December 2012

Evaluation of Research Capital Funding (SRIF2006-08) to Higher Education Institutions 2006-2008

Case studies

Report by PACEC to the four UK higher education funding bodies and the Department for Business Innovation and Skills

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Case Studies

Introduction

In February 2012 Public and Corporate Economic Consultants (PACEC) was commissioned by the three higher education funding councils of England, Scotland and Wales, the Department for Employment and Learning and the Department for Business Innovation and Skills to quantify the benefits that have arisen from research and infrastructure capital funding provided under the Science Research Investment Fund in the period April 2006 to March 2008 (SRIF2006-08). The primary aims of this evaluation of SRIF2006-08 were:

- To assess whether the research capital funding provided from April 2006 to March 2008 has led to the achievement of the outputs, outcomes and objectives set for those capital programmes.
- To identify where the outputs, outcomes and objectives of those programmes have not been met, the reasons for such non-achievement and any lessons to learn for the future.
- To assess and where possible to quantify the benefits that have been achieved through SRIF2006-08 capital funding.
- To prepare 10 case studies, to be selected from 30 case studies undertaken, to provide an economic appraisal of the returns of the of the project.

This report presents the 10 case studies and illustrates the ways in which individual projects were supported by the SRIF2006-08 investment.

PACEC would like to acknowledge the help and co-operation we received from many individuals at the HEIs during the course of the case study visits. We acknowledge the help provided by the senior HEI managers in facilitating access and providing the context for the projects described here, in terms of how the infrastructure supported by the SRIF2006-08 investments fit into the research capital investment strategy of each HEI. Lastly, we must thank most sincerely the project managers and individual users who participated in the main stage of the research interviews.

Cardiff University

Project: Refurbishment of School of Medicine and Associated Equipment

Value: £5.459 million (£6.784 million in total)

Introduction

The background to the project was that SRIF2006-08 followed the SRIF2 round of research capital investment, which in turn followed SRIF1. According to the Project Manager, the SRIF investments were "*a lifeblood of significant infrastructure change for the School of Medicine*". The context of the investment was the merger of the School of Medicine with the university. Prior to the merger, the School of Medicine would have received its own SRIF allocation. Post-merger, the university received its allocation of SRIF funding, from which the School of Medicine received a 'goodly' proportion, which became part of its capital and facilities planning. But this was also at the same time as the school was rationalising its own facilities. Thus, whereas previously the model was to fund individual successful research groups for items of equipment, the idea now was use the new funding to follow individual technologies or technology platforms deemed to be necessary, in terms of quality research outputs, and running them as a co-ordinated entity, with the formation of a Central Biotechnology Services (CBS; http://medicine.cf.ac.uk/cbs/). This is the new way that the school runs its core facilities, i.e. central provision of high-end technology platforms and technical support available to all academics.

With regard to the infrastructure, the SRIF2006-08 funding was used for the specific refurbishment of the school's Cancer and Genetics building, which was part of the expansion of research capacity into particular areas. The school looked at its own infrastructure requirements in specific areas of research, as well as particular areas of technology to support those areas. Consequently, the vast majority of the SRIF2006-08 investment was focused on the upgrading of genomic platforms, in order to support cancer and genetics research. Thus, the investment supported new equipment as well as the refurbishment of buildings to house that equipment in an environment of appropriate quality (e.g. housing an expensive microscope in an air-conditioned dark room, because it would work better in that environment). According to Project Manager:

> *'Strategically, what we have always tried to do with SRIF money is always a balance between funding those areas of 4* research, but also underpinning activity in other areas and thus facilitating the pathway to excellence. In this way one can have a balance of support across the whole institution.'*

Aims and objectives of the project

The overall objective of the SRIF investment was to address past under-investment on the university's Heath Park campus. In terms of research capital investment, Cardiff University wanted to use the SRIF funding to drive the institution into an improved position, with respect to where they were in the world rankings compared with universities worldwide. The university's target then (and now) was to be in the top 100 of universities. Whilst Cardiff University was the

top university in Wales, it was readily acknowledged that was not where the competition was. And briefly after this period of SRIF investment, Cardiff actually moved into the top 100 ranking of worldwide universities, because part of the SRIF investment, especially in bio-sciences, led by Professor Martin Evans who was awarded the Nobel Prize in 2007, made a big impact on the university's research capability.

> *'What we wanted to do with the SRIF2006-08 funding was to do a mixture of things; either refurbish laboratories to make sure they could do high end research there, or to purchase cutting-edge equipment that would allow us to do that.'*

The SRIF 2006-2008 investment was a priority for the research capital investment strategy of Cardiff University. By building upon previous SRIF investments, the university was in a position to use SRIF2006-08 in a more strategic way. Thus, a small grouping of senior academics and managers was formed within the university, based on the research committee and strategy and resources committee, to oversee what high quality research could be supported through the SRIF funding. It was clear that whilst the university could support some research from core funding, the size of the SRIF2006-08 funding of over £26 million was much larger than anything the university could reasonably afford. With regard to the selection of the types of projects that would be supported, the criteria to apply included:

- How they fitted with the university's research strategy of ultimately becoming one of the top 100 universities in the world and staying there. This was achieved, although Cardiff has since dropped further down the rankings.
- Creating a framework within which really excellent cutting-edge research is carried out, so that the university does not become dependent or responsive to Research Assessment Exercise (RAE) and Research Excellence Framework (REF) considerations; i.e. that the research agenda is such that the university is able to address any problems that arise from the REF.

According to the Project Co-ordinator:

> *'We're doing research so that we take those sorts of things in our stride, and that the REF is just a mile post along the way of enduring excellence in research in Cardiff University.'*

SRIF2006-08 inputs

The School of Medicine received £5.5 million from SRIF 2006, plus a further £1.3 million from the university for a combination of refurbishment and estates work, and for the purchase of equipment. Of the total of £6.8 million available, it was anticipated that £4.8 million would be used for refurbishment and estates work, and £2 million for equipment purchase. It was anticipated that the refurbishment work would involve a total area of around 4072 m^2. This would consist of the following[1]:

- Extension to the genetics building and additional floor to the Tenovus.
- Refurbishment of poor quality laboratory space in Tower Block 1, Tower Block 2 and Link Block 4.
- Refurbishment of laboratory accommodation in Neuadd Meirionydd.

The equipment purchase related to three main areas of provision:

[1] Higher Education Funding Council for Wales (HEFCW), Cardiff University application, 2006.

- Equipment for protein research using proteomics technology – MALDI/TOF mass spectrometer with nano-liquid chromatography system and plate spotting robot.
- Cell imaging equipment – upgrade of multi-photon laser scanning platform, a scanning confocal microscope, and a live cell fluorescence tracking system.
- Expansion of a platform of complementary genomics technologies.

Implementation

There were no major problems in the selection and implementation of the projects supported by the SRIF investment. A total of 17 projects were supported across a broad range of engineering, physical sciences, bio-sciences and medicine. These are considered the areas of great innovation in science, and the strategy was that the university should use SRIF funding to invest in those areas in order to attract further investment from research councils or European funding. It was a case of how to pump-prime work in particular disciplines in order to get far better returns on research.

To a large extent, the SRIF investment was addressing a problem of significant under-investment in research capital infrastructure at Cardiff University. It is acknowledged that this was a problem going back some three decades, during which time British science in the broadest sense bio-medical science etc. – was very under-funded, compared with the situation in, for example the US. There was a wide gap between UK universities and those elsewhere, which had led to the UK losing staff to other countries on a regular basis. The previous SRIF investments began to address the problem of under-investment through science research capital funding. This, in turn, made it much easier for UK universities to start catching up and narrowing the gap, so much so that by the time of the SRIF2006-08 allocations, the UK had finally caught up with the US in a benchmark of investment. In this regard, there is some concern that the SRIF funding has been subsumed by other funding arrangements, so that the UK is seen to be once again losing its competitive edge.

Additional funding

It was anticipated that additional funding would be required to support the projects, and this was included in the financial planning to support the original bids that were submitted to the funding council. In principle the real recurring costs of the projects were staff, followed by maintenance to ensure that the facilities were kept in top condition. All this was automatically built into the way the university operates. One example was the purchase of the MALDI/TOF spectrometer. This was a project where the full cost was met from SRIF2006-08 funding to purchase what was a unique facility. It enabled the academics involved to be retained in Wales, but also to grow their research, because the university was successful in obtaining several other research grants on the back of that project.

> *'That is the sort of example of how you can use the funding, and although maybe one is not providing additional costs to the capital, the fact is that you are paying the salaries of the various people involved; and the related cost – in this case an instrument that requires liquid helium, which is a very expensive item – is all borne by the university and the university research grant.'*

Perhaps not surprisingly, the SRIF-funded project required additional non-capital expenditure, estimated at around £105,000 per annum, to cover operating and maintenance costs. This was anticipated, and the School of Medicine has received additional funding to support the SRIF investments. It was anticipated the additional funding would come from a variety of sources. In certain cases there is really good access to funding from industry; in which case SRIF funding would be used to underpin getting some good, fundamental research from outside. This is equally true across the charitable organisations. For Cardiff, the overall strategy was to use SRIF as a source of funding which could grow a lot more money to the university. To put it in context, in 2009-2010 the university research income was £150 million. But before then it was typically £70-100 million. Thus, the SRIF2006-08 investment of £26.5 million secured by Cardiff University was a significant proportion of the university's research income. But investing that amount of money has helped underpin substantial increases in the amounts of research grant obtained.

Activities

The bulk of the investment was focused on research. This is not surprising, as any new building (development) infrastructure is likely to have resonance, in terms of teaching. Thus, if teaching is research-led, then SRIF investment in building infrastructure creates an environment that is likely to facilitate both research and teaching, and fulfil the wider mission of the HEI. Indeed the Project Manager's view is that it is important not to underestimate the fact that the technologies and platforms that are used in the research outputs are the same technologies that are used to create new entities, new patents and new intellectual property. In this regard it is the whole gamut of university activity that is supported by the SRIF infrastructure investments.

The SRIF-funded infrastructure is heavily utilised. As might be expected, the refurbished buildings have full (100%) utilisation throughout the year. The equipment supporting specific research projects are used on average around 95% of the time, as are the equipment supporting generic and core research capabilities and activities. The usage of the infrastructure also reflects the priorities of the project, with research activities taking up around 70% of the time the infrastructure is in use. Of the other activities supported by the infrastructure, it is estimated that postgraduate teaching takes up around a tenth of the time (10%), knowledge exchange with external users around a similar proportion of time (10%) and undergraduate teaching around 5% of the time. There is little variation in the usage of the infrastructure among different groups of university members. It is estimated that the facilities are used by around 75 academic research staff, 100 postgraduate students and about 80 undergraduate students.

The SRIF-funded infrastructure has also attracted external users or customers. Through targeted development, the School of Medicine has had what can be described as the classic external relationships. It supports for example the research operations of local companies such as GE Healthcare for various aspects of what they do. The school undertakes similar activities for other HEIs and individual academics in different universities. More recently, the school has developed a 'code-share' operation with a pharmaceutical company, whereby the company has based its European technology platform within Cardiff University. The university runs that platform for the whole of Europe on behalf of the company. The company finds its own customers and brings all the samples it collects to the school, where they are analysed by research staff employed by the school. The company pays for the provision of that service at commercial rates. The school

provides the infrastructure and the laboratory environment for the company to do that, and makes a margin for providing that service. The school benefits further from the fact that it also has preferential access to the firm's latest technologies. The Project Manager believes this is the only set-up of its kind in Europe. Moving forward, the school has extensive plans for further commercial developments, which the Project Manager believes is an important way forward for HEIs, particularly at a time when public sources of funding are severely constrained. But this will only happen if HEIs have the appropriate infrastructure already in place.

Consequently, the business case for the Central Biotechnology Services (http://medicine.cf.ac.uk/cbs/) is that the school must demonstrate how much investment it has leveraged in by using the SRIF-funded infrastructure as the initial major investment. Indeed, since the completion of the project in 2006, the school has had an estimated turnover of £1 million per annum, and has also expanded the number of customers that have been serviced in a sustainable way. The Project Manager believes that without the initial SRIF investment, it would not have been possible to leverage that level of activity. Unsurprisingly, the Project Manager also has no doubts about the importance and significance of SRIF investment:

> *'SRIF needs to be brought back because it is so critical to development. The withdrawal of SRIF made the university think that all of a sudden we didn't have any money; and when you don't have the money you are not able to be creative. It is not that the university does not have significant resources, but these are across the whole university, which means that schools will only get a proportion of this. So even though we may be the most active in a research area, we don't necessarily have the internal resources ourselves to support strategic development.'*

The business case for SRIF is also strongly made, particularly how HEIs now use the investment in a more strategic and focused way.

> *'In previous incarnations of SRIF, I wouldn't say the same thing because the equipment money went largely to individual researchers or groups. And there are sadly examples from SRIF1 and SRIF2 investment of items of equipment that were purchased (for very large sums of money) which were aspirational and not necessarily strategically driven. Some of these are now obsolete and have not been fully utilised of used in a sustainable manner. Whereas for SRIF2006-08, because we did it in a completely different and much more transparent and strategic way, there is not a single penny of investment that has been wasted.'*

Outputs

The Project Manager is in no doubt that the SRIF investments are an important part of the lifeblood of research in HEIs. The rationalised argument for Cardiff University is that investments of the type and magnitude provided by SRIF2006-08 enabled the university to make a step change in the provision of support for research and teaching. The two go hand-in-hand, particularly where there is development of physical infrastructure like new buildings. The rationalised argument also suggests that SRIF is almost irreplaceable, in the sense that it is the only opportunity HEIs have every three years to make significant and targeted capital investment in particular areas of research. The Project Manager states as a matter-of-fact that since the completion of the project, there has not been a single science-based publication from the School of Medicine which does not involve activity performed on equipment funded through SRIF2006-08.

> *"We were often asked to produce the metrics on the performance of the SRIF investment in facilities and infrastructure. The reality is that there are very few sets of experiments which in some way or other have not benefited from either the facility or building in which you've housed it or equipment underpinned or funded wholly through the SRIF mechanism. The impact is colossal. You simply cannot overstate it.'*

The SRIF investment has created employment (and leveraged school funds), particularly for those individuals who support the facilities. It has also created development, in terms of ISO accreditation and quality assurance processes; it has made it clear that if HEIs are to work successfully with external organisations (the pharmaceutical industry, small and medium enterprises etc.) they need to run their facilities in an accredited and quality controlled and competitive environment. The SRIF investment has facilitated a step change from the days in academia when there were no formal quality standards, where academics performed their research with little reference to internationally recognised standards.

> *'Now researchers come to a machine (at a time they have booked through an electronic booking system) that they know will have been calibrated and that has undergone regular scheduled maintenance or to a machine which is run by a highly trained and accredited professional staff, and machine that always works. If there are technical problems, they will be sorted out quickly and their expensive experiments unaffected. In the financial environment we find ourselves, where every single penny counts, you can't overstate how important investment to support setting up such a system is.'*

The Project Manager further believes that without the SRIF investment, the School of Medicine's RAE returns would be much poorer, and its academic outputs and impact would be significantly reduced. The Project Manager cites examples of impact in the areas of Infection and Immunity, where the investments in flow cytometry and cell sorting have enabled ground-breaking work to be done over the past five years. The original technology was funded through SRIF2, and the upgrading was funded through SRIF2006-08. In this regard, the legacy of SRIF2006-08 is that even if the equipment is deemed no longer state-of-the-art, it has been used to trade-in for the next generation of equipment; which means that the value has been used perpetually, and the school has earned enough income through its managed use (and charge-out rate structure) to support this future investment. This has had a knock-on effect, by making it much easier for the university to invest limited central resources in more strategically driven research capital infrastructure.

The Project Co-ordinator and Pro-Vice Chancellor of Research confirmed, and reiterated, the widely held view that the SRIF2006-08 investments have had significant impacts (outputs) and have generated significant longer term benefits for Cardiff University. Another notable success is the amalgamation of the university's Information Services with high end computing to set up the Advanced Research Computing @ Cardiff (ARCCA) facility. The establishment of ARCCA has provided a significant opportunity for many researchers to become involved in using high performance computing, who otherwise would not have done so. It is conservatively estimated that hundreds of researchers have been able to access the facility, and have published hundreds of publications and papers as a result of it. According to the Project Co-ordinator, this is where the SRIF investment has been most significant, with the funding council for Wales' contribution of £2.9 million leading to a long-lasting benefit.

It was possible to identify further outputs from the SRIF2006-08 investments. In pursuit of the balanced economy approach, the School of Medicine advertises the availability of their equipment across the whole of Europe, and is approached by external organisations: universities, small and medium enterprises (SMEs), pharmaceutical firms and others, from the UK and elsewhere. For academic activities, the school has established charge-out rates at FEC or charity rates and applies these to work done for other UK HEIs. However, if working with external organisations, then it will build in a sustainability margin. Under this system any surplus generated is ring-fenced for reinvestment in facilities such as match funding for equipment applications made by individual researchers to research councils or charities. The rationale for pursuing this strategy is an acknowledgement of the fact that every research capital funding opportunity now comes with the need to leverage local support. For example, the university recently funded the purchase of cell sorter equipment through its central (core) large research equipment fund (LREF). This funding only covered the cost of purchasing the equipment, but none of the other costs, such as service contract, maintenance etc. It was expected that the School of Medicine would fund this either from future activity and cost recovery, or from its own resources. Another example comes from the school's recent application to a large UK based charity for funding to purchase a next-generation item of equipment, and in its funding application indicated it would fund 20% of cost from its own resources. However, the funder only agreed to provide funding if the school contributed 50% of the cost. According to the Project Manager:

> *'Leverage is a facet of the funding landscape and there is the expectation that this will be sourced either from central university funds or from the sustainability built from having a robust (fEC) cost recovery model on core equipment facilities. With any application there will always be leverage of internal university resources, and that can be at university level, but more and more this occurs at a school level. So without a mixed economy of academic and external activity and funding, the model simply does not work. If it was based on pure academic activity there would be insufficient recovery of costs to generate a sustainability fund (particularly in areas with a high proportion of charity (non-fEC) funding). We have to have other sources of income, and so our approach has been to develop these other sources of income. But all of the surpluses from these activities go back into future equipment purchases or facility support. In order to deliver services at the level that external organisations will accept, you have to have some form of accreditation. CBS is one of the only ISO accredited facilities in any university in the UK. You also have to have quality assurance systems in place so that external companies will be reassured about the quality and reliability of any work done.*

Assessing the counterfactual

The considered view of the Project Co-ordinator is that at the time of the SRIF2006-08 investment, the alternative sources of funding for Cardiff University were limited:

> *'What SRIF2006-08 was able to do was to give us access to high levels of capital to commit to specific projects; getting high levels of capital is not easy at any time. What we would have had to do was probably to be more selective than we have been, which would have been difficult because all the projects supported have been very successful. The same level of support would have been there from within the university.'*

It is true to say that the university has resources of its own which could be invested in some of the projects funded from SRIF2006-08. But it would have been faced with a dilemma with regard to prioritising. The Project Co-ordinator also believes the university would have gone ahead with the

high end computing project, as well as the medical upgrade, because this was necessary after the merger of the Medical School and university. It is also more likely that projects relating to organic chemistry would have gone ahead, as the university was finding money for that. But these would have involved much more difficult decisions on investment policy, and the university's ability to play on a wider world stage would have been diminished dramatically. But even more significantly:

> *'We wouldn't have retained some of the staff we managed to retain. There is an interesting part of staff retention, in particular retention of excellent researchers. The UK does not have enough excellent researchers. The current government wants a knowledge-based economy leading the country out of recession. [But] you cannot do that if you haven't got top troops on the ground. But you also need the right equipment.'*

The consensus view of the senior academics interviewed for the case study at Cardiff University is that there were no credible alternative funding sources to the SRIF investments for the refurbishment of the School of Medicine and purchase of associated equipment. The only realistic alternative would have been that an individual award would have been made to an investigator (researcher); who could quite conceivably restrict access to the facility by saying *'this is mine, and I'm not going to let anybody else use it.'*

But it is also a fact that the funding landscape has changed fundamentally, and funders now have individual investigator awards, where they invest in an individual and would give that individual investigator everything that they want. This has been to the exclusion of the wider general researcher population, who no longer have access to research funding other than through institutional, or occasional applications to funders on an annual, competitive basis with the whole of the UK. And even here, applications are more likely to succeed only if they are supported by significant matched funding from the HEI. But this has also created a paradoxical situation, whereby the equipment secured in this way is likely, when arrives, to go into an environment which is supported by development which is underpinned by the SRIF2006-08 investment.

