several of the departments in the 'snapshot' update had also received some JIF funding, often for new buildings or facilities. Virtually all had applied to both JREI and JIF – in the latter case most having been unsuccessful. All departments welcomed the existence of both initiatives, while noting the limited resources provided.

While both initiatives are widely welcomed, there are reservations. Especially in the case of JIF, a huge amount of effort is involved in putting together a high-quality proposal. As CVCP has observed, there a general issue here about the move away from block funding towards competitive funding mechanisms that absorb a greater and greater proportion of researchers' time (relative to the chances of success). This is made more acute since in most - if not all – institutions there is a separate internal selection process before a proposal can be submitted to a major funding initiative. The major reservation encountered in the 'snapshot' surevy concerns the burden that JIF imposes for generating and submitting proposals, which is seen as out of proportion to the likelihood of receiving benefit. Nonetheless, departments and institutions will continue to invest the time required because JIF represents the only prospect of major infrastructure and equipment investment for most university departments.

In the case of both JIF and JREI, departments noted that proposals are required to be closely tailored to the existing research profile of the institution. Both initiatives are thus poorly suited for supporting moves into new research areas. Just as important, neither scheme is suitable for meeting broader equipment needs – the challenge of the

‘well-found laboratory’ remains largely unaddressed by the post-1996 funding initiatives.

The lack of any effective funding mechanism for essential supporting equipment was the greatest concern of many of the respondents. It was argued that the provision of specific, leading-edge equipment for highest quality research via JIF and JREI should go hand in hand with the provision of supporting equipment and infrastructure, since without the latter, the best and most efficient use is unlikely to be made of the former. The value from investments in new equipment already made through JREI and JIF, then, is not being maximised due to growing deterioration in the generic research equipment and infrastructure to support day-to-day research work.

Finally, several respondents noted that, while it is now somewhat easier to get funding for specific items of research equipment, it remains extraordinarily difficult to obtain funding for teaching equipment, with one respondent commenting that the quality of teaching equipment was ‘spiralling down’. A good deal of research equipment, as will be shown below, eventually becomes teaching equipment – and indeed this is a key argument for investment in research equipment. However, as some respondents pointed out, not all research equipment is suitable for teaching purposes. The need for (sometimes specialised) teaching equipment for laboratory-intensive subjects goes beyond that which can be met by handed-down research equipment. However, the level of funding council support is wholly inadequate to meet these needs, and the competitiveness of research training in UK higher education remains as a result under threat.

4 Equipment Item Snapshot Survey

4.1 1996 Equipment Item Survey

Among the questions included in the 1996 equipment item survey was one that asked respondents to estimate, for each item, the likely remaining useful life. Taking all those items with an expected lifetime of five years or less, in total approximately 820 items from our overall sample of 1300 or so pieces of equipment should by now have gone out of use - and by implication should have been replaced. This is roughly 60% of the 1996 sample.

Of these equipment items:

- 32% were in the biosciences cost centre. 27% were in physics departments, 21% in chemistry departments and 18% in mechanical engineering departments.

- 40% were judged by respondents to be 'no more than adequate' in terms of technical capabilities, while a further 15% were judged to be 'no longer adequate'. Only 29% were 'very good' and 15% technically 'state of the art'.

- 47% were used for 'general research' in 1995/96. A further 31% were 'dedicated to a particular experiment', while 18% were used for both 'research and teaching'. The remainder were inoperable or unused.

- The average cost of replacing all of those items over £14K (at 1996 prices) for which full replacement costs for each category were given in the original data (n=459) would be:

    - For a basic replacement – £81K (total cost of replacing all items in sample would be £37m);
    - For an item of equivalent capability in relation to the field as the original item stood in relation to the field at the time of purchase – £145K (total replacement cost £67m);
    - For a 'state-of-the-art' item – £449K (total replacement cost would be £206m).

For the four cost centres, the average costs of replacement items were as follows:-

	Basic item	**Enhanced item**	**State of the Art item**
Biosciences (n=145)	£44.9K	£64.8K	£85.7K
Chemistry (n=101)	£109.6K	£135.4K	£318.7K
Mechanical Engineering (n=70)	£56.4K	£75.7K	£137.2K
Physics (n=143)	£101K	£259K	£378K

(figures are given only for those items where estimates were provided for all three replacement categories)

4.2 Approach

Fourteen respondents to the original equipment item survey – which was distributed to four cost centres in seven universities – were selected randomly and recontacted. From these fourteen interviews we were able to update our information on thirty items of equipment present in the 1996 database.