Maintenance and sustainability

With regard to the maintenance and sustainability of the investment, the whole ethos behind the amalgamation of support services at Cardiff, in terms of facilities, was with sustainability in mind. Indeed, the arrival of SRIF2006-08 investment coincided with the arrival of 'full economic cost recovery'; therein the challenge for senior managers was to convince academics that they should start paying for things in a sustainable way. Therefore:

> *'We built all of the SRIF2006-08 expenditure in facilities and equipment into a sustainable model of cost recovery. CBS is economically sustainable because of this, through a mixture of internal activity, where the costs are recovered, institutional support for charity-funded activity through charity uplift now within QR funding and external activity. So there is a balance, and the only way it [the model] is sustainable is if you have this balanced economy. But the balanced economy cannot compromise academic activity, and so there is a difficult balancing act to be achieved between how much external business we can take on, with a margin, versus our core mission in serving the academic community. They must of course have priority access; they must always have access, immediately because they rightly would not accept anything else.'*

The Project Manager's view is that without regular capital investment, it is simply impossible for universities to keep abreast of the rapid change in technology development. Even so, what appears to have happened since SRIF2006-08 is that there has been a decline in the number of external sources of research capital funding. Thus, for example, the Wellcome Trust now only runs a scheme for applications (for funding) once a year. It is competitive across the UK, as well as internally within institutions themselves. Thus, HEIs have to pre-rank their bids before they submit their applications. This also means that HEIs are not able to submit limitless numbers of bids. Other opportunities for capital investment in equipment now always come with strings attached, in terms of leverage or matched funding. Consequently, Cardiff University is prepared to work with any organisation that is a likely source for funds, including the Wellcome Trust for capital equipment, and with any initiatives that come from the research councils or charities

University of Central Lancashire

Project: Measurements In The 21st Century

Value: £408,139 (total project cost £626,097)

Background

At the time of the SRIF2006-08 investment, the University of Central Lancashire (Uclan) had a school of Science with a number of faculties, including the Faculty of Science. Within the Faculty of Science was the Department of Physics, which had expanded significantly, following the transfer of staff from the Department of Chemistry, which had been closed down. The Department of Physics itself was associated with a research centre, the Centre for Material Science, which also included the Department of Biology and Biological Sciences. At this time, Uclan operated a system where there was an instrument pool for large equipment; and the two departments, but Physics predominantly, used equipment from this pool. The Department of Biological Sciences had access to the pool of large equipment as a priority user. When the SRIF2006 funding was released, the University set up the Centre for Forensic Science, which grew rapidly to become a department. Whilst these changes were taking place, a new school structure emerged to replace the faculty structure; and within this new structure the university developed a School of Pharmacy and Biological Sciences and a School of Forensic and Investigative Science.

It is from within the School of Forensic and Investigative Science that the University of Central Lancashire has been able to re-grow chemistry, so that there is now a vibrant chemistry degree offer. In terms of student numbers, it is expected to recruit more students into chemistry than into forensic science in 2012. The development and growth of the School of Pharmacy and the re-establishment of chemistry are now regarded as representing a step change for the University. Nevertheless, the viability of both those areas was also considered to rely heavily on having a good equipment base. This was the impetus for Uclan's bid for SRIF funding for the Measurements In The 21st Century project; in essence, the acquisition of a good chemistry equipment base. As the Project Manager acknowledged:

> *'Without that, I think it would have been very difficult for those two initiatives, and they have been two major initiatives for the university.'*

In this regard, the project was considered to be a priority for the University, at least in the extent that at the time Uclan only had pockets of research that were acknowledged as excellent. The university had produced good RAE returns in physics (astronomy based) and materials science, and it was decided to grow those areas of research. It was the improvements in the RAE returns that convinced the university to prioritise its areas of research to those areas of excellence and activity, and the desire subsequently to try and grow those areas. The university's desire to develop excellence in research has been successful, such that it is now able to submit more people across the university to more units of assessment than it has ever done before.

> *'The university has a vision to develop as a world class university, which requires us to have world class research and world class teaching. I am a big believer that what we do here is right, and we give our undergraduate students access to state-of-the-*

> *art equipment, because that is the way to enthuse and invigorate those students. So we don't segregate research equipment, and it's only very specialist equipment which is in research laboratories. Our general equipment under this (SRIF2006) bid is a resource for education development both at undergraduate and postgraduate levels.'*

Aims and objectives of the project

Uclan's application bid for SRIF2006-08 funding highlighted the importance of the project for the university's commitment to developing its research base through its 'Enabling Research Excellence' strategy. That strategy, in place from 2003, placed emphasis on the university providing support for research through increasing investment in high priority areas, establishing centres of research excellence, and targeting key areas for development.[1] Towards this goal, the strategy focused on replacing and/or upgrading equipment in order to maintain the productive capacity of the existing research infrastructure. More specifically, the instrumentation acquired for the Measurement In The 21st Century project was needed to strengthen and further develop the capability of the Faculty of Science's Analytical Unit, which houses equipment used by the Faculty's Centre for Astrophysics and the Centre for Materials Science. The replacement and upgrade of existing equipment was intended to provide new capacity to the Analytical Unit to ensure that it provided state-of-the-art facilities to both staff and students of the Faculty. It was considered the new instrumentation would aid the development of the faculty's research activities in a number of ways, including "asteroseismology of rapidly rotating oscillating stars, solving long-standing problems of the internal structure directly; characterisation of template nanostructured nanoelectrode surfaces; characterisation of nano-composites and minerals; direct investigation of basic enzyme/substrate binding events; and the development of enzyme-catalysed materials preparation route.[2]

The project itself appeared to fit into the university's broad strategy (for 2001-08) to generate research output that would reflect on the RAE and, going forward, that would form the baseline for research teaching. In particular, at the stage of the SRIF2006-08 investment, the university had a clear strategic plan (for 2008-09) to push forward research in a strategic number of areas in science. According to the Uclan Director of Research (and the Project Co-ordinator):

> *'You look at your strategy, and you look at the areas that you believe would make most impact for the investment that could be made. And you align that with the equipment that you have to see if you need to refresh that, or if you need to build upon it, as well as stretching out to buy facilities that are different and fresh, and meet both the research and often the knowledge transfer needs.'*

Indeed, there have been significant changes in research capital investment strategy at Uclan since the SRIF2006 funding round, particularly regarding the processes involved in the selection of projects put forward for funding. For example, at the time of the SRIF investment in 2006 the university had not gone through the RAE, although it was planning for that, and was investing in equipment and facilities that were expected to maximise the impact on the RAE. It was the preparation for the RAE which also determined the choice of investment projects submitted by Uclan for SRIF2006 funding.

[1] Higher Education Funding Council for England, *University of Central Lancashire SRIF 2006 application*.
[2] Ibid.

In this regard, the choice of investment was much influenced by the fact that there were clear needs in those areas of science research which would be fulfilled if the funding was used to purchase pieces of equipment that would further enhance the areas of excellence that the university could support into the future. The clear objective of the strategy was that any capital investment in science research needed to make a big impact. Here too, the Director of Research explained both the concept and rationale in this way:

> *'When it comes to things like making a choice of investment, there are two ways of looking at it. You can take the margarine approach, or you can take the jam approach. The margarine approach is you take the investment and spread it evenly everywhere; and the trouble with that is that you tend not to get the impact that you actually want. If you take the jam approach, you dollop the investment in the areas that you actually think you are going to get something from. And in our case, this was very much the 'dolloping', particularly in those areas that we thought we could make a difference. And this also informed the four areas that we chose, including Measurements in The 21st Century.'*

Given that Uclan is as an institution that is only 20 years old, it has been important for the university to think in a more strategic way when making its investments. And the SRIF2006-08 investment has enabled the University to 'travel a long way' from where it was as an institution that had only pockets of excellence, and growing these to achieve excellence in other areas of science. At the same time, though, the SRIF2006-08 funding has also been important in addressing a problem of under-investment in some areas, and in helping the university to sustain and maintain other existing research capital infrastructure.

SRIF2006-08 inputs

The Measurement in the 21st Century project received £408,139 of SRIF funding for the purchase of new equipment to support generic research capability, and to upgrade existing equipment to support specific research projects. The specific equipment items secured with the SRIF2006-08 investment were: Liquid Chromatography Mass Spectrometer; 400MHz Nuclear Magnetic Resonance Spectrometer (with solid probe); X-ray Diffractometer; Atomic Force Microscope; and High Resolution Echelle Spectrograph.

It is notable that although the Uclan bid was for funding of equipment for the Physics department, in practice, the mass spectrometer goes with the microscope, and the other pieces of equipment, such as the 400MHz Nuclear Magnetic Resonance Spectrometer (NMR), X-ray Diffractometer, Atomic Force Microscope and Liquid Chromatography Mass Spectrometer which are all very much related to chemistry. Indeed, the drivers for the equipment were people who previously worked in the Chemistry department and moved to the physics department; and who wanted to drive forward and maintain the strong instrument base to support their research, and thus secure the platform to launch other initiatives.

> *'Having the SRIF money has allowed us to attract other money from the university. But without that money we would not have been able to buy other things. I always think you can't just look at what you've spent the money on, but what it has allowed you to do as well, such as launching other initiatives.'*

The internal implementation process for the project involved establishing a small committee that was tasked with taking stock of the likely amount of funding that could be secured for capital

investment projects which had been identified as priorities. The final decision on the investments that could be supported would then be made by the deputy vice-chancellor, as to where the funds would go. On this project, the deputy vice-chancellor gave a strong lead and indicated that the investment would go to priority areas that would make a difference and where a step change was going on, rather than be spread evenly across the board. Given that before the RAE of 2008-09 Uclan had a good chance of making very large steps forward in the identified areas of science, that is what the university endeavoured to do.

It was decided during the application process for SRIF2006 funding that all the equipment purchased should be sufficiently versatile so that they would not be monopolised by one group of researchers, but could be used by a wider group of researchers from different disciplines, such as chemistry, forensic science, pharmacy, dentistry, built environment and environmental science. According to a respondent senior academic interviewed for the case study:

> *'It was about creating a facility for development and measurement in the 21st century across the university. The lead was from Physics, but the aim and the vision was to build something that would serve the whole university.'*

Additional funding

The University of Central Lancashire contributed substantial additional funding of more than £200,000 in order to realise the vision to set up the equipment base that would provide a platform for cutting-edge research. In this regard, the university used the SRIF2006-08 investment almost as seed corn to grow its research. Apart from the capital costs, the SRIF-funded project requires further non-capital expenditure, estimated on average at £53,000 a year, to cover operating and maintenance costs. The Project Co-ordinator believes that providing for the additional non-capital expenditure to support the SRIF2006-08 investments was an especially steep learning curve for the university. It has been necessary to mandate that the schools have strategies in place to sustain and maintain investments in research capital infrastructure. Indeed, given the fact that the university now has excellent facilities (for example, the JB Firth Building), the strategy for science research capital investment now requires potential proposers to look for packages that will cover more than the cost of simply buying a piece of equipment. Instead, the university now seeks to establish how the piece of equipment would look like in, say, three years' time; and how it would be maintained, who would be involved in doing that, and how it would be sustained during that period.

> *'The SRIF money has been good especially as it gives you that extra burst, but even when you spend that burst there is a consequence in how you are going to man the equipment. As some of the equipment is very expensive, we have to factor that in to what is actually happening.'*

It is also worth noting that the schools have put other measures in place when purchasing new equipment. There is now a senior academic member of staff who has responsibility to oversee the maintenance of large pieces of equipment. In addition, a dedicated technician is assigned to any piece of equipment, and is responsible for its general running and maintenance. This has ensured that equipment are in good working condition and producing the required data. The university has also taken steps to minimise the problem of duplication, and having the same or similar type of

equipment in different departments. It has established central laboratory spaces that can be used by different departments or schools.

> *'We realised that we won't have the luxury of Pharmacy, Forensics and Physical Sciences all having the same piece of kit sitting in their buildings. We cannot sustain that. So we have to think about how to manage how people use that. So we are looking at how we can maximise the return on current pieces of equipment.'*

Overall, though, it is the university that provides the necessary funding, from its own central resources, to cover recurrent expenditure, including upgrade costs.

Activities

The SRIF-funded equipment have had about medium utilisation since they became operational. It is estimated that on average they are used about 65% of the time – 50% of the time on projects or programmes supporting generic research capabilities, and 15% of the time to support specific research projects. The equipment support a range of key activities. It is again estimated that 60% of the time the equipment is in use is devoted exclusively to research, 10% of the time to postgraduate research, and 10% to undergraduate research. The equipment is accessed by external organisations, albeit on a small scale, estimated at about 5% of the time, and mainly for knowledge exchange activities. In this latter regard the School of Forensic and Investigative Science works with a number of companies, both locally and nationally, who send in their samples for analysis, or sometimes send their staff in to be involved in the analysis in situ. There are similar links with other HEIs locally, including Lancaster University.

There is extensive use of the Measurements In The 21st Century equipment by different people internally, although the usage does not appear to wholly reflect the utilisation by the different groups of research and academic staff. It is estimated that on average around 40 academic research staff, 50 postgraduate students and 120 undergraduate students have used the SRIF-funded infrastructure each year since it became operational.

The senior academics interviewed for this case study were unequivocal in their views that the equipment have enabled Uclan to make great strides in research in areas such as chemistry. Perhaps unsurprisingly, the demand for the use of the equipment from this discipline has outstripped the levels of usage estimated at the time of the SRIF2006 application. The fact is that the university now has more students studying chemistry than was the expectation at the time of the SRIF investment. There have been similarly large increases in student numbers in pharmacy. The infrastructure brings together scientists and associated researchers who use the equipment, so there is increased collaboration between research academic staff and students. In particular, the focus on students having access to the equipment has driven demand significantly, and with impressively positive results.

> *'We are seeing the results of providing undergraduates access to these equipment. Some of our undergraduates presented some of their project work at a national conference which was open to postgraduates and post-doctorates, and they won a prize there. They are now going to present in Europe later this year. What we are seeing is that the enthusiasm of our undergraduates for research now is spiralling. We now have undergraduate students who come in during the afternoons to do*

research, instead of, say, going to play sports. There is a real culture change, and there is a really vibrant atmosphere.'

Outputs

The SRIF-funded infrastructure is considered to have had high impacts on academics and research students, but also on the university's research capability more generally. It is considered there are high research-related impacts: in increased quality of research; increased research productivity; opening up new areas of research; and improvement in the reputation of the School of Science. With regard to academic staff and students, it is considered there is increased morale, which is a reflection of the improved quality and quantity of research training for students. The impacts, with regard to staff retention, the quality of new staff recruited, and improvement in staff research skills, are considered to be medium rather than high. On the other hand, the infrastructure is considered to have a high impact on the university's internal and external partnerships; with increased collaboration between academic disciplines, and the generation of new non-academic external partnerships with industry. The increased interaction with external organisations is particularly significant, as they now have improved access to equipment and research infrastructure for innovation, and improved access to the university's cutting-edge research capability.

The Project Co-ordinator uses the RAE as the benchmark with which to begin to assess the true impacts of the SRIF-funded infrastructure, by comparing the current state of research at Uclan as it prepares for the REF in 2012, to the institution's situation four years ago. Before RAE 2008, research at Uclan was considered to be a low level activity, and was carried out in only a small number of areas, such as Physics. The total funding from public sources for research capital investment then was about £700-800k a year, which the university invested as best it could. After RAE 2008 – for which Uclan submitted 16 different units of assessment, with the majority in science – the university's funding from government increased to about £4 million. It is estimated that 11 of the units submitted obtained a 4* rating, and the rest all received a 3* rating. This appears to represent the step change that has enabled the university to push science research much further forward in a relatively short period of time. The success of RAE 2008 has encouraged the university develop plans to establish a Centre for Science in 2014. The university is also aiming to put about 40% more people forward for the REF 2012 than it did for the RAE 2008. Moreover, the candidates put forward are expected to be of higher quality compared with the RAE 2008 submission. The university's improved research capability has had another knock-on effect, with the University increasing its external grant receipts by some 50-60% over the last two years. These are all considered to be strong indicators of how public investments, such as SRIF2006-08, have helped lever in other funding, and increased the research capability and potential of the university.

There was considerable circumstantial evidence about the impact of the SRIF2006-08 investment, particularly from the perceptions of users of the infrastructure. The case study interviews with academic research staff provided particularly useful insights about the outputs and benefits from the SRIF-funded equipment and facilities. The views of two senior research academic staff are pertinent, and are reported extensively here.

The first senior lecturer (SL1), at the time of joining the School of Forensic and Analytical Sciences in 2008, thought the equipment was of higher quality than what was available in their previous academic position. With regard to impact, the level of technical equipment has allowed SL1 to generate a modest group of one post-doctoral researcher, two PhD students, and a student who has just completed a Masters degree. The research group has published a number of papers and has been able to apply for 'a lot of grants'. The group has also registered a patent, based on their work with the NMR and mass spectrometer equipment. The group is now working and collaborating with external organisations, including multinational pharmaceutical companies and the NHS (Royal Preston Hospital), to exploit the outputs from their research. In terms of dissemination, SL1 has been able to produce close to 10 publications since joining Uclan. SL1 believes the equipment available has enabled them to do that. Having the equipment readily available means not only that academic research staff can carry out their research, but it means they can also turn things round quickly; which in turn means an increase in the quality and quantity of research output.

The second senior academic (SL2) joined Uclan after working at more established chemistry departments at some of the largest universities in the country, but considers the level and quality of equipment at Uclan to be comparable to those institutions.

> *'Some of the universities I have worked at, they don't have the full range of equipment that we have here. When I was at [named former university] doing a post-doc, if we wanted to do solid state NMR, we didn't have a solid state NMR in the department, and we had to go to [another named university] to use theirs. So to have it on site, and to have all the equipment that I need to do my research was part of my decision to come here.*

SL2 is in no doubt that the SRIF-funded facilities have had wide-ranging research related impacts, not least by increasing the quality of research, and by increasing research productivity. According to SL2:

> *'We can make our samples, and we can analyse our samples to see whether or not we have made what we wanted to make, and we can make adjustments pretty quickly and get more research done in the same time span, rather than wait around, or go to other universities to analyse our results.*

SL2 further believes the availability of the equipment has increased the research capabilities of undergraduates and postgraduate students. The exposure of undergraduates in particular to high specification equipment has increased the quality of their research outputs, and is reflected in the fact that:

> *'We've got undergraduates doing research and presenting work at conferences, their results are getting published, and they are getting places on funded PhDs in other institutions, and things like that.'*

Lastly, there was some evidence from the interviews with senior academics that the SRIF-funded investment has helped Uclan to improve its retention of high calibre academic staff. The Project Manager acknowledged that it is part of the role of the head of schools to attract high quality academics, and to keep them as well. But this is only possible if the ambitions of the academic staff are fulfilled and their expectations are met. Consequently, the retention of high calibre academic staff relies for its success on the provision of a high quality research infrastructure.

'I want to attract the staff and I want to keep them. Therefore, I have to be able to fulfil their aspirations. I have to make sure that infrastructure is in place. That's my role, and that's what I want to do; and up to now, I've been able to do that. In SL2's area, since SL2 arrived, we have been able to purchase equipment (SRIF) which is a technique SL2 was keen to have, and we have been able to do that. To date we have done that in other areas for other academics, so that they feel fulfilled and feel we are supporting their ambition. You've got to attract good staff but you've got to keep them as well, especially for an institution like this, where it is easy to lose good staff, and that's the last thing we want to do when looking to the future.

Assessing the counterfactual

At the time of the bid, the value of the SRIF investment represented a significant amount of money that would have been difficult for the University of Central Lancashire to find from elsewhere. This is notwithstanding what senior managers describe as the university's "can do attitude". Every year the university establishes a teaching equipment funding round and a research equipment funding round, and in the time since the SRIF2006-08 investment it has built on that. As a result, the university was in a position to use its own resources to support the initial SRIF investment in order to meet the total cost of the project. But the SRIF2006-08 investment has been a catalyst for the development of extensive capital infrastructure to support research, including new laboratory buildings. Indeed, one of the major construction projects that followed the SRIF investment was driven by the need to bring together all the pieces of equipment that were hitherto dispersed in different locations. This had made it difficult for technical staff to provide adequate support, and restricted access by undergraduates to those pieces of equipment because of difficulty of supervision. Subsequently, it is considered that the SRIF investment has had a positive and significant effect on the everyday lives of students and staff.

In assessing the counterfactual it was pertinent to ascertain to what extent the investment, outputs and impacts described would have occurred had the funding not been available. One way of doing this was to ask respondents about the most severe consequences for the university had it not received SRIF2006-08 funding. The Project Co-ordinator (the University's Director of Research) was unequivocal about the full ramifications of the investment:

'We wouldn't be sitting in this building that we are sitting in now, because I don't think we would have had the confidence to invest in other areas without having showed that this investment has actually paid off. I don't believe we would have had our performance in the RAE areas without having this investment, and I don't believe we would be in the confident position we are going forward for the REF. It is often difficult to characterise the impacts of investment in terms of pounds and pence, or bums on seats. Universities make decisions strategically as well as everything else. But if you wanted to kick-start a particular area in the particular way that we tried to do in 2006, then the SRIF investment was the only means you could use to make the step change that you wanted.'

As to whether there were alternative sources of funding to SRIF, both the Project Co-ordinator and Project Manager were convinced that an institution such as the University of Central Lancashire, which is not "cash-rich", would not have been able to secure the level of SRIF investment of nearly £500,000. The considered view of the Project Manager is that the university would have been able to only partially provide some of the infrastructure from other sources of funding; for example, by applying to external bodies and charitable organisations, albeit with no guarantee of being successful. The School of Science itself could also have applied directly to the

university for funding from central resources during the annual or bi-annual spending rounds. However, the limitations of core [university] funding were also clear, in the sense that the maximum amount of money that a department or school is able to bid for from central funds is capped at £100,000. The limitations placed by such restriction on research capital investment were also clear to the Project Manager:

> *'If I were to say, "could I have bought a new 400MHz NMR, this would cost the best part of £200,000 today"; which means the School would have to find £100,000, and this would have been difficult.... But it also means that you would not be able to buy the important, big pieces of equipment, which are critical for science research. I believe that to do world class research and research informed teaching, you will need to make those investments in those bigger pieces of equipment. And if you don't, you will never achieve what you are setting out to do. Therefore, it would have been very difficult without the SRIF money how we would have got where we are today.'*

Lessons from SRIF2006-08

SRIF2006-08 was a lifeline, and has enabled the University of Central Lancashire to meet its aspirations for science research. Indeed, because it is not cash-rich the university has endeavoured to 'squeeze out' the maximum benefits from any funding and investment in infrastructure; and to get the maximum value it possibly can from its investments. In this way the university believes it gets a lot more added value from all its investments. The senior academic respondents were convinced that looking from HEFCE's perspective, one of the main lessons from SRIF2006-08 is that for certain institutions this type of investment can help make the step change that they want. In their view it is not an exaggeration to say that it is not always the case that a large institution requires a large amount of money, or vice versa; but that a strategically placed investment in an area that it is possible to get value from, makes a difference. In this regard it is important that funding follows quality, and not necessarily the reputation of the institution, or upon the critical mass associated with it.

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University College London

UCL 28: Eastman Dental Institute
Fourier Transform Infrared Spectroscopy Microscopy System

Value: £100,000

Introduction

This capital equipment investment, the Fourier Transform Infrared Spectroscopy (FTIR), has provided a unique new microscopy system with both infrared and Raman chemical analysis. The equipment is used by a number of teams working in various disciplines worldwide. The following will, however, focus largely upon the main user group at UCL Eastman Dental Institute (EDI). Acquisition of this instrument has helped them grow as a team and become world leaders in dental and bone composite cement research.

Patient demand for aesthetic materials has led to dental composites replacing amalgam for restoring anterior and posterior teeth damaged by caries. Furthermore, modified dental composites are beginning to replace conventional “PMMA” bone cements in orthopaedic applications. At the time of the SRIF2006-08 funding allocation EDI had an FTIR / Raman system which allowed the measurement of the bulk chemical properties of these composites. The new equipment, however, enables investigation of areas 1000 times smaller (micron instead of mm diameter). This is achieved by combining microscopy with FTIR / Raman. Through subsequent computer analysis of hundreds of spectra, chemical maps of materials are gained. With inhomogeneous materials such as composites, the maps generated have various colours associated with different components (see Figure 1a). Knowledge of chemical distributions aids understanding and subsequent improvement of bulk mechanical properties and biomaterial-cell interactions.

A major problem with conventional dental composites is that they shrink during set. The microgaps generated and lack of antibacterial action lead to higher levels of bacteria accumulating below conventional dental composites than amalgam. As a result, composites require more frequent replacement. The new microscope, however, has proved highly beneficial in the development of dental composites that are antibacterial. These new composites additionally contain re-mineralising components that encourage self - repair of surrounding tooth structures that have been damaged by bacteria. These properties should reduce the level of disease affected tooth structure removal that is required during restoration and prevent re-infection / need for frequent replacement. Furthermore, major problems with PMMA bone cements include early toxicity, heat generation during set, limited bonding to bone and far from ideal mechanical properties. The new microscope has aided development of composites that overcome all these problems. It has also proven that the new materials promote rapid precipitation of self – repairing bone – like layers upon placement in simulated body fluid (see Figure 1b).

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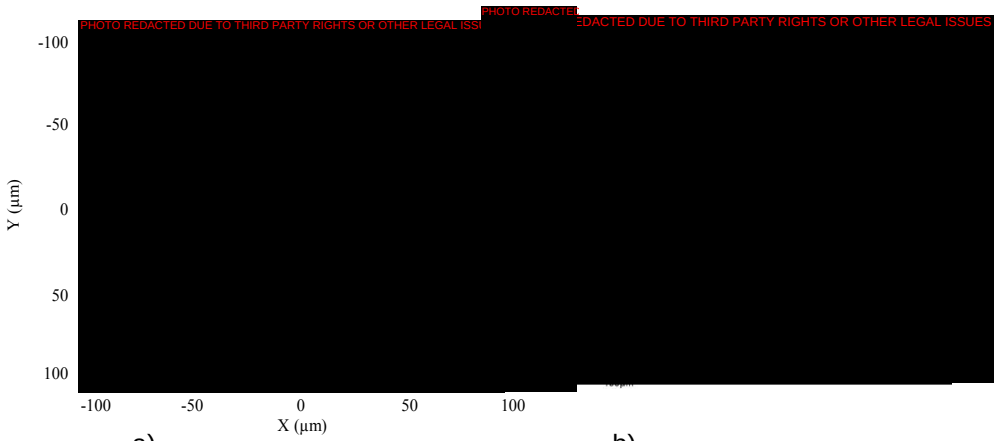


a) b)

- Figure 1 a) Chemical map of the core of a composite bone cement showing particulate fillers of two different chemical types and sizes (green and red regions) dispersed within a set polymer matrix phase (blue area). The scale bar is 10 micron. In body fluids the new technique demonstrated the materials absorb water causing the fillers to react thereby improving mechanical properties. This feature has been covered by an EDI patent.
- b) Scanning electron microscopy image of 10 micron thick layer formed on the surface of a new bone cement after 24 hours in simulated body fluids. Raman mapping has confirmed this layer is chemically similar to bone and dentine. It additionally, contains antibacterial components that also promote human cell attachment. The crack across the centre enables visualisation of the underlying composite and furthermore, how the bone – like layer can re-grow if damaged.

The equipment, at the time of acquisition, was seen as important in supporting collaboration both within University College London, with other universities and potentially with external commercial organisations. It was anticipated that the equipment would help forge stronger links with Chemistry and support two EPSRC funded projects in conjunction with Warwick University and the University of Kent. In addition to these links, other work has subsequently been undertaken with groups as far afield as Canada, Australia, Libya and Korea. Most of the work undertaken has been in a biomedical field. Materials investigated include ceramics, metals, phosphate glasses, degradable polymers, bacteria, bone, dentine and tumours.

Funding

The SRIF2006-08 funding for the FTIR microscope was £100k. This has aided generation of significant other income by various groups. For example, information obtained using this microscope provided evidence for EPSRC to provide further funding of £800k for bone cement development at EDI in 2009. As a result, a dental and bone cement patent was generated that was recently granted both in the EU and USA. UCL Business (UCLB) provided initial funding for and aid with patent and licensing arrangements. Subsequently, £100k came from a start-up company (Ozics). With this funding, UCL Eastman aided the development of the composite bone cement, Comp06 for vertebroplasty. This minimally invasive treatment aids rapid repair of and pain relief from vertebral fractures caused by osteoporosis. This composite received CE marking earlier this year. In 2010 a proposal to generate a similar material for tooth restoration was

ranked as the top healthcare proposal in an EPSRC call. This resulted in a further £500k support at UCL EDI. Smaller levels of funding were obtained from the SME dental company Schottlander to commercialise a re-mineralising, antibacterial dental composite developed within this project. In this case an equity share arrangement has been made so that future profits can support continuing research at UCL.

Outputs

The microscope is being used intensively by a wide variety of users in addition to those discussed above developing cements for tooth and bone repair. Use has been enhanced in research years by training of a technician to support the equipment. During peak periods, equipment usage can be 24 hours per day, with many students having to work at weekends to gain access. The primary use is for research although an important additional output is improved postgraduate and post-doctorate research capability. The equipment is also used by research staff to undertake research on behalf of commercial organisations and university users external to the university.

The quantity of composite research has been significantly increased by the rise in student numbers and post-doctoral staff at EDI. The quality and novelty of the research has also been a significant consequence of the new equipment. The quality of the research without the new microscope would have been lower. Furthermore, the patent discussed above would have been more difficult to defend through the various legal processes.

The number of PhD students and postgraduate clinicians working in the bone and dental cement field has increased three-fold at EDI since 2008. Many of these are from overseas and generate UCL income of ~£30k per person per year. The quality of their training has been much enhanced by the experience gained in undertaking research with the new microscope. In the absence of the instrument and subsequent above funding to support research, postgraduates and post-doctorate researchers in the institute might otherwise have trained or pursued their research careers elsewhere. Increased research capacity and capability have raised the reputation of the institute in this area of research which in turn has further supported the emergence of a critical mass of research capability and expertise.

> *"For the amount of money it is a major piece of equipment for me and a major piece of equipment for my young new colleagues…….. It's been useful for a lot of the clinicians coming in to do projects."*

Benefits

The benefits emanating from the research outputs made possible by the acquisition of the microscope are potentially substantial and of a high impact, benefiting a diverse range of individuals and organisations including:

- The Institute and UCL more generally, benefit through novel high quality world class research enhancing their reputation.
- Research staff and postgraduate students in both the Institute and other departments in UCL engaged in inter-disciplinary research with the Institute or using the Institutes new microscope, benefit through improvements in their technical capabilities and improved research output and publications.

- Research staff in other universities collaborating with researchers in the Institute or using the new microscope benefit by raising their research capabilities and research quality.
- The wider economy and potentially millions of dental and orthopaedic patients benefit through the development of new products for various treatments. With most current fillings lasting for two to three years and the average UK adult for example with six fillings in their teeth the new dental product will potentially have a major beneficial impact on the dental health of the population. New product developments made possible by the new equipment can reduce significantly the number of fillings by stopping bacterial micro leakage and secondary caries which are the main causes of restoration failure. Use of the new bone cement for vertebroplasty could benefit the increasing number or patients suffering osteoporotic vertebral fractures.
- The NHS benefits though improved dental and orthopaedic treatments and reduced costs.

Overall the benefits to the UK economy are increased global competitiveness of UK research and an increased ability of the group's research to meet the needs of industry. The new microscope has also improved innovative capabilities and facilitated the development of new approaches to dental and bone restorative technologies.

Constraints

To date there have been limited constraints faced by the research group in exploiting the research opportunities made possible by the new microscope although potentially some might emerge. The microscope is heavily used and a growing number of researchers wish to use it. However one issue that is arising is the ability to continue to use the microscope whilst upgrading its capabilities through the use of new programmes for its computer. New programmes are developing so fast that the company manufacturing the computer cannot easily and inexpensively upgrade the microscope to state of the art performance. The consequence is that equipment purchased six years ago is inferior because its computer does not incorporate more recent software improvements, although it can continue to be used in research.

A second emerging constraint is the sustainability of multidisciplinary research involving chemists, microbiologists, cell biologists and clinicians, in circumstances where the institute is losing research staff and not replacing them owing to some research staff in the institute facing difficulties in securing grant funding to enable them to continue their research. Although some research activities have been outsourced, such as histology, sourcing other areas is potentially problematic.

Project performance

Effectiveness (project achievements relative to objectives): This project has achieved both its objectives and continues to meet the needs of the research group to a large extent.

SRIF2006-08 has made a moderate impact on reducing any backlog of investment in equipment and major investments will be required in the coming years to continue to support the high quality of research that has been undertaken by this group in the UCL Eastman Dental Institute.

University of Edinburgh

Informatics Forum Building (Part of Potterrow Phase 1)

Value: £14 million

Background

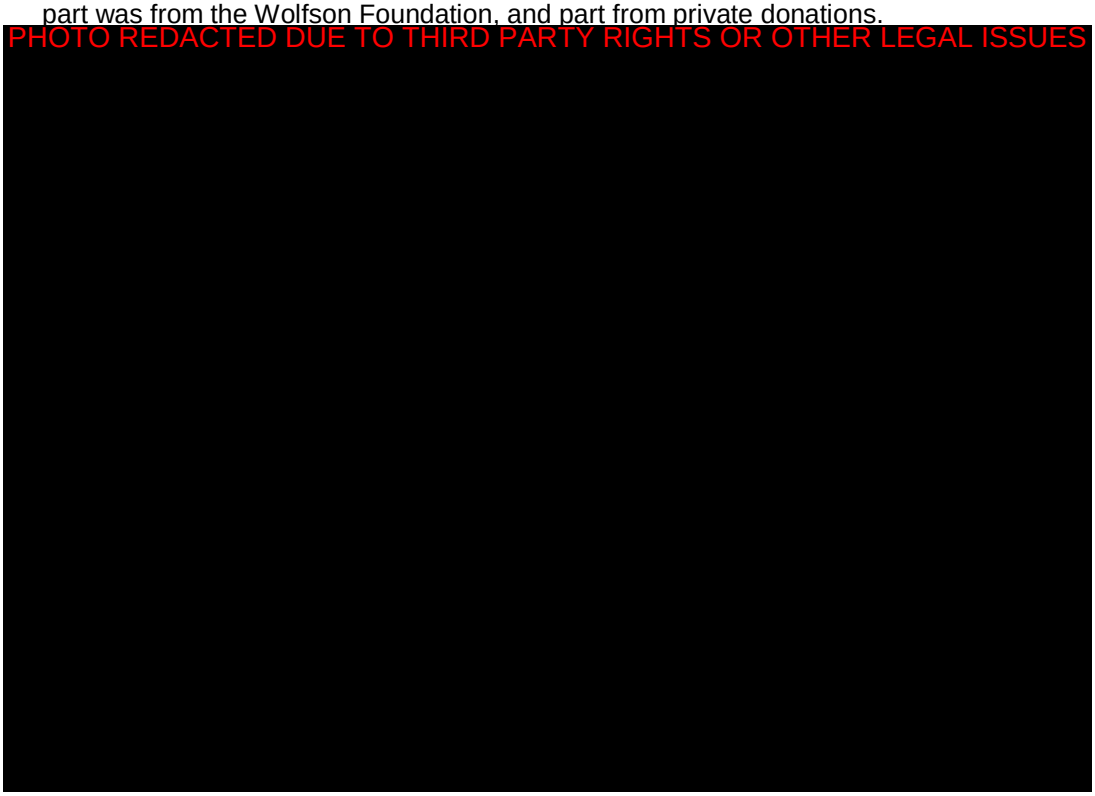
The School of Informatics at the University of Edinburgh is a relatively recent creation, and was formed from the merger of previous departments and faculties involved mainly with computer sciences. Until about 12 years ago, what is now the School of Informatics comprised different faculties and departments, such as Computer Science, Artificial Intelligence, Cognitive Science, as well as research institutes, such as Artificial Intelligence Application Institute and Human Communications Research Centre. This set-up was quite fragmented and there was a feeling within the university that there was much to be gained from joining together the different fragments into one single department. But this did not happen immediately (or for some time). Instead, the departments continued to operate from at least five separate buildings. Some of these were near the present location near the city centre, ant others at locations on the main campus, in the Kings Buildings. Initially, these were relatively light touch 'cost centres'; i.e., where the departments were independent, but with a cost centre that managed all the finances.

Shortly after this re-organisation, the university moved to a 'schools system', where much of the teaching was integrated. The geography was separate, although for practical reasons the school split up into different institutes. This was social engineering, to some extent; the idea behind this being to lose the older departments, and to have in place a different structure that provided better intellectual coherence. It was important, in particular, to break down the barriers presented by the old departments, and not end up with the two large departments, Computer Science and Artificial Intelligence, and the smaller Cognitive Science department, dominating the new school; hence the inclusion of the six research institutes. Nevertheless, the geographical separation remained.