4.3 Summary of results

Although, as discussed above, the 1996 equipment item survey responses indicated that approximately 60% of the items covered would be out of use by now, the 'snapshot' suggests that many of these items may still be in use. Indeed nine out of the thirty items for which updated information was obtained should have gone out of use between 1996 and 2000, according to the original survey responses. However none of these items has gone out of use, and indeed respondents generally gave a similar estimate of the remaining useful lifetime for these items to that which they had given in 1995/6. It must be borne in mind that the sample of respondents re-contacted for this 'snapshot' is very small, but it is nonetheless interesting to speculate as to the reasons why the 1996 responses seem to underestimate the remaining useful lifetime.

Most obviously, continuing financial pressures on departments may make it necessary to keep items in use beyond the expected lifetime. That this is an important factor and it is strongly supported by other results from the 'snapshot', which confirm the 1996 finding that equipment items tend to pass through a series of categories of use (and usefulness) over time, from 'dedicated research use' or 'general research' use to 'research and teaching'. More generally it is difficult to estimate remaining useful lifetime for many complex items of equipment – which can often be kept going through replacement of parts or periodic overhauls or upgrades. Indeed many of the items covered in the snapshot had been upgraded in this way. The key issue then is not so much remaining useful life – many of those items which make up the 60% from our original sample may have some remaining useful life ahead of them as teaching equipment – but fitness for purpose.

Of the nine items with an expected useful life of five years or less in 1995/6, seven were dedicated to a particular experiment or experiments in 1996, and two were used for general research purposes. The 'snapshot' found that only three items are now used for dedicated research, with two used for general research. A further three are used for research and teaching with one inoperable/unused. Again, in 1996, seven of these items were rated 'state of the art' or 'very good' in terms of their technical capabilities, and the remaining two were rated 'adequate to meet research needs'. The 'snapshot' found that of these nine items five are today rated 'state of the art' or 'very good', whereas three are rated 'adequate' and one is un-rated by the respondent. As the results overleaf show, a similar pattern holds for the sample as a whole.

4.4 Equipment item 'snapshot' results

Use of Equipment

	1996	Present
Dedicated	13	6
General research	9	13
Research and teaching	7	10
Inoperable/unused	1	1

Of the 13 items out of our sample which were reported in 1996 to be 'dedicated to a particular experiment', five remain dedicated while four are used in 'general research' and a further four in 'research and teaching'. Of the nine items which were used for 'general research' in 1996, one is now 'dedicated' to a particular experiment, and four remain in 'general research' use. Three more are now used for 'research and teaching' and one is inoperable. Of the seven items used for 'research and teaching' in 1996, three are now used in 'general research' and the remaining four are still used for 'research and teaching'.

Technical Capability

	1996	Present
State of the Art or Very good	22	14
Adequate to meet research needs	6	14
No longer adequate for current research	2	-
No answer	-	2

Working Condition

	1996	Present
Very good	19	16
Adequate	9	12
Poor	1	1
Inoperable	1	-
No answer	-	1

4.5 Equipment item 'snapshot' results by Cost Centre

Mechanical Engineering
(n=7)

	1996	**Today**
Use		
Dedicated	5	3
General research	2	1
Research and teaching	-	3
Inoperable/unused	-	-
Technical Capability		
State of the art or Very good	5	3
Adequate	2	3
No longer adequate	-	1
Working condition		
Very good	4	2
Adequate	3	4
Poor	-	1
Inoperable/unused	-	-

Physics
(n=11)

	1996	**Today**
Use		
Dedicated	4	3
General research	4	4
Research and teaching	2	4
Inoperable/unused	1	-
Technical Capability		
State of the art or Very good	5	2
Adequate	4	8
No longer adequate	2	-
No answer	-	1
Working condition		
Very good	5	4
Adequate	4	7
Poor	1	-
Inoperable/unused	1	-

Chemistry
(n=4)

	1996	Today
Use		
Dedicated	3	-
General research	1	2
Research and teaching	-	2
Inoperable/unused	-	-
Technical Capability		
State of the art or Very good	4	3
Adequate	-	1
No longer adequate	-	-
Working condition		
Very good	4	3
Adequate	-	1
Poor	-	-
Inoperable/unused	-	-

Biosciences
(n=8)

	1996	Today
Use		
Dedicated	1	-
General research	2	6
Research and teaching	5	1
Inoperable/unused	-	1
Technical Capability		
State of the art or Very good	8	5
Adequate	-	2
No longer adequate	-	1
Working condition		
Very good	6	7
Adequate	2	0
Poor	-	1
Inoperable/unused	-	-

5 Conclusions

This 'snapshot' study has found that the substantial efforts made to improve the provision of equipment in UK universities have led to some improvement in the situation since the 1996 survey. Nonetheless, there are still important issues which remain to be addressed, most notably that of the 'well-found laboratory' and the related issue of teaching equipment. The highly selective nature of JIF and the funding rules for JREI have created an uneven landscape in which there are outcrops of high quality provision but where equally high quality work, even in departments winning funding under these schemes, remains heavily constrained.