From around 1997, pressure started to build, mainly from academics, for a new building. In order to address the anomaly of a School of Informatics located in five buildings, most of which were not purpose-built, or fit for the new demands of the discipline; such as South Bridge (refurbished), James Clarke Maxwell Building (purpose-built, but getting old), Buccluech Place (old houses put together), and Forest Hill (former army training corps buildings). Although there was pressure from the school for a new building, it was acknowledged this was expensive, and meant there was a financial hurdle to overcome in order to get the new building. About the same time, the university itself was encouraging the school to 'throw its hat in the ring' for a new building; and the push for this became a priority for the university. But it was not clear where the money for a new building, estimated at around £40 million, would come from and, particularly, whether the university could undertake such a project on its own. At this stage even those who were advocating for a new building thought "something would have to move" to make it possible".

At this stage there were a number of almost simultaneous developments. First, the university had a large space in the city centre, much of which was a car park, but which the university

considered could be developed if a useful proposal for a project was put forward. Second, the School of Informatics had also done well, in terms of performance, and had been consistently at the top or near the top in the Research Assessment Exercise (RAE) over several years. This indicated that Informatics was a prestigious research grouping. But it was also recognised that Informatics did not have commensurate accommodation to match its prestige, and was being held back from doing even better. There was a good feeling in the university to tackle this anachronism, and some senior people from both the school and the university had already started fundraising campaigns to raise money, from mainly private sources, for a new building. Third, it was during this period that the building in which one of the research institutes of the school was located (South Bridge premises) was destroyed by fire in 2002. This meant that almost overnight one of the most lucrative institutes in the school did not have a home. Following this tragedy, the university moved very quickly to start refurbishment of open plan spaces in the Appleton Tower to accommodate the staff from that institute. Whilst it was a pivotal achievement to accommodate a large number of staff at short notice, it was also recognised this was only ever going to be temporary solution and, moreover, that this was all the university could have done at that time. But all this meant the university was faced with two important issues: it had goodwill to construct a new building; and one of the top performing institutes in the university had no home. The two issues prompted the university to move, and it put together a patchwork of funding that would support a new development. Part of this was the university's own funds, part was SRIF funding, part was from the Wolfson Foundation, and part from private donations.



Aims and objectives of the project

The Informatics Forum was conceived as a landmark new building that would permit co-location of the university's world class (RAE 5* A) School of Informatics and collaborations with associated disciplines ranging from science and medicine, to business and the humanities. The Forum would be part of a complex which would form a hub for academic, commercial and public engagement

activities. The buildings would be carefully designed to provide a high quality research environment, attractive to world class scientists, while respecting overall space utilisation norms. In addition to housing all research staff and research students from the School of Informatics, it was intended that the building would provide a focus to attract international visiting researchers for sabbaticals, seminars and research-intensive meetings, with benefits flowing to students and researchers throughout Scotland.[4]

Implementation

Planning permission for the Informatics Forum Building was granted in 2004. The building is part of the development in the Potterrow area of Edinburgh and is on what was the Crichton Street car park in the city centre. The Informatics Forum Building is part of a development that is planned to cover the entire city centre square. There are 3 or 4 phases of the development plan. The first phase was intended to be a building just for the School of Informatics. However, it was decided to add another wing to the building to accommodate the School of Philosophy (PPLS), and this phase of the development was completed in 2007. The two wings are connected by doors which are 'policed' strictly. This is significant, because in order to be exempt from VAT during its construction, Informatics undertook not to carry out any profit-making activities in the new building for the first 10 years. Profit-making was defined in this case to include teaching and commercialisation activities. This means that the School of Philosophy carries out teaching in its wing of the building, whilst Informatics is not permitted to do so presently. Instead, the School of Informatics carries out teaching and other commercialisation activities in the nearby Appleton Tower, whilst the Informatics Forum Building is given over exclusively to research. However, this does not preclude people from industry, and elsewhere, coming to meet with research staff to see what they are doing, and to participate in non-profit making events.

SRIF2006-08 inputs

The Potterrow Development had benefited from £8.1 million of previous SRIF funding for the initial stages of the construction works. The SRIF2006-08 funding was to assist in the funding of the construction works post March 2006. It was proposed the new building would have a gross floor area of some 11,815 m^2 at an estimated cost of £41.8 million, of which the SRIF contribution would be £14 million. There is no doubt that the project had been considered a priority for a long time. But the high costs involved had made it extremely difficult for the university to commit to the development. It was reasonably certain that some of the sources of funding to meet the development costs were known: for example, the university itself, the public sector (SFC), charitable organisation and foundations etc. But it was also thought that some funding would also come from industry, although this did not materialise in the end.

Additional funding

The project has attracted a lot of additional funding. Part of this funding has come from the entrepreneurial programme that was instituted around the same time as the start of the

[4] Scottish Higher Education Funding Council, University of Edinburgh application, 2006.

development. The university was able to convince the Scottish Funding Council (SFC) and Scottish Enterprise (SE) to fund part of the development from the Prospect Programme. The success of the entrepreneurial programme also enabled the university to convince the SFC and SE to fund more of such programmes, leading to the development of the Aspect Programme. These programmes are funds that the Scottish Government has set up to help people start or create businesses around an academic hub. Both SFC and SE accepted that Informatics was a top school in the UK for computer science, but could also compare itself with world-renowned universities, such as Stanford (US). The idea behind the Prospect and Aspect programmes is to have academics doing research, but having around the periphery people who are being stimulated to think about entrepreneurial activity. Thus, the academics themselves do not change what they do; instead, they attract people (researchers) who may decide they do not want to follow an academic path, but see a business opportunity they want to exploit. The programme makes it easier for such people to take their first steps into entrepreneurship. It is hoped that if this is done enough, it would generate an entrepreneurial culture among academic staff themselves, but also among postgraduate and post-doctoral researchers. Indeed, the programme has enabled some academic staff to attract venture capital investment funding. Indeed, entrepreneurship has become increasingly important for HEIs, and according to the Project Manager:

> *"I believe it is important for university departments to do this. But to do that properly, you need things like Prospect, Aspect and other such programmes to give you the funding to jump-start it, because we are not Stanford, and cannot do it on our own, and we are not sitting on a pile of cash which we can just spend. So you need a bit of pump-priming. The fact that the university was clearly investing in Informatics through the building, and bringing in SRIF funding, all help to lift things together."*

On the other hand the school undertakes other activities that involve companies. For example, the school is a centre for excellence in Europe, and has done work for ARM, the UK microchip developer. Indeed, many of the major companies that are in the informatics business invest in the school in some way. The key ones include IBM, Google, Cisco, Microsoft, Intel and ARM. Although the amounts they invest are not huge, they are nevertheless useful.

Non-capital expenditure for the project is met from the university's own resources. This is significant, as the university is not able to claw back any money by levying charges on external users of the building. This is a little inconvenient, as there is high demand for the use of space in an iconic building for events. The compromise arrived at to reduce demand is that use is restricted to only activities that are closely associated with, or connected to informatics. However, allowance is still made for events that have an over-riding social or community (university) need, e.g. hosting an overseas delegation. Such events also generate considerable goodwill, which compensates for the non-charge:

> *"We do an awful lot of entrepreneurial work here. We have programmes in entrepreneurship which have been very effective. They are funded by the Scottish Government and by industry, to some extent. As a consequence of that, we have a very good record in spin-out creation."*

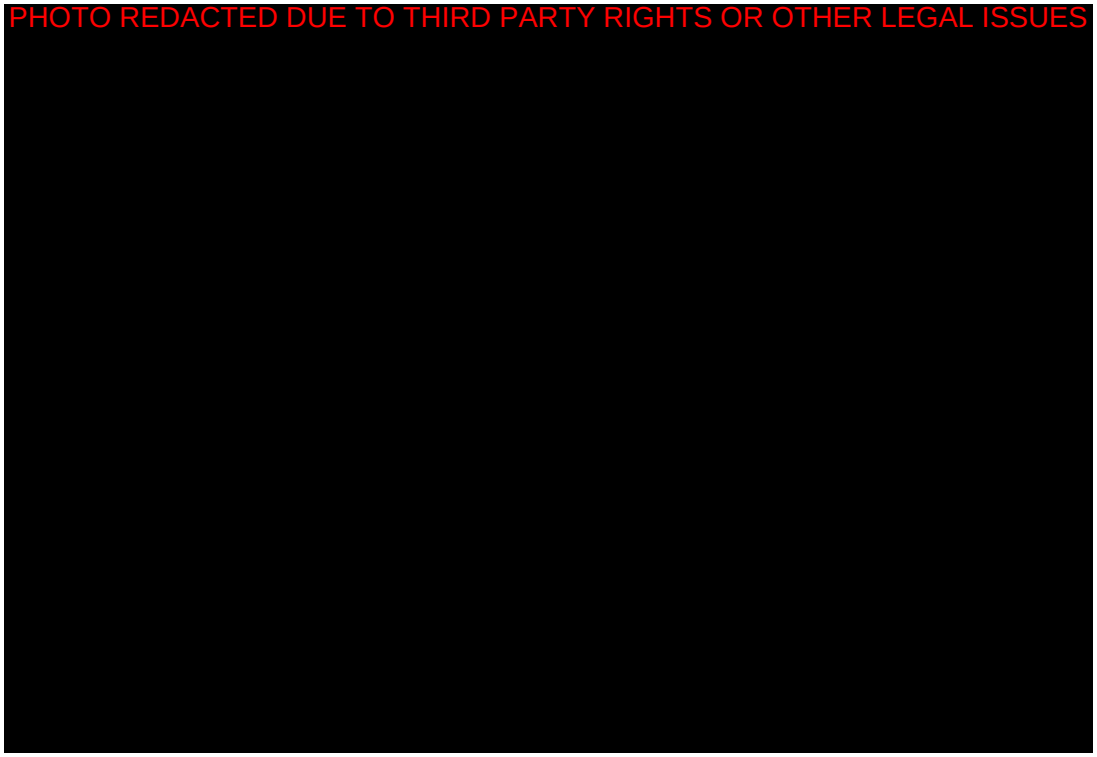
According to spinout.co.uk, a company that gathers data on spin-out from UK universities, during the last decade the University of Edinburgh comes top on spin-out creation. Indeed, Edinburgh features a lot in the most recent data, which show that for informatics across all UK HEIs, the university comes top, and the school by itself is placed 4th.

The Informatics Ventures website lists Engage, Invest and Exploit, an activity that is run by the School, is the 'fiesta' for entrepreneurial activities, and is a big and popular annual event. Although there is no direct commercial activity involved, the event attracts a wide audience, and brings in venture capitalists, some of them from international organisations (such as HP). The view of the project manager is that it would have been hard to attract such audience without the development:

> *"It would be pretty hard to do that without the building. I wouldn't go so far to say that we couldn't have done it without the Informatics Forum Building. But I would go so far to say that without buildings like this to be able to demonstrate that we are doing well, I don't think things would run the same way they currently run."*

Activities

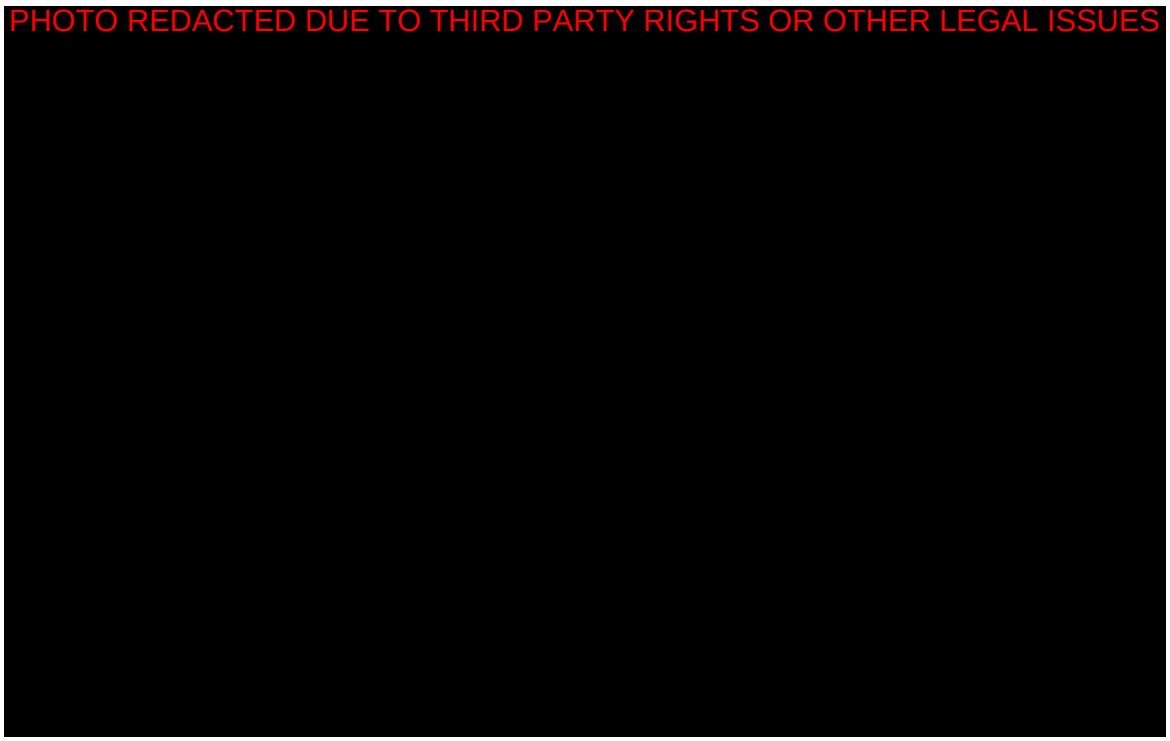
The infrastructure has heavy utilisation. Indeed, the iconic nature of the building is such that it is utilised fully (100%). In terms of usage, the building is devoted exclusively to research and postgraduate teaching. At the time of the case study interview, it was estimated that approximately 250 academic staff and 250 postgraduate students used the infrastructure. The facility is also used extensively by external organisations, including companies, public sector organisations, including other HEIs, and third sector organisations. On the whole, the demand for use of the infrastructure is much higher than was anticipated at the time of writing the proposal for SRIF2006-08 funding. In the last month (May/June 2012), for example, it has been necessary to make some changes in order to meet capacity. This is because academic staff numbers are up, as are research staff numbers, and the number of PhD students. To put these developments into context, the Informatics Forum was built for the capacity that the school had previously.



Outputs

The impacts of the SRIF2006-08 investment can best be assessed within the context of the way in which changes in the UK economy as a whole, and perceptions about the role of higher education, have led HEIs to start to stratify. In crude terms the stratification means there are now different categories of HEI. At one end of the scale are HEIs that are involved in a race to the top; where this means, typically, that they charge a lot for what they do (in tuition fees, research funding, overheads etc), They aim for high quality, and the money they generate is recycled back into high quality provision for their researchers and students. At the other end of the scale are those involved in a race to the bottom; where HEIs cut costs in order to attract more people in to pay for existing facilities and infrastructure. This stratification poses a challenge for HEIs, but one for which in Edinburgh's case the SRIF2006-08 investment offers a riposte. As the Project Manager noted:

> *"If you have a race to the top (as Edinburgh) then what you must do is have a high quality environment, and then rely on that to pull in better quality people, and ramping up that way. This is reflected in Edinburgh's recruitment, where the CVs of applicants are stellar. It is, in fact, recruiting people whose CVs are above the average for the organisation as a whole. Such applicants also tend to ask a lot of questions about the quality of the environment. They don't want to work in places that are dingy, or where they are going to have terrible office space."*



In the case of Edinburgh the Informatics Forum Building is considered a huge asset when recruiting high calibre researchers. The building provides another advantage, especially for the quality of research, in the fact that it brings all the academics in the school together in the same building. This contrasts with the situation previously, where departments and institutes were scattered, and academics had to walk long distances in order to meet with those in other disciplines.

> *"Now if people want to work with others in robotics, systems, theoretical computer scientists etc, they can wander around and see all those other people in one building, and lots of them; and they can't do that anywhere else in the UK."*

The foregoing intuitively suggests there are significant impacts from the SRIF3 investment. However, it is not clear there are formal systems in place for monitoring and evaluating the impacts of the project. The school appears to rely on external information sources for evidence of impact: for example, data collected by external organisations, such as Spinouts, on entrepreneurship; and the RAE rankings. The school can also point to evidence from its large research portfolio, which is currently estimated at over £50 million; and more than £10 million spent on research each year.

Assessing the counterfactual

It is difficult to say to what extent the SRIF2006-08 investment has enabled the developments, benefits and impacts at the University of Edinburgh to occur. The reason is that more than one thing has happened at once: the building, the merger of the departments into a school, and the entrepreneurial funding that came in and provided a boost; and they all happened almost at the same time. Again, the Project Manager's view is instructive:

> *"It is really hard to know whether if you took one part away, it wouldn't have worked. But if you are asking me to guess, I would say the entrepreneurial stuff would not have worked without having the co-location of departments. This building allowed us to move all the academics closer together; and for entrepreneurial activity, you must have that. People who are venture capitalists are very interested in that kind of cluster; they are very keen on meeting people, and want to know where they are. It's a personal thing, and you must have a physical hub for it to work."*

Nevertheless the Project Manager believes the project would not have happened without the SRIF2006-08 investment. This view appears to be partly informed by the funding climate at the time of the investment. Thus, although the university was keen to undertake the development, there was not sufficient private funding to make it viable. In particular, the university needed to find equivalent matching funding from elsewhere. There were two possible ways of finding matching funding. One way was from external sources, and SRIF2006-08 could be considered as such. The other way was to draw on contingency funds to meet a specific need; and the destruction of the research institute in a fire necessitated funding for the re-build. The co-incidence of the two factors stimulated the development.

For the University of Edinburgh, the most severe consequences of not receiving the SRIF2006-08 funding would have been that the university, on its own, would not have been prepared to spend that amount of money, or at least not at that time (in 2006). The effect would have been that the school remained separated and fragmented. In practice, part of the school would have remained at the King's Buildings site, which is located some two miles from the university Central Area; and others would have remained in the city centre. Whilst this arrangement would have been somehow made to work, the result would have been to operate at a sub-optimal level financially. The reason is that the financial costs involved in running the school are considerable, when it is spread as it was then: costs in terms of time and real cash in moving people around; but also costs in lost opportunity, because it makes a difference whether people want to come and work there. There is as well, what can be described as 'intellectual cost'; and in this case the mixing of people now has helped in the development of (new) projects that the school could not do previously. The best example is in the area of Machine Learning. Before the Informatics Forum Building development, Machine Learning, as a discipline, was being taught in the Artificial

Intelligence (AI) department and had only one lecturer. As Machine Learning grew as a discipline and an important subject, there was a need to invest in more academic staff, such that there are currently about eight (8) lecturers. It is acknowledged this would not have been possible in the old AI department, as it would have constituted 50% of the department. This would have also required a bigger space to accommodate the increased number of lecturers and researchers, which would not have been possible in the old premises. Another significant and additional benefit is that Machine Learning appears in almost all the disciplines of the institutes in Informatics. Before the project the institutes were located in different buildings. Now, it has been possible to establish a Machine Learning group, which is accessible to all institutes and every discipline in the school.

Legacy and sustainability

It is perhaps too soon to say how the investment will continue to meet future needs. But the Project Manager believes growth in Informatics in Edinburgh will happen in two ways. First, there will be organic growth from the current operation of the facility. This is already evident, in terms of increased numbers of academic staff, PhD students and undergraduates. In terms of the use of physical space (i.e. from a buildings point of view), the other area of growth, and one that is likely to be more even more significant, is that informatics now has application in a lot of other disciplines. In practical terms, every computer science department has an inter-disciplinary element to it, at least to the extent that computers are used almost everywhere. Thus, it is not only that computer science has become more applied, but because other disciplines are becoming more like informatics. This is evident in biology, medicine, aspects of engineering, physics (including astrophysics) etc. Thus, there are many people who can be classified as genuinely inter-disciplinary, and want to work with others from different disciplines. In this scenario, the anticipated growth is likely to come from these inter-disciplinary areas. If this trend continues, as it might, then it is possible to imagine there would be a high demand for physical space. This, in turn, would mean building additions (extensions) to the current infrastructure.

The Informatics Forum Building has helped to address a major problem of the school, which had run sub-optimally for a long time. Moving everybody into a high quality building of this kind has, therefore, been a step change. It has, though, taken about two years for the school to take advantage of the facility to run at an optimum level.

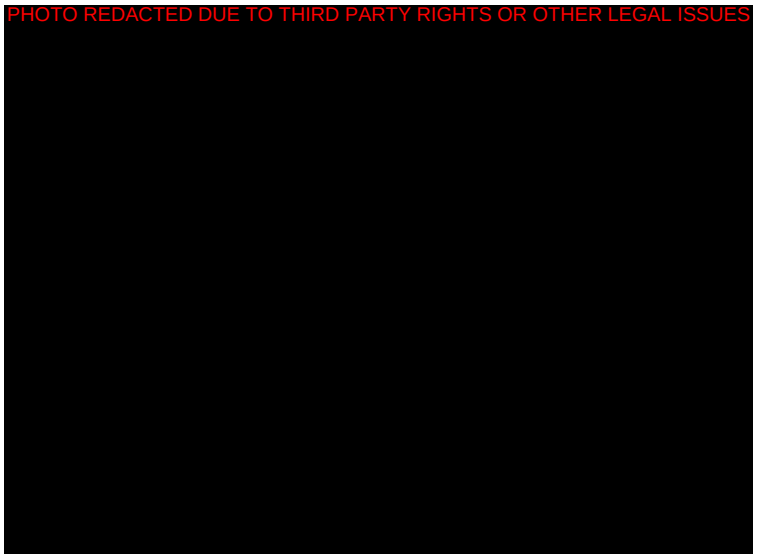
University of Glasgow

Glasgow Biomedical Research Centre (GBRC) and Glasgow Cardiovascular Research Centre (GCRC) Equipment

Value: £1 million

Introduction

The project is concerned with provision of equipment for the Glasgow Biomedical Research Centre (GBRC) and the Glasgow Cardiovascular Research Centre (GCRC). The GCRC is part of the Institute of Cardiovascular & Medical Sciences, and is located in the new British Heart Foundation GBRC Sir Graeme Davies Building that was completed in 2006. The building development itself was a joint venture funded by many independent donors and external organisations. There were charitable donations from the British Heart Foundation (BHF) and the Wellcome Trust, as well as funding from the University of Glasgow itself. In 2003, the University of Glasgow received donations from the BHF for the GCRC building, and from the Wellcome Trust for the adjacent GBRC building. But these donations were not enough, and it required more to start the building. The university stepped in at this point, and the Principal Sir Graeme Davies (after whom the GCRC building is named), allowed the development to commence before all the funding required was in place, and also led the university's fundraising campaign. However, the Project Manager is in no doubt that the SRIF investments, in particular SRIF2 and SRIF2006-08, were the main catalysts instrumental in making the development happen.



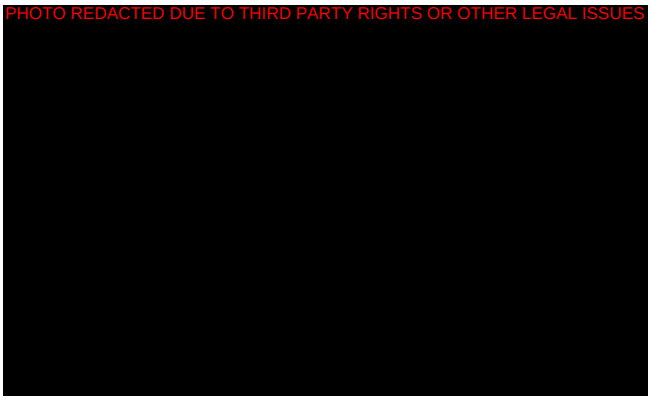
Aims and objectives of the project

The University of Glasgow's application bid identified the project as critical in contributing to significantly improve the environment for many of its research students, allowing them to be more productive in both practical and IT-based activities, and giving them more conducive surroundings for interacting with each other and with senior staff. In this regard, it was anticipated that expenditure on the building complex would pull together groups of scientists from different

backgrounds to promote new ideas. The concept was to develop a Multi-disciplinary Research Centre, which would be allied with the new Biomedical & Cardiovascular Research buildings, in order to facilitate, sustain and improve the [research] environment for cutting-edge research groups across the disciplines.[5]

Specifically, the main aim of the SRIF investment was to allow the university to purchase essential equipment for the study of molecular mechanisms of cardiovascular and inflammatory diseases, with an emphasis on translational research. This equipment was essential to enable academic research staff and students to continue to work in a safe environment, and also to satisfy the legal requirements of the Health and Safety Act.

The evidence from the respondent Project Manager and other senior academics interviewed during the case study visits confirmed that the development has allowed the university to bring together clinical projects (GCRC) with more basic science, such as structural biology, immunology and parasitology. The university fundraising was specifically earmarked for the GCRC, because it was much easier to link it to research into heart disease which, consequently, attracted funding from the BHF. Other funding from the Wellcome Trust and the university itself was earmarked for the GBRC building. The university then combined the two developments to create a single, large project, with the two [separate] buildings connected by a walkway. This has enabled the bringing together of scientists [from the two buildings] on a daily basis, thus encouraging cross institute collaboration and, as well, attracted external visitors from overseas and [postgraduate] research students. As a result there is much cohesion and collaboration, which has been significant for the university. The Project Manager and colleagues were the first people working in that discipline at the university to highlight the importance of bio-medical science research; and they were successful in persuading the university to establish the College of Medical, Veterinary and Life Sciences.



SRIF2006-08 inputs

The Glasgow Cardiovascular Research Centre received £1 million of SRIF funding for the purchase of equipment. It was not necessary to leverage in matching funds specifically to support the SRIF investment because the University of Glasgow had already assembled the necessary funding for the construction of the basic structure of the two buildings, which cost around £25-30 million. The university had also planned meticulously for the running and maintenance of the infrastructure, and from about 2001 had put plans in place to accommodate the new facilities.

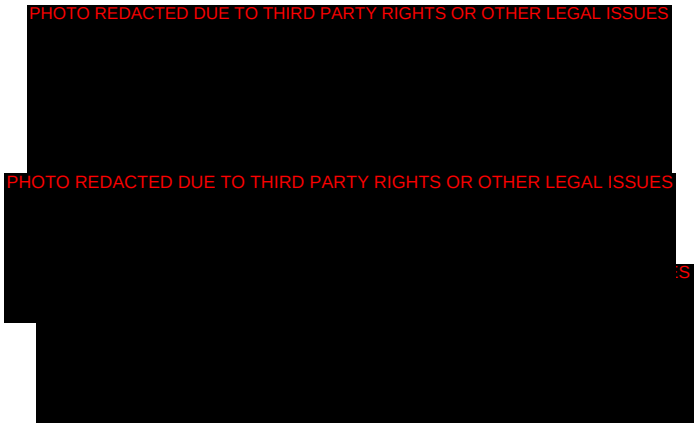
[5] Scottish Higher Education Funding Council, *University of Glasgow SRIF 2006 application*.

Thus, it was anticipated that the running costs would be met entirely from university (core) funding.

> *'From about 2001, we've been planning how we will accommodate this new facility; and the running costs are entirely provided by the university, and have been built into planning from the beginning. So by the time we got this funding from SRIF3, the way we would operate both buildings was fully agreed and costed and funded by the university.''*

Nevertheless, and as might be expected, the project has required non-capital expenditures in addition to the SRIF funding. These are principally operating and maintenance costs, and are estimated, on average, at about £200,000 a year. Although there is some support from research council grant, for the most part the centre charges a 'bench fee', on a per capita basis, for research staff, students and post-doctorates to cover much of the non-capital expenditures. These, together, fund the running costs of all the central services, such as wash-up, glassware and the maintenance of equipment.

Apart from the 'bench fees', the GCRC facilities are used by external organisations. The research centre has linkages with the National Health Service (NHS), so that one floor is given to a clinical research facility and is run jointly with the NHS. Thus, for example, NHS patients are recruited for studies that are run jointly with the research and development of the NHS. This also means that NHS consultants undertake clinical trials there. In addition, NHS nurses work in the centre to support clinical trials. This is a unique example of a successful joint working relationship with the NHS on university premises and using university equipment within the UK.



There is also a lot of other public engagement. For example, there is an apprenticeships programme, and the centre runs a work experience scheme for students from local high schools to learn about working as laboratory technicians. By making the GBRC-GCRC facilities available more widely to the NHS in particular, the Centre has been able to tap into, and attract further investment from non-profit organisations, in addition to regular charitable donations from alumni and individuals, and has used these to upgrade equipment. In this regard, it is notable that the Centre has not received any further investment from central or public sources since the completion of the SRIF grant in 2008 to support the project.

Activities

The SRIF-funded infrastructure has had heavy utilisation since it became operational. It is estimated that the building housing the equipment is utilised on average about 99% of the time a year, while the SRIF-funded equipment itself supports generic research capabilities on average around 60% of the time. It is also estimated that around 80% of the time that the SRIF-funded infrastructure is in use is given to supporting specific research projects, 10% to postgraduate research, and five per cent [each] to undergraduate research and knowledge exchange with external users, respectively. There is extensive use of the GBRC-GCRC equipment, with the usage reflecting the utilisation by different groups of academic staff and students noted above. It is estimated that on average, about 250 academic research staff, 100 postgraduate students and around 50 undergraduate students use the SRIF-funded infrastructure per year since it became operational. Apart from academic staff and students, the GBRC-GCRC facilities are used extensively by a wide range of external organisations. They include small and medium enterprises (SMEs), large companies, higher educational institutions, public sector organisations and third sector and voluntary organisations.

The usage of the infrastructure is well planned. For example, the public engagement programme is a long-standing one. The Parasitology Department (in the GBRC building) always had a strong public programme, and this has been reinforced and extended in the new premises. And although it was always planned that there would be linkages with the NHS, it was a charitable donation that made it possible for the centre to procure equipment for clinical research facilities, such as beds and resuscitation trolleys, at the GCRC. Another activity which was planned, and which has worked even better since the development, was the establishment of links with external bodies. There is considerable international engagement, for example, which brings international colleagues to come and use the facilities, to be trained, and to do joint research at the centre. As a senior academic respondent observed:

> *'At any one time, you can go next door and there will be probably 10 or 20 people who are visiting from abroad, and benefiting from the facilities and the research that we do here.'*

Outputs

Despite the relatively small size, by value, the Project Manager is convinced that the SRIF2006-08 investment has been very important for the success of the development and establishment of the Glasgow Cardiovascular Research Centre.

> *'It was hugely significant. We couldn't finish the building, because [on] every project people are ambitious, and want fantastic facilities, and there isn't enough [money]. Without this £1 million, we would have bits unfinished; we wouldn't be able to equip it. For example, you can't write up a grant for wash-up facilities. No normal grant body, such as MRC, would give you money for this. That's what came from this [SRIF] grant.'*

This view was corroborated by another respondent senior academic, who said that:

> *'There is a concept of a well-found lab (sic) that underpins everything else that goes on in these buildings; and when you raise money to build these buildings, the thing that is most difficult to get is the underpinning money for equipment, the basic*

> *equipment that you expect every laboratory to have; which you can't go to a research council and say "please give me 144 benches and freezers". That won't happen. So this money [from SRIF] provided the foundation of a well-found lab (sic) that allowed everything else to happen, and all the big, expensive equipment, and the grants to flow as a consequence of having a well-found lab. Without that, that, it [the building] would have been a shell that we actually couldn't utilise.'*

The SRIF2006-08 investment has had a high impact in several areas. The GBRC & GCRC buildings are the location for the Institute of Cardiovascular & Medical Sciences, Institute of Infection, Immunity and Inflammation, and Institute of Molecular, Cell and Systems Biology. This means that three out of seven institutes in bio-medicine research in Glasgow are accommodated at the GBRC/GCRC development. The existence of the building and equipment has changed the way the research centres carry out research work in the areas of discipline that are accommodated there. There is now more international collaboration, well-funded laboratories, and collaboration between clinicians and scientists; which is important for producing translation research, i.e. research that matters to patients. All these would not have been possible if the building did not exist.

In terms of other impacts, the research centres have attracted increased grant funding since the infrastructure became operational, which is a reflection of national and international recognition of the quality of research undertaken there. The centres now attract EU money into the UK; which they could not do before. They also attract international students, and there are at least three Marie Curie programmes for international PhD students, and there are further collaborations with European universities. More importantly, the GCRC has developed close collaboration with Columbia University; so that there are researchers from New York [Columbia] using facilities at the centre for work on polyomics, genomics on patients and proteomics.

Thus, there are measurable impacts on every level. But the impacts can be assessed more particularly by the extent to which research staff and students are attracted to the university and departments because of the availability of the infrastructure. For GCRC, the Vice-Chancellor of a university in Malaysia is due imminently to come and sign an agreement for a joint Masters degree programme. It is contended that what 'swung' it was the facilities in the two buildings, which impressed the delegation from Malaysia during their visit, as well as the research being carried out in the buildings. It is anticipated that there would be further academic impacts in the future

The respondent senior academics interviewed believe there are wider impacts from the SRIF-funded infrastructure for the UK government and for society as a whole.

> *'It gives the public very good understanding of science. It gives very good connections to joint work with industry, because when they come here they can see the quality of the people, and that is an impact that is growing. It takes time to attract good people, to get them to come, to build up your reputation. But that is now growing exponentially.'*

In this regard, the usage of the buildings and equipment by external organisations, in particular, is welcomed by the senior management of GCRC. Whilst it was always hoped that this would be the outcome at the time of the SRIF (2006) application, that dream has now been realised. This is not to say that the outcome has been completely unexpected. Rather, the centre had a high ambition at the outset that is being realised.

In other respects, much bigger impacts have been realised in areas that are critical for the GCRC's future development, by attracting high calibre staff. According to one respondent senior manager:

> *'What exceeded our expectation is how big asset these buildings are for recruitment of permanent staff; not just for people to come for a while, but recruitment of high quality professors. The most difficult recruitment in academia is leaders; people to truly make a difference and stay. And we have been extremely successful because of the infrastructure. Prior to this (i.e. before 2006) we would have stood no chance. So that for me is a major step.'*

Assessing the counterfactual

The Project Manager and senior academics interviewed for this case study acknowledged that there were no alternative funding sources available to the College of Medical, Veterinary and Life Sciences at the time of applying for SRIF funding for the GBRC-GCRC equipment. The University of Glasgow had exhausted all the capital investment that was available; and at that stage it was either SRIF or nothing. The Project Manager believes that without the SRIF2006-08 investment, there was a strong possibility that the building would have stood as a shell, because there would have been no money to 'kit it out'; and there was a real possibility that the university would have turned its attention to other competing and urgent priorities. The issue then would have been which elements of the overall project had to be prioritised, and with what consequences. A respondent senior academic manager spelt out the implications for the Centre of having to make that choice:

> *'If we didn't have the basic underpinning that SRIF gave us, colleagues would not have moved into the buildings. If you want to move your best people into new accommodation, you have to provide that underpinning even to get them to move at all. And so the building would not have been occupied without this basic equipment.'*

As to whether there were alternatives, in terms of prioritising the level of investments, the Project Manager is categorical that the usage of the new accommodation was itself the end result of the department prioritising its needs.

> *'We only chose the best researchers to move to this building; and it was occasionally a painful process. We had other cardiovascular researchers and other immunology researchers whom we didn't bring here. We brought here well-funded groups who were excellent, and internationally competitive, and could make a difference. We didn't bring here everybody who was in the old building. We left them behind; some in not great accommodation in the old hospital building. But that was necessary because we were already selective.'*

The significance of the SRIF funding can also be seen from the lengths the institute went to ensure that if had identified the right priorities for the investment. The Project Manager acknowledged that, just before the end of the project, there was a lot of pressure on the department not to finish the clinical floor, which is now an integral and important part of the GCRC. But in the Project Manager's view:

> *'That would have been an enormous mistake because the whole translational and impact on health idea would have been dead for years to come. That is why we went out to raise more and more money. And SRIF came at just the right time to cover all*

> *the things we couldn't cover from other moneys. And that allowed us to use the wonderful last donation to furnish the clinical floor.'*

A respondent senior academic manager supported this view:

> *'I don't believe we could have got these facilities from any other source. Without this [SRIF] the building across the road (GBRC) would not have been finished; and the best people would not have come into them.'*

The high impact of the SRIF investment, compared with its value (£1 million) is explained by the Project Manager thus:

> *'If you write a grant proposal, it's not difficult to get a grant for a big, fancy piece of equipment. But if you want fridges to go underneath benches, or the nuts and bolts of a wash-up machine, or central facilities, there is no way you can get that.'*

The Project Manager and the respondent senior academics interviewed were in no doubt that the most significant consequences of not receiving the SRIF funding would have been that the initiative as a whole would have floundered; or the very least, would have taken longer to finish. It is also highly likely that it would not have been the success it is now. The fact is that the type of research carried out in the two buildings is very competitive nationally and internationally; and it is highly likely that if the project had been delayed, the centre would have lost its competitiveness, especially at international level.

Legacy and sustainability

The lifespan of the investment will depend on the type of equipment. For example, the wash-up equipment has a relatively long lifespan of about 15 years. But other equipment, such as x-ray developers or water purification systems would be expected to last about 5-8 years, whilst a high speed centrifuge will last about 10 years. This means that the GCRC has to build into its financial planning ways of building up resources to meet the cost of replacement. The sources of finance for maintenance of the equipment are a mixture of core [university] funding and external grant funding. These are supported further by the maintenance guarantees which are available with the purchase of specific equipment from manufacturers, as well as 'bench fees'.

Notwithstanding the capability for meeting the present costs of maintenance and replacement, the Project Manager believes there is a clear need for further capital investment in the near future and beyond, by drawing lessons from personal experience.

> *'Across the UK, as I travel and see what people build, there are lots of institutes like this. If there is no continuation, and if we forget that we build fantastic facilities but need to maintain them, there could be a lot of disrepair, disuse and wastage.'*

Indeed, the need for further SRIF funding to help in maintenance and sustainability of research capital infrastructure is increasing, particularly as the way that research councils fund equipment has changed. HEIs now receive only about half of research council grants or funds they apply for, and are expected to find the rest from other sources. As a result, HEIs are increasingly compelled to prioritise their provision of grant-funded equipment, which tends to be 'high end' equipment, with departments expected to provide the more basic equipment themselves. It is not clear how the University of Glasgow will deal with this situation in the coming years.