It should be stressed that this study has focused upon institutions that have benefited most from selectivity of research funding, and it is highly likely that the general situation is somewhat worse. On the positive side, there is some evidence that the reorganisation of equipment into better managed facilities and suites makes the provision more efficient and cost-effective, although this tends to be happening within institutions rather than between them. This finding bears out the original recommendations of the 1996 report and the earlier study on sharing which showed that additional management costs are incurred for shared equipment[2].

The study has found that the substantial efforts made to improve the provision of equipment in UK universities have led to some improvement in the situation since the 1996 survey. Nonetheless, there are still important issues which remain to be addressed, most notably that of the 'well-found laboratory' and the related issue of teaching equipment. The extremely selective nature of JIF and the funding rules for JREI have created an uneven landscape in which there are outcrops of high quality provision but where equally high quality work, even in the same departments, remains heavily constrained. It should be stressed that this study has focussed upon institutions which have benefited most from selectivity and it is highly likely that the general situation is somewhat worse. On the positive side, there is some evidence that the reorganisation of equipment into better managed facilities and suites makes the provision more efficient and cost-effective, though this tends to be happening within institutions rather than between them. This finding bears out the original recommendations of the 1996 report and the earlier study on sharing which showed that additional management costs are incurred for shared equipment

Three key sets of factors support the argument that further substantial action is needed on the research equipment front:-

First, the 1996 survey predicted that 60% of the total equipment stock of 1996 would be out of leading-edge research use by now. This has been confirmed by the update, in effect if not literally. Many of these items may still be in use, but they are no longer employed at the leading edge, and are in transition towards mixed use or teaching use. These 1996 data have been used by others to calculate a remaining funding gap of the order of £600 million[3]. The more complex picture painted by the snapshot suggests

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[2] Halfpenny P, Georghiou L and Yates J, "The Scope for Increased Sharing of Academic Research Equipment" in Irvine J et al (eds) *Equipping Science for the 21st Century*, Elgar: London, 1997.

[3] A figure based on the total replacement costs of these items minus the new investments in research equipment made through initiatives such as JREI and JIF. As our own study suggests that JIF and JREI funding is not

that continuing funding problems mean that departments are often forced to patch up and keep going items which they had expected to be out of use by now. The key funding issue now is generic research equipment and the battered concept of the well-found laboratory.

Second, the update shows that, for our sample of four cost centres in four institutions, many of the priority items listed in 1996 still have not been obtained, and further that severe funding constraints are continuing to determine research priorities and research directions. Project funding and the unpredictable patterns of success in peer reviewed competition for funds prevent a strategic approach being taken towards equipment provision.

Third, the extent of the over-subscription of JIF by proposals rated 'excellent' (even in the face of the large cost of proposal relative to the low chances of success) is testimony to the urgent unmet needs of many departments. JIF grants for new or refurbished buildings have presented the only way in which significant funds can be directed towards the more generic (as well as the highly-specialised) research infrastructure needs of university departments. JREI funding, while welcomed by the community, is restricted by the condition for matching funding. Availability of such funding is unlikely to extend much beyond the present levels.

A final caveat is that this study has provided only a snapshot of the present state of equipment provision and needs. The timescale for the research was determined by that of the Government's current spending review, necessitating a highly selective approach to the challenge of updating our 1996 results. A proper appraisal of the situation can only be made on the basis of a full equipment survey following the previously established PREST/CASR methodology. Several interesting trends beyond the scope of this short study remain to be investigated, including:

- the significance of the rapidly growing capital intensiveness of the life sciences;
- whether the emergence of new organisational forms of research such as interdisciplinary schools provides a more effective environment for the management of equipment;
- what consequences arise from a growing dependence of universities upon access to industrial equipment; and
- whether increased selectivity in research funding has consequences for the organisation of teaching of final year students and postgraduates.

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primarily being used to replace out-of-date equipment however, this figure of £600 million could be argued to be an underestimate of the true remaining funding gap.