There is a great deal of satisfaction with the success of the SRIF2006-08 investment and that it has met its overall objectives. The investment made a significant contribution towards innovation in research capital funding at the University of Glasgow. The Project Manager reflected that:

> *'This is the first time ever that joint fundraising has happened (i.e. between the BHF and the university). It's never happened before, and is not likely to happen again. It is very difficult to bring two fundraising teams to work together. So there was another level of leverage, with local and national fundraising, which was unique. The local fundraising team trebled the initial donations from BHF, from £5 million to £15 million in two years.'*

The lesson to be learnt from the project is how initial funding is able to leverage in significant and high levels of funding. The Project Manager believes that developing the two buildings together, rather than separately, was an enlightened way of doing things because:

> *'We have produced much more for the same amount of money than we would have, had they been two separate projects.'*

University of Manchester

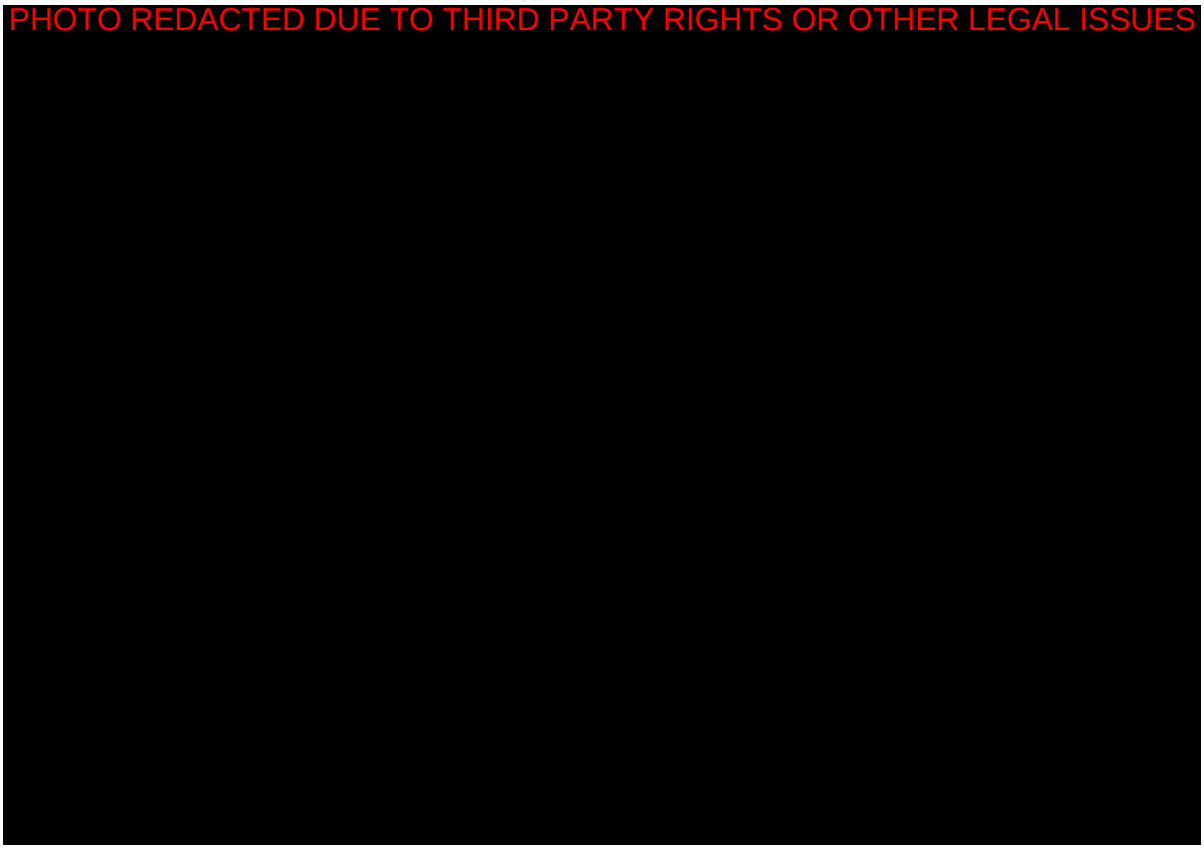
Project: The A V Hill Building (SEP: A new build laboratory building)

Value: £11,595,506 (Project cost = £35.7 million)

Introduction

Specifically, the SRIF infrastructure was the Smith Extension Project (SEP), an extension to the Faculty of Life Sciences' existing Michael Smith Building. The project was overseen from its inception, through commission, and to completion, by a client team who were also part of the design team for the project. The client team included a senior academic, a senior administrator (Project Manager) and two technical managers. The team was responsible for the interface with the architectural design team, and articulated the vision for what was needed.

The design itself was conceived to provide a more generic, flexible working laboratory space, in order to get the best use out of it. This was because, in the past, the tendency was to design a laboratory to the specific requirements of a principal investigator (PI), but this ran the risk that if that PI left, then very often a new laboratory would have to be remodelled, and often at significant cost for the next PI.



Aims and objectives of the project

The investment was considered to be a priority for the Faculty of Life Sciences, and was driven by two important factors. First, prior to the development, a large section of the faculty was based in

accommodation that was constructed in the 1970s. That building did not have modern infrastructure, such as extract ventilation systems etc, and was not compatible with some of the modern laboratory techniques that are used now. Alongside this, there was a need to integrate the biology departments from the former University of Manchester Institute of Science and Technology (UMIST) and the former Victoria University, and consolidate these on one site. Second, there was an ambition to expand, grow and get better, which involved recruiting new scientists from around the world to come and work at the faculty. In order to do this, it was important for the university to have good infrastructure in place to support that ambition. In this regard the development was needed to make the faculty competitive in science research both nationally and internationally.

SRIF2006-08 inputs

The University of Manchester received approximately £11.5 million of SRIF funding towards the construction of SEP. This represented a third of the total project cost of £35.7 million.

The project leveraged in additional funding, mainly from the North West Development Agency (NWDA) at the time. In any case, it was always envisaged that SRIF would fund only part of the cost of development, and that additional funding would come from a variety of other sources. The NWDA, at the time, had a particular focus on biomedical research and biomedical interaction within the region itself, which made the agency a good partner for some of the additional investment required. Much of the rest of the funding came from the university's own resources.

There were no particular problems encountered during the implementation of the project. In addition to the cost of development, the project also requires non-capital expenditure, which is estimated at around £1.1 million per annum, to cover operating and maintenance costs. The university had anticipated to a large extent the non-capital expenditure for the project. In particular, the infrastructure itself is joined to other buildings via a bridge link. Joining up four buildings together, which the project made possible, has created overall efficiency savings in non-capital expenditure. This means it is also possible to share services between the buildings in a way the university could not do before, including the movement of people.

Activities

As might be expected for this type of development, the SRIF funded infrastructure has very high utilisation, and is used 100% of the time. With regard to specific activities, the infrastructure is used on average to support research for 80% of the time it is in use, and 20% for postgraduate research.

The usage of the infrastructure appears to have been well planned. It was always recognised that it would not be possible to accommodate the whole of the faculty in the new building, hence the selection of potential users on specific criteria. Indeed, whilst at the time the infrastructure would have adequately met demand of existing staff and students, it was decided that the building would be used almost exclusively by people who are research active. This means, for example, that the building does not accommodate academic staff who only teach, and do not undertake research. In this regard the university was quite clear that the building would predominantly house people

who were neuroscientists or immunologists, and this was also the remit for the client and development teams assembled for the project.

> *'So, we didn't find ourselves in a position where we would put up the building, and we didn't know who was going to go in. We were always clear who was going to use the building. And that also helped the design, that we were designing a building for specialities.'*

The groups using the building also reflect this priority of the university. It is estimated that approximately 40 academic research staff, 100 research staff and 60 postgraduate students use the infrastructure on average each year since it became operational.

Demand for the infrastructure does not appear to have been affected by the economic downturn. On the contrary, the top floor of the building, which was not fitted out at completion of the building, is about to be fitted out, as the faculty has recruited new staff as part of the plan to maintain its competitiveness, nationally and internationally. The demand is being driven largely by the Research Exercise Framework (REF).

Outputs

Most of the staff in the building previously worked in a system where they had individual laboratories, with an office within this. In this system, the individual lead researcher would have a group of about 4-5 people working for them, all of them working in that enclosed space. In contrast, the new building is open-plan, and it is claimed that taking the physical barriers away, has encouraged greater interactions between researchers. The open plan within the new laboratories also enables greater sharing of equipment, techniques and ideas, and encourages people to collaborate more closely than they did before. The bridge links between the building and others also facilitate people moving between them, thus stimulating ideas in the process. The other significant impact is the increased morale among people working in the building. As the Project Manager noted:

> *'The space that people worked in before was of very poor quality, and when they come into this building which is flooded with a lot of natural light because offices and seminar rooms have huge ceiling to floor glass walls and windows create a vista, and encourages people to work more closely together, rather than be hunched over and huddled in a dark office space in the old building.'*

Indeed, the positive impact of working in a much improved environment was highlighted by a senior technical manager.

> *'Previously, I had a cupboard in Stopford (old faculty building). I was in an office that was on a corridor. I had no natural light. It was literally a dark corridor, so if someone turned the light out I could not tell you what time of day or night it was. But here you can see we have floor to ceiling windows; and it just lifts the mood.'*

Intuitively, therefore, it might be expected that improved facilities and improved space would also result in improved quality of research. This is partly attributed to the increase in interaction between researchers, but also to the quality of the facilities provided in that environment. The case study interviews with internal users provided useful insights about impacts of the SRIF

funded infrastructure, with respect to the facilities and internal research networking. From a research associate:

> *'Regarding the way we do experiments, this is a high quality research environment, and we are doing research in standardised environmental conditions. We have a nice, clean and modern building, which has improved the way we carry out research. For example, the old building was cluttered, so experiments could not be stored in controlled environmental conditions. Here, we have cold rooms, and this means that you have more consistent results. We are more aware of which equipment we can use because we can see them, and you also see more people, and what they are doing, so you can discuss your work with them.'*

This view was reiterated by a research fellow:

> *'The biggest difference by far is to the science we can achieve. There is increased collaboration and increased interaction, because our previous building was very segregated and closed off. It's [SRIF infrastructure] by far a much nicer place to work, in terms of the quality of the premises, the light, state of repair and so on. So the two things are that the quality of work environment aspect has greatly improved, but the science perspective has also improved.'*

There are as well individuals who have purposely relocated to Manchester, or chosen to remain, because of the availability of the new research facilities. Here too, the evidence from interviews with users suggests that the quality of the infrastructure has enabled the recruitment and retention of high calibre research academic staff, as well as high quality technical support staff. The views of three respondents are illustrative.

From a research fellow, who has recently become independent to run their own laboratory, working in metabolism and bodyweight regulation:

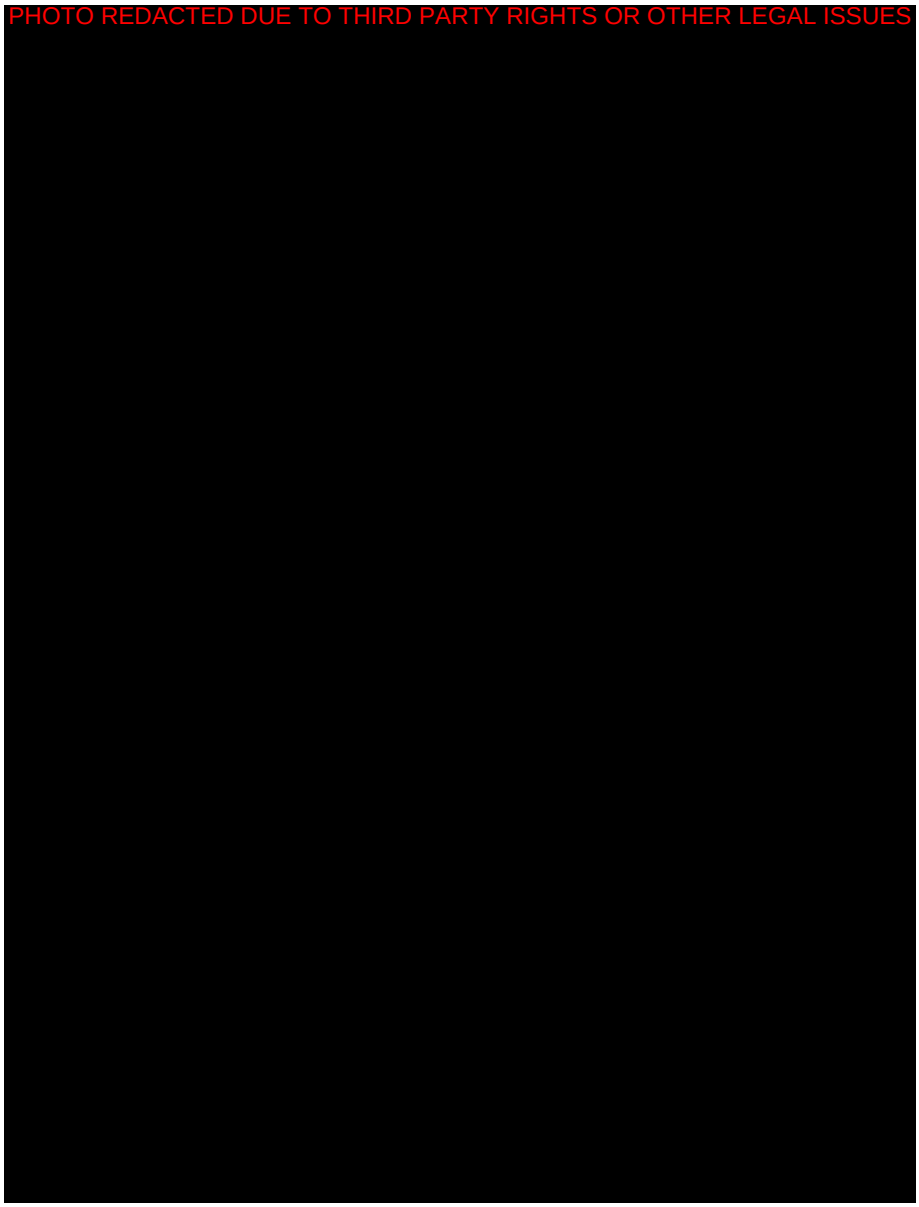
> *'For me personally, I had negotiated a position outside the country, and certainly one of the deciding factors for me staying was the facilities. So very directly for me, it was eight months ago that I made the decision whether to stay or not. If you're trying to get people who have options to go elsewhere, then it makes a difference, for sure. It also shows internally because everybody wants to work in this building. There is a huge demand internally.'*

From a research associate doing post-doctoral research:

> *'It is a much better environment. We are all in the same place, which makes it easier to interact with other people. This influenced my decision to continue and do my post-doctorate here because everything you need is here; it's all in one place, and you know if you don't have something in your lab, you can find it within the building, for the most part.'*

And from the senior technical manager:

> *'When we do interviews for technical staff... they are gob-smacked by the state-of-the-art facility. And they can see it from people who work here, and word spreads that it is a magnificent building. And it is clean, and it feels healthy, with lots of air and lots of light, so you don't feel as oppressed as you were in Stopford. It's got a much better ambience.'*



There was some evidence that the new building and its facilities are also accessed directly by other external organisations and individuals. Increased collaboration with external companies is demonstrated by the fact that there has been a significant increase in the number of companies that want to collaborate with the faculty since the completion of the project. For example, a multinational pharmaceutical firm has seconded an individual to work in the building one week a month, and collaborates with researchers within the building. The people with whom that individual collaborates used to be located in different buildings, but the new infrastructure has brought those researchers together under one roof, making it much easier for them to work with the secondee. It is true to say this type of interaction was not planned, but has been enabled by the provision of the infrastructure. The overall impression gained from the case study research at the University of Manchester is that external companies collaborate on several levels with individuals working in the building. It is true to say, though, that there are no formal systems in place for the monitoring and evaluation of the impacts of the project.

Assessing the counterfactual

The Project Manager's view is that there were no alternative sources of funding for the project, at least not on the scale and flexibility of the SRIF funded infrastructure. The Project Manager acknowledged there are charitable organisations and foundations (e.g. the Wolfson Foundation) that fund research capital infrastructure, but that these tend to be for specific research projects, and are not on the scale of the SRIF investments. The Project Manager was also in no doubt that without the scale of the SRIF funded infrastructure, the university would have likely sought a compromise solution to address this particular backlog of under-investment by refurbishing the existing old buildings, albeit with unsatisfactory results.

> *'Without the scale, we probably would have ended up trying to refurbish the other space. The building that most of the people in here came from, yes you could have refurbished it, but it still had huge limitations. It is a huge building, very dense, the light penetration is still poor because of the size of it, and so you'll never get to this sort of environment.'*

The Project Manager was convinced furthermore that the most significant consequence for the faculty had it not received the SRIF funding would have been loss of very high quality research staff. The faculty had already lost valuable research staff, most of who had left because of the poor quality of their working environment; and there were others who had indicated they were looking to move elsewhere. As was noted earlier, there are people who have stayed in Manchester because of the infrastructure that has been put in place through the SRIF investment.

Legacy and sustainability

The University of Manchester has put plans in place to maintain and sustain the SRIF funded infrastructure. The university is currently looking at its strategy for the area of the campus where the building is located, and has drawn up a five year plan for refurbishment of buildings on the whole site, including the SEP building. The overall plan is driven by the university looking to maintain its competitiveness by hiring high profile researchers who will be provided with a high quality working environment. In this regard the SRIF investment may be seen to help clearing the backlog of underinvestment in research capital. On the whole, the SRIF2006-08 investment went a long way to helping the university clear the backlog of underinvestment. There is, overall, very high satisfaction with the SRIF funded infrastructure, partly because of the build quality, but also because it has significantly lowered the non-capital costs of maintenance of capital infrastructure.

University of Oxford

Central Proteomics Facility

Value: £2.9 million

Introduction

Proteomics is a powerful and informative approach for establishing and measuring an indicator (i.e. a molecular feature or biomarker) that can provide clues about the underlying biological process when monitoring a disease and its progression. Recent years have seen important technical advances in the analytical equipment for measuring molecule features (biomarkers) much more precisely. These are mostly proteins and peptides. SRIF2006-08 supported the procurement and installation of mass spectrometry equipment to support research in Proteomics, specifically equipment encompassing a range of technologies involving protein separation and the establishment of the identity, amount and modification of individual polypeptides and protein cohorts. The technique of measuring the mass of proteins and peptides based on mass spectrometry is very powerful, and measurements can be made of hundreds and thousands simultaneously, thereby providing a broad picture of the biological processes at work in a diseased individual and establishing how it differs from those of a normal person. The technology has been very successful in the area of infectious diseases such as HIV and hepatitis.

SRIF2006-08 inputs

The overall project funding for the Central Proteomics Facility from SRIF2006-08 was £2,810,051 of which half (£1.4million) came to the Sir William Dunn Pathology School and the other half to the facility located at the Centre for Cellular and Molecular Physiology, Wellcome Trust Centre for Human Genetics in Oxford University. This case study only covers the former.

In addition to the SRIF2006-08 funding further funding was obtained from both the public and private sector to extend the scale of the project and to cover replacement costs. The spending of SRIF2006-08 money subsequently attracted £0.5million from two local trusts plus some additional money from the Dunn Pathology School and the Medical Sciences Division. Average annual non-capital operating and maintenance costs are estimated at £140,000.

Within the university's overall research capital strategy the project was selected for funding centrally from a long list of projects submitted by departments and divisions. Priorities and project selection were made by applying the general criteria of prospective research excellence but adding that the projects should have been in existence for some time and should not have been generated by the prospect of SRIF2006-08 money. In what was perceived to be a burgeoning field of great scientific and medical potential, with rapid advances in technology increasing the speed of analysing the proteins in samples, it was also recognised that obsolescence was accelerating with equipment becoming out of date within two to three years for software and five

years for hardware. Pressure from external granters of research funds and contracts was an additional factor taken into account in the selection process.

Activities and use of project investments

SRIF2006-08 funding was primarily used to acquire new equipment to support both generic research capability and specific research projects. Some funds were also used to support the adaptation of existing buildings.

The facilities provided by this project are used very intensively for research with equipment and buildings in use 7 days a week, 24 hours of the day, for most of the year. The equipment is used for research by both academic research staff (30 individuals) and postgraduates (20 individuals) and some external organisations, particularly other parts of the university and other HEIs and, as well, commercial organisations and third sector organisations undertaking research. Demand has also risen as the university has moved to full economic costing (FEC). This encourages the Centre to look for work, assisted by ISIS Innovations, with the result that there are now surpluses to plough back to update equipment.

Impacts, outputs and benefits

At a general level the main impacts on the university's research have been in contributing to new science by generating streams of data to move analyses towards 'systems biology'. Systems biology is a holistic approach focusing on complex interactions within biological systems allowing many feedback effects influencing the behaviour of the system.

Specifically, SRIF2006-08 has had a major impact on the quantity and quality of research of the school, opened up new areas of research and significantly enhanced the reputation of the school. More research funding has been attracted and researchers in the school are able to engage more effectively in knowledge exchange.

With respect to the university's research capability the shift towards a 'systems' approach has required greater interdisciplinary working, a major challenge, which in turn requires new teams and skill sets including mathematical modellers and statisticians. In time this will allow new links to be made to medical/patient studies and clinical links to DNA analyses.

The new equipment has indirectly increased the number and quality of staff recruited and has had a high impact on improving the skills of research staff and the quality of research training. The project has kept Oxford at the cutting edge in terms of attraction of scientists and research outputs, and a major impact has been increased collaboration across academic disciplines within the university and more interactions with other universities.

Positive impacts also extend to newly generated non-academic external partnerships with industry that have been encouraged by new equipment funded by SRIF2006-08. A major benefit is in the external contract use made of equipment (and in research grants now possible because of the equipment). The pressure from companies offering grants, wanting equipment use and offering research contracts has all grown significantly. Improved access to new equipment and

cutting edge research capability has contributed substantially to the innovative capability of companies and reduced their costs of innovative activity.

In the absence of SRIF2006-08 the acquisition of new state-of-the-art equipment (software and hardware) would not have been possible and it is clear that the quantity and quality of research outputs noted above would have been significantly lower. Knowledge exchange income would also have been moderately lower as would the number of staff employed. With such a new technology project, grants from alternative sources would have been difficult to obtain. Moreover, because the funding was for a multi-equipment package that could not usefully be disaggregated, efforts to obtain partial funding support would have raised difficulties in prioritising elements of the package and would most likely have been unsatisfactory.

Legacy and sustainability

The project has fully met its objectives enabling the acquisition of state-of-the-art research equipment and largely securing the necessary scale of research infrastructure. It has provided a platform for subsequent advances, in both research capabilities and in scientific outcomes. Also the backlog of investment was largely made up by this project. However over the next five years further substantial investments will be required of at least £1.5 million focused mainly on the technological development of the existing equipment rather than in new concepts and new equipment.

Constraints

The main issues/constraints faced in ensuring that the project fully met its objectives related to funding but there were also issues relating to key scientific personnel. The long time taken to secure funding was perceived as of particular importance. Other funding issues of somewhat lesser importance included funding insufficiency, funding inflexibility, increased funding requirements and unexpected operating and maintenance costs. Support for personnel with the experience to use and operate new technologies is critical. For example in the context of proteomics, the bioinformatics infrastructure and personnel were pointed to as being poorly supported but of critical importance. Recent technologies such as mass spectrometry based proteomics produce vast amounts of data on a biological system but bioinformatics resources and infrastructure to extract meaning and understanding is critically important.

University of Plymouth

Consolidated Radio-isotope Facility (CORiF)

Value: £376,761

Introduction

Research in the field of radioactivity has assumed increasing importance in public policy debates in recent years, as a result of the decommissioning of the UK's ageing nuclear reactors and the search for alternative sources of energy. Academic researchers at the University of Plymouth have noted a particular upsurge in interest in radioactivity research in marine and catchment environments at national and international levels, with particular focus on the detection of gamma counts from very small samples. This includes environmental radioactivity applications in climate change and sustainable environmental management research.

The Consolidated Radio-isotope Facility (CORiF) at Plymouth University is a dedicated laboratory for the manipulation and analysis of natural and enhanced radioactive materials. Commissioned in 2006, the CORiF project now boasts three state-of-the-art gamma spectrometers and two liquid scintillation counters. Two of the gamma spectrometers and one of the liquid scintillation counters, together with various other pieces of equipment, were purchased as part of the SRIF2006-08 investment in the CORiF project. The funding of CORiF was one of three projects supported at Plymouth, and accounted for around 16% of the university's total SRIF2006-08 portfolio.

The CORiF Group is an inter-faculty and interdisciplinary grouping, involving young lecturers, readers and professors. The group received £1 million of grant income over the three years prior to the SRIF2006-08 funding, fuelling its ambition to become a NERC-recognised and sponsored facility.

Aims and objectives of the project

At the time of the SRIF2006-08 funding allocations, the consolidation of the university's science research capacity as far as possible onto one campus was a prime objective for the University of Plymouth.

Prior to the SRIF investment, the existing research equipment and facilities of the CORiF Group were in different areas of the university campus, and on various floors within the same building (e.g. the Davy Building), which prohibited a number of research activities from being carried out, causing inefficiencies which resulted in spending significant amounts of money buying in services, such as geochronology from other institutions. In order to address this problem, it was proposed to fully consolidate resources into a single new facility. The CORiF concept would, therefore, allow the university to re-develop part of its infrastructure, which was considered to be of low quality and was under-utilised.[6] The consolidation of resources was also intended to bring together a range of advanced instrumentation into a single ergonomic teaching and research

[6] Higher Education Funding Council for England, *University of Plymouth SRIF 2006 application.*

space that was capable of accommodating a larger number of research students and staff than previously. It was hoped that this would increase the amount of experimental work being done and raise productivity, whilst also supporting the university's broader objective of resource consolidation. It was expected that the move would bring about substantial efficiency gains, make more effective use of research funding, generate improvements in training and increase the effectiveness of the CORiF Group in attracting external funding. Lastly, the project sought to bring the CORiF Group facilities in line with current safety regulations for the use of radioactive materials.

SRIF2006-08 inputs

SRIF2006-08 contributed £376,761 to the CORiF project, accounting for around 90% of the total cost of refurbishment of buildings and the purchase of new equipment to support specific research projects. The remainder of the project costs was funded from university internal sources. It was also anticipated from the outset that the infrastructure would require non-capital expenditures, mainly operating and maintenance costs, estimated at around £10,000 per year, which would be covered from core funds.

The CORiF project has received further capital investment in the years following the completion of the SRIF2006-08 grant, for the purchase of additional instrumentation to extend the project scale. The additional investment has come from the public sector, complemented by additional funds from commercial sources, particularly organisations in the biomedical field, and consultancy. The CORiF Group intends to further broaden its capabilities through continuing investment.

Activities

As part of the implementation process, the CORiF Group was required to prepare a detailed business plan in order to bid for SRIF2006-08 funding, as part of the internal competitive tendering process ran by the University of Plymouth to determine the distribution of its funding allocation. As the consolidation project had already been identified as a priority some time before the SRIF2006 application, the CORiF team's detailed forward planning was successful in the competitive process. The original proposals submitted for the bid were closely followed at the implementation stage; and it is considered that the implementation process itself went smoothly, with only minor difficulties encountered. The difficulties related mainly to the stringent licensing requirements of the Environment Agency with respect to the handling of radioactive materials, but were successfully met, nevertheless.

The CORiF facility is fully licensed by the Environment Agency, and the University of Plymouth is now one of only two universities in the UK to have ISO 9001 certification, which it received in 2007. Through this certification, the CORiF Group is able to deliver consultancy services, and training for staff and students, to industry standards. The proceeds from its consultancy services enabled the CORiF team to purchase a third gamma counter in 2010.

The CORiF facility is now operational almost round the clock. In terms of usage, it is estimated that the refurbished buildings are utilised on average about 80% of the time since it became operational. The instruments that support specific research projects are utilised on average about

95% of the time (except during maintenance), and equipment supporting generic research capabilities, about 70% of the time. There are some differences in the usage of the infrastructure for various activities. It is used to support research for half (50%) the time; for postgraduate research about 30% of the time; undergraduate research, 10% of the time; and knowledge exchange with external users about 10% of the time the infrastructure is in use. Usage by different groups of university staff and students appears to be low. It is estimated that only 10 academic research staff, 8 postgraduate students and 10 undergraduate students use the SRIF funded infrastructure.

The facility is also used by external organisations, including SMEs, other UK higher education institutions, as well as overseas universities. External users are able to access the facilities for a set fee, which is calculated using full cost pricing, which generates surpluses that can be used to maintain the equipment and support future capital investment requirements.

Outputs

The academics participating in the case study interviews at the University of Plymouth highlighted the significance of the SRIF2006-08 investments as a substantial funding stream for a university of this size; it is typically unable to attract the scale of investment funding that the UK's larger research universities command. Consequently, it was felt that SRIF2006-08 had played a vital role in elevating the work carried out at Plymouth to internationally-recognised levels, but also enabling the university to extend its outreach to external organisations at the same time.

More specifically, it was considered that the SRIF funded project has had significant and high impacts in research-related activities, staff and training, and on internal and external collaborations and partnerships. The research-related impacts included increased quality of research; increased research productivity; opening up new areas of research; improving the reputation of the CORiF Group; increased ability to attract research funding; and engaging more effectively in knowledge exchange. With regard to staff and training, it is considered that the CORiF project has had high impacts by improving staff morale; improved staff research skills and staff retention; and improved quality of research training for students. It is considered that the facility has had a relatively low impact on the number of staff recruited. In relation to partnerships, a high impact is noted in increased collaboration between academic disciplines and significant enhancement of external academic collaborators and clients. But there has been only moderate impact on strengthening existing external partnerships with industry, for example; and a low impact in the generation of new non-academic external partnerships with industry. Notwithstanding this, the ISO 9001 certification that followed the consolidation of CORiF facilities appears to have increased the levels of external engagement and knowledge exchange conducted by the group. This increases the financial sustainability of the group by substantially increasing commercial income and reducing dependency upon public funding. It also enables CORiF to produce more 'industry-ready' undergraduate and postgraduate students, who are now experiencing greater exposure to external organisations as part of their studies than they would previously have been able to.

Consequent to achieving ISO9001 accreditation, in 2012 the CORiF Group, along with other ISO-accredited laboratories in the university, participated in the S-Lab national competition on the

"Effective Laboratory" funded by the HE STEM Programme. The University of Plymouth won the category "Making a Difference" against strong competition from its peer-group.

Assessing the counterfactual

The precise additionality of SRIF2006-08 is difficult to quantify. The most likely eventuality in the absence of the SRIF investment would have been for the project to have not gone ahead at all. It was thought that whilst other sources of funding were technically available, the University of Plymouth would have found it extremely difficult to access such a level of funds when competing with universities with a long-established reputation for research.

Whilst it is believed that such an outcome would have had moderately detrimental effects upon the quantity and quality of research conducted by the CORiF Group, the impact upon the number of postgraduate students trained would have been far more severe in the absence of SRIF2006-08.

However, examining the positive outcomes, the Group would have not had the opportunity deliver enhanced, advanced training using modern instrumentation, as well as improved working practice, and to develop an additional income stream.

Legacy and sustainability

On the whole, it is considered that the SRIF funded CORiF project satisfied its overall objectives to a considerable extent. In particular, the project allowed the university not only to acquire the necessary scale of research infrastructure to meet its overall research objectives in this field, but also to acquire state-of-the-art research infrastructure. The investments made have been seen as very effective in raising research capability and the reputation of the university and the CORiF Group. The project is thought to have played a significant role in allowing the CORiF Group to alleviate the backlog of past underinvestment. Moreover, the instrumentation is continuing to meet the needs of the team some six years after the funding was granted, and the continued flow of contracts suggests its ability to deliver excellent science will be secure in the medium-term.

University of Ulster

Process Nano Engineering Centre

Value: £1.5 million

Introduction

Over this past ten years the Engineering Research Institute (ERI), based at the University of Ulster's Jordanstown campus, has seen the strategic development of a Nanotechnology facility, with many key research themes being addressed by the institute. However, the area of nanoparticle production had received relatively limited attention, and this provided the motivation for a team of scientists and engineers, headed by the Project Manager, to apply for SRIF2006-08 funding (in 2005) in order to address this particular weakness. The overarching objective was to develop the university's Process Nano Engineering Centre (PNEC) into a centre of excellence through the refurbishment of space and provision of state-of-the-art equipment. At the time of the application for funding, a number of diverse research units throughout the university – NIBEC, ECRE (Composites), Built Environment, Fire, Biotechnology etc. – had all shown interest in the co-development of such a facility, in order to derive new concepts related to the benefits of a nano approach to a wide range of applications. The objectives and outcomes for an envisaged centre of excellence were influenced by both a fundamental and applied interest from by the institute's management team, which included industrialists. The SRIF2006-08 investment, which complimented previous SRIF funding for building extensions and equipment, was both timely for the Engineering Research Institute, particularly in the extent that it appeared to align with many of the UK's manufacturing strategies[7], as well as Northern Ireland's Plan for Government[8] and MATRIX[9].

For its part, the Engineering Research Institute itself is identified by the University of Ulster as a high priority research area; and over the past 25 years has had a high profile in research, and has generated impacts associated with structural and advanced functional materials relating to connected health, medical devices, tissue engineering, nanomaterials, plasmas, photocatalysis, coatings, sensors, composites and metal forming. The institute's work has focused on its three research centres, the Nanotechnology and Integrated Bioengineering Centre (NIBEC), the Engineering Composites Research Centre (ECRE) and the Advanced Metal Forming Centre (AMFoR). The institute has a particular focus on interacting with industry, clinicians and the wider society in order to benefit all communities within the growing knowledge based economic environment. As well, the institute members (65 researchers) collaborate with numerous international partners, and particularly strong international collaborations have been established with researchers in India, Taiwan, USA and Japan, from which the large infrastructural funding attracted has highlighted the importance of this rapidly growing area of science research. Even

[7] UK High Value Manufacturing Strategy 2012 http://www.innovateuk.org/_assets/pdf/publications/TSB_High_Value_Manufacturing_Strategy_2012-15_web.pdf

[8] Northern Ireland Plan for Government: http://www.northernireland.gov.uk/index/work-of-the-executive/pfg.htm

[9] Matrix: http://www.matrix-ni.org/

more importantly, technology transfer is a key objective, and the institute is one of Northern Ireland's leaders in intellectual property exploitation, with more than six successful spin-out companies created to further exploit the outputs from research.

Aims and objectives of the project

The overall aim of the Engineering Research Institute for the Process Nano Engineering Centre project was to investigate the structure-function relationships of, and the interactions between materials, processes, devices and performance, in support of the economic and social development of science, engineering, industry and technology transfer. Towards this latter end, it was intended that the equipment to be purchased as part of the Process Nano Engineering Centre project would be aimed at enabling further collaboration with industrial partners. In particular, "the state-of-the-art equipment would be made available on an open access basis to industrial partners who could not afford the equipment themselves". In this way the centre would meet the technical needs of both large and small companies by providing access to the latest nanotechnology and, through interaction with academic researchers, consider industry relevant problems. At the time of the application, over 30 companies had already been identified, but with further expectation that around 100 companies would be working with the centre within three years. The anticipated overall impact was that the volume of collaborative research would increase significantly[10].

The ERI set more specific (long-term) objectives for the development of the SRIF funded infrastructure. These included:

- To have installed and commissioned all the requested resources by June 2007.
- To have initiated and completed 5 significant scientific projects with our various partners.
- To launch the SRIF funded equipment at an event in September 2007.
- To have published at least 10 international papers related to the equipment by December 2007.
- Within three years, to have grown the new facility to accommodate over 100 users.
- To have attracted with a period of three years major grants valued at over £3 million.
- To have attracted a mix of DTI, EU, EPSRC and industrial type funding in the area of nanotechnology within a three year period.

The evidence from the respondent Project Manager indicated that at the time of the case study research all these objectives had been successfully completed or achieved.

SRIF2006-08 inputs

The Process Nano Engineering Centre project received around £1.5 million of SRIF investment, earmarked for the refurbishment of buildings (£100,000) and the purchase of new equipment to support specific research projects (£1.4 million). It was not anticipated that the project would require specific non-capital expenditures, in addition to the SRIF2006-08 funding. However, it was anticipated that the project would attract further investment, and this has been the case since the

[10] Department for Employment and Learning (DELNI), *University of Ulster SRIF 2006 application.*

completion of the grant in 2008. In this regard the SRIF2006-08 funding received by ERI builds on the previous SRIF1 and SRIF2 investments, as well as subsequent Cross Border[11], RCIF, BIS and INI investments totalling over £6 million (mostly capital), that can be associated with the university's engineering research. These investments have all strategically complemented each other in a co-ordinated inter-faculty plan, aimed at building a critical mass in science research capital investment, in response to the university's research strategy. The University of Ulster's research strategy highlights research as a significant driver of regional, economic, social and cultural development, and one of the university's key priorities is to foster excellence in research so as to enhance the regional knowledge-base.

The SRIF2006-08 funding had a range of application objectives; with the key capital equipment considered as setting the foundations for a new drive on composites research, bio-engineering (which has led to major connected health activities), and electronic materials (which has led to major capacitor and hard disc investments). Overall, it is estimated that over £12 million of additional funding has been attracted, since SRIF2006-08, for capital investment projects from a variety of sources, such as EPSRC, EU, DEL, INI, HEA and TSB, including over £3.5 million of DEL Cross Border Funding (Connected Health and Tissue Engineering at NIBEC).

Activities

The SRIF funded infrastructure is fully utilised, with the refurbished buildings and the equipment either supporting specific research projects or supporting ERI's generic research capabilities, in full use all year round since the completion of the project. It is estimated that the infrastructure is used for research only about 60% of time it is in use, about 15% for postgraduate research, 5% for undergraduate research, and around 20% of the time for knowledge exchange with external users. With regard to internal usage, it is estimated that on average around 25 academic research staff per year use the infrastructure, as do around 44 postgraduate students and 200 undergraduate students. The group of external users comprise on average about 20 small and medium enterprises (SMEs), five each of large companies and higher education institutions, and other public sector (2) and third sector (2) organisations each year, since the completion of the project.

Outputs

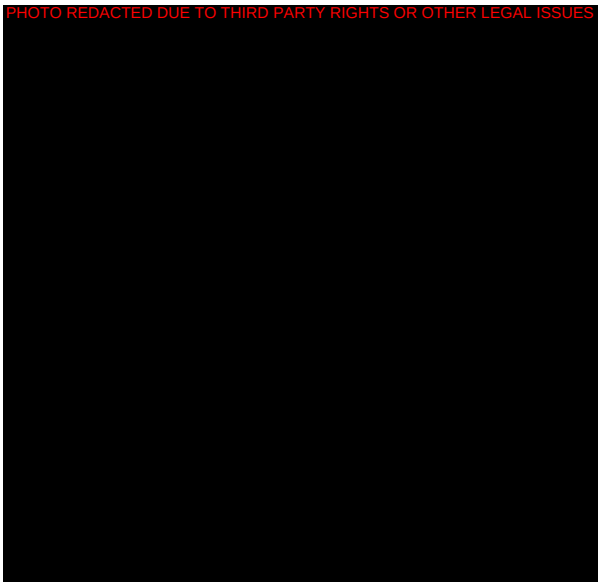
Notwithstanding its relatively small size, by value, the SRIF funded Process Nano Engineering Centre project at the University of Ulster has had significant impacts on research-related activities, staff development and training, and on the development of partnerships both internally and externally. The research-related impacts include: increased quality of research; increased research productivity; opening up new areas of research; improved reputation of the ERI; improved ability to attract further research funding; and engaging more effectively in knowledge exchange. All of the research related impacts are described as high. The staff development and training impacts include: increased staff and student morale; increase in the number of staff recruited; improved staff retention; improved staff research skills; improved quality of research training for students; and increased quantity of research training for students. All the impacts here

[11] The £2 million grant was mainly to fund staff.

are described as high. The partnerships impacts include: increased collaboration between academic disciplines; the generation of new non-academic relationships (e.g. with industry); and strengthening existing external partnerships with industry in particular. Again, all the impacts are considered to be high. It is also notable that the project has significantly improved the number and rate of spin-outs from the ERI.

The case study research provided further insights from the Project Manager about the impacts and benefits of the SRIF investment. It is notable, for example, that nanomaterials research has, over the last 5 years, built a solid track record in the preparation, analysis and processing of carbon-based materials, including diamond-like carbon (DLC), carbon nanotubes (CNT), nano-silicon, and nano-titanates. The research has also received substantial support from EPSRC, DEL, the Royal Society, the EU and industry, including Seagate, AVX, Shrader, Analog Devices, Medtronic, Labcoat, Cross, SiSaf Intel, and Glaxo-Smith-Kline. This work has subsequently generated commercial outputs relating to:

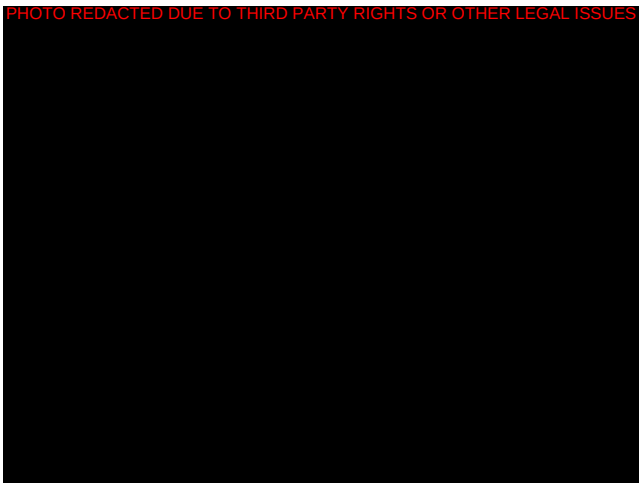
- AVX: 100nm particle fabrication and characterisation for multi-layer capacitors
- Seagate (Irl): 1.5nm diamond Like carbon coatings
- SiSaf: Nanosilicon particles for a drug carrier
- Bombardier: Nanoparticles as filers
- Lear-Med: Nano Biofunctional Coatings



AVX Capitors nano-barium Titantane

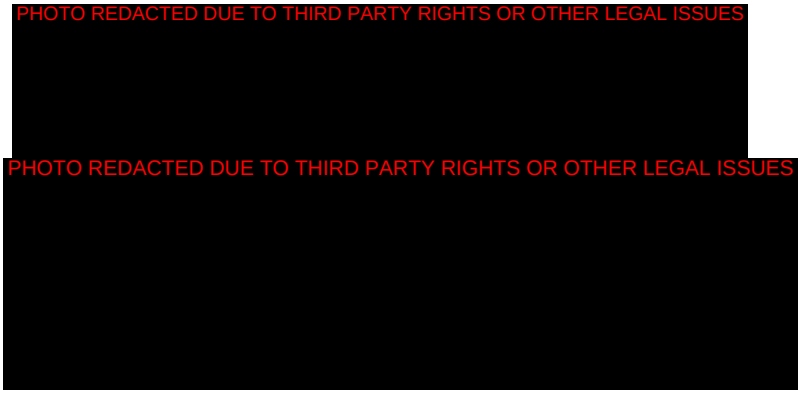
Some of the specific equipment funded from SRIF2006-08 in particular have led to the creation of one of the most advanced academic and innovation based laboratories for carbon thin-films, nanoparticle production and characterisation in the EU. The fundamental strengths of this development include novel multi-techniques for measuring hardness, thickness, internal stress and adhesive strength on ultra-thin (1nm–50nm) carbon layers, nanoparticle characterisation and fabrication (laser and plasma), nano-scale surface science, and HRTEM analysis. The thrust of the research has led to the design and construction of a suite of advanced multi-functional plasma systems, with integrated specialist diagnostic tools for concurrent measurement of plasma and

material properties during growth of nanoparticles. This facility is being developed towards high-pressure capabilities for general large area/low cost processing and precision three-dimensional coatings for medical implants, with four patents and commercialisation in progress. It is notable that a company (called SISaF) has been established as a spin-in (with the university as a shareholder). The company collaborates on nano-silicon for drug delivery applications.



Si nanoparticles – Spin-in SiSaf

Perhaps the most significant impact of the SRIF2006-08 investment is that its contribution to the research in application of composites has now led to the opening of a new £6 million centre called the Northern Ireland Advanced Composites and Engineering Centre (NIACE). The centre, which was opened in January 2012, is a technology hub for the research and development of advanced engineering and advanced materials technologies across a range of industrial sectors. Member companies are co-located with academic staff from Queen's University Belfast and the University of Ulster to work together to develop world-class technology solutions for a breadth of manufacturing applications. The centre will help Northern Ireland's manufacturing sector to grow and develop its capabilities, and enable it to compete more successfully on both a national and global scale.



NIACE Building – Composites Research

The co-location of staff and facilities will allow companies to work at a scale and in collaborations not currently feasible. It will also promote the development of skills and rapid knowledge transfer between the universities and industry, ensuring the development of innovative new product and manufacturing technologies.

The construction of the centre was funded by the Department of Business Innovation and Skills, Invest Northern Ireland and Bombardier Aerospace. It operates a membership model similar to those being adopted by the National Composites Centre in Bristol and the Manufacturing Technology Centre in Coventry, with an emphasis on industry-friendly access and participation arrangements. NIACE is envisaged as a not-for-profit organisation, based on collaborative partnerships between industry and the universities, which will support major manufacturing companies and their supply chains to improve competitiveness. The centre can host up to 120 research and technical staff from participant organisations, and is providing a collaborative office environment, a composites research laboratory, materials analysis laboratories, meeting rooms and a lecture theatre, as well as a wide range of laboratories and workshops equipped by Bombardier and the two universities.

It might be expected from the foregoing that there would be direct benefits to the external organisations that have had direct use of the SRIF funded infrastructure, and this was confirmed during the case study research. The evidence indicated that for the external organisations the infrastructure had had a high impact on: the development of new products and processes; improving access to cutting-edge research capability; improving access to equipment and research infrastructure for innovation; sharing the risk of R&D and innovation investments; reducing the cost of innovation activities; enhancing skills and capabilities; increasing willingness to collaborate for innovation; enhancing the networks between academics and industry; and improving overall business performance.

Lastly in this section, it might also be expected that there would be wider benefits to the UK as a result of the SRIF funded project. Here, the evidence from the case study research presented a mixed picture. According to the Project Manager the project had high impacts in some areas, but only medium impacts in others. High impacts were considered to be evident in: increased global competitiveness of UK research; increased ability of research to meet the needs of UK industry; facilitating the development of new technologies and technological platforms in industry; improving innovation capabilities; and increasing the ability of research to meet the needs of third sector organisations. In contrast, there have been only low to medium impacts with regard to: increasing the flow of knowledge into the UK economy; increasing the ability of research to meet national strategic priorities; improving the efficiency and effectiveness of the public sector, and improving the ability of the public sector to deliver its policies.

Assessing the counterfactual

The Project Manager was in no doubt about the significance of the SRIF2006-08 for the success of the Process Nano Engineering Centre project at the University of Ulster. The evidence from the case study research was unequivocal that only up to a quarter of the overall project investment would have been carried out in the absence of the SRIF funding. On this basis, the Project Manager was also convinced that the project outputs, in respect of the quantity and quality of research, the number of postgraduates trained, knowledge exchange income and the number of staff employed, would all have been lower. In the view of the Project Manager, SRIF has been an excellent route to boosting the overall capability of the ERI. This may not have happened if the institute had used its own resources to invest in particular areas, such as microscopy. These are the types of areas for which it is difficult to get funding.

Legacy and sustainability

On the whole, the SRIF funded Process Nano Engineering Centre project has satisfied its overall objectives, as set out in the original bid to the Northern Ireland Department for Employment and Learning (DELNI). The project has, to a large extent, allowed the Engineering Research Institute to acquire the necessary scale of research infrastructure to meet its overall objectives. Even more significantly, the project has enabled the institute to acquire state-of-the-art research infrastructure and in the process enabled the institute to meet the backlog of investment in research infrastructure, particularly for the types of equipment and staffing that university departments have great difficulty getting funding for.

Looking ahead, there is no doubt that the University of Ulster will require major capital investments in the coming years in order to secure its ambitions for science research. For the present, though, the SRIF funded project is meeting the needs of the Engineering Research Institute. In particular, the laboratories established with the SRIF investment are now very well kitted out and the institute's links with industry, through collaborations, spin-outs and spin-ins, are of a high quality; outcomes that would not have been possible otherwise. The Project Manager believes that the impacts of SRIF2006-08 are now being fully realised, with the establishment of the new centre (NIACE), new spin-outs and collaborations with major global organisations, such as AVX Ceramics, Bombardier and Seagate.

University of Warwick

Warwick Digital Laboratory

Value: £3.6 million

Introduction

The Warwick Digital Laboratory is a unique £50 million, state-of-the-art multidisciplinary research initiative bringing together collaborative research and knowledge exchange activities across disciplines including psychology, medicine, computer science and mathematics, supported by the expertise of the Warwick Manufacturing Group (WMG). These disciplines bring together a range of technologies, from simulation and modelling, to experiential engineering, to informatics and virtual reality, in search of solutions for the three application domains of digital manufacturing, healthcare sciences and service science.

The laboratory offers a range of business services to organisations of all sizes in the West Midlands, running regular workshops and conducting collaborative and contract research. It serves as an important networking hub, granting external organisations access to high quality academic expertise from across a wide range of disciplines.

The four-storey high energy efficiency building provides a state-of-the-art teaching and research environment, with a strong emphasis on knowledge exchange for product development with manufacturing and medical companies. The focus is principally on companies in the West Midlands, where there is a special zero cost access to SME programmes that were originally funded by the regional development agency, Advantage West Midlands (AWM), but have subsequently been funded by the Department for Communities and Local Government (DCLG).

Aims and objectives

The principal aim of the laboratory is to foster multidisciplinary research of the highest quality and to promote collaboration with industry, whilst also providing a high profile environment to showcase technologies to external collaborators and the general public. More specifically, the objectives set out at the outset of the project included:

- Increase research funding by 10% per annum.
- Reduce barriers between departments so as to enable more effective collaborative activities, whilst opening up opportunities for greater interaction with user communities.
- Improve research efficiency through co-location of activities (e.g. the sharing of equipment provided by industrial collaborators).
- Improve the profile of the university through the showcasing of technologies and capabilities to collaborators and the general public.
- Strengthen knowledge exchange.

- Strengthen teaching capabilities through new courses, curriculum development and new laboratory facilities.

SRIF2006-08 inputs

The Digital Laboratory was part of a major WMG project costing some £50 million. The building costs were estimated at £13 million, of which the SRIF2006-08 contribution was £3.6 million, or 28%. The remainder of the funding for the building was made up of £9 million from AWM and £2.4m from central university sources. In addition, there were substantial contributions from large private sector companies, such as Siemens, NEC and Dassault, including some £30 million worth of computer software and £7 million of equipment.

It was anticipated from the onset that the project would require non-capital expenditures, in the form of operating and maintenance costs, in addition to the SRIF funding. In this regard the University of Warwick has funded the associated staff costs to deliver the AWM outputs. The university and EPSRC sources fund the staff costs of the core academic teams engaged in activities in the building.

The Warwick Digital Laboratory has received further investment following the completion of the project. In particular, the success of the laboratory in attracting external users and fostering knowledge exchange activities, enabled the project's knowledge exchange team to secure additional funding from AWM to assist SMEs up to 2013. NHS Midlands East and West have also subsequently contributed £4.7m towards an Institute of Digital Health Care at the laboratory, in partnership with the WMG and the Warwick Medical School. In addition to this, University and EPSRC have funded a number of new professorial positions in order to strengthen the academic capabilities of the laboratory. The ongoing investments have been both necessary and required to enable the Digital Laboratory meet the upgrade costs of the equipment in the new building.

Activities

The idea for the Digital Laboratory was first mooted in about 2003, although detailed planning only commenced in 2005. Only few changes were required to be made to the original proposal submitted to the funding bodies, although some extensions to the project were implemented as additional funds became available in the run up to the opening in September 2008.

The implementation of the project went largely according to plan, with very few delays in the process. Negotiations with AWM took a little longer than anticipated, which in turn meant that some construction costs increased from their expected levels, although these increases were accommodated within the project budget. The Warwick Digital Laboratory, renamed the International Digital Laboratory, was officially opened in 2008 by the then Prime Minster Gordon Brown.

The Digital Laboratory is expected to have a lifespan of at least 30 years. It is difficult to estimate the future capital requirements of the facility, especially because of the fast-changing nature of the research conducted there; it is acknowledged that much will depend upon the development of existing and future partnerships both internally and externally.

Outputs

The Warwick Digital Laboratory project is fully utilised, with the building used all year round since it became operational. The SRIF funded infrastructure is used principally for research, for an estimated 80% of the time it is in use. For the rest of the time (20%), it is used for knowledge exchange activities with external users. Usage of the infrastructure by different groups reflects the activities carried out in the building. It is estimated that more than 150 academic research staff and over 80 postgraduate students use the infrastructure on average each year since it became operational. Indeed, around 15 academic staff are based in the building. There is no teaching of undergraduates in the building, although they may attend some activities, such as presentations.

The Digital Laboratory has seen a high level of external users accessing the facilities; and it is estimated some 250 external users regularly have access at present. The laboratory also hosts an SME support programme and collaborative research programmes with larger companies, as well as seminars, conferences and community events. The popularity of these activities has led to a new partner building being planned to stand alongside. It is anticipated that the new facility will help expand the University of Warwick's knowledge exchange capacity in the application of new digital technologies to a wide range of sectors and user communities.

The Warwick Digital Laboratory has made a significant impact, by opening up new areas of collaborative, multidisciplinary academic research. Furthermore, the laboratory attracts new, high quality staff and, therefore, increased research funding, which in turn has enhanced its reputation and that of the Warwick Manufacturing Group. The infrastructure, with its fully fitted, built-to-specification laboratories has attracted a number of new, high quality research staff to the university, and in the process also attracted a host of new research students.

The availability of the state-of-the-art facilities has generated new academic-industrial partnerships with companies of all sizes. It is believed that the improved relationship has generated substantial benefits, in terms of increased productivity and industrial output in the West Midlands, especially through the support and services provided free of charge to local SMEs by the Digital Laboratory. As well as the research outputs from the direct formal partnerships generated by the Warwick Digital Laboratory, it is believed there are benefits to the wider UK economy, including those generated through events such as conferences and seminars for industrial engineers and managers.

It is anticipated that further impacts would emerge in the future, as the reputation of the laboratory spreads among industry, and as more leading academics and different types of external organisations are attracted to the facility. The laboratory will work with growth-oriented firms, linking with the Manufacturing Advisory Service and various government R&D programmes. One potential new development for the laboratory may be in assisting banks to improve their judgement about prospective borrower companies. There are further priority plans for the Warwick Digital Laboratory to facilitate international linkages between West Midlands companies and global organisations.

The university has systems in place for the monitoring and evaluation of the impacts of the project in an academic sense via the REF and a Quarterly Reporting Group; and uses those systems to

measure the efficiency of the building, as well as its financial cost to ensure that there is no core cost to the university of the building or equipment.

Counterfactual

At the time of applying for SRIF2006-08, a number of potential alternative funding sources existed, including the RDA, Advantage West Midlands and a number of private sector partners that had previously worked with the Warwick Manufacturing Group. With regards to external funding, the WMG had an added advantage from its well-established reputation. Whilst it is true that AWM and partner companies were already making substantial contributions to the project, it is not certain to what extent these funding sources would have been able or willing to support the project by themselves. It is in this respect that the SRIF2006-08 funding could be considered as pivotal for the entire project, and offered financial leverage, particularly with regards to the physical infrastructure.

The project team was particularly satisfied with the timely and flexible manner in which the SRIF2006-08 funding was delivered by HEFCE, which enabled the project to move quickly and responsively. This was particularly important for the timings of the other funding partners and companies involved in the project.

The evidence from the survey research with the Project Manager indicated that had the full SRIF2006-08 investment not been realised, it is unlikely that the investment in the Digital Laboratory would have gone ahead at all. Without the facilities and equipment provided by the laboratory, there would have been far less research in the relevant areas, and the outreach activities and engagement of the WMG with external organisations would have been severely restricted. The Project Manager believes that this would have had particular repercussions: for example, the Institute of Digital Healthcare would not have been established, and a number of the high calibre international academics currently working at the university would not have decided to join the University of Warwick.

Legacy and sustainability

On the whole, the Warwick Digital Laboratory is considered to have been a great success, and is now an establishment with much future potential. It is considered that the project has completely satisfied its overall objectives, as set out in the original bid to HEFCE. The project has enabled the university to acquire the necessary scale of research infrastructure, as well as state-of-the art infrastructure. To a large extent, the project has helped the Warwick Manufacturing Group in particular to address some issues relating to past underinvestment in research capital infrastructure. The project is continuing to meet current research needs, although it is also acknowledged that the university would continue to require substantial capital investments in the coming years to secure its overall research objectives.