

## A Consultation on Proposals for Long-Term Capital Investment in Science & Research: a response to the UK Government Department for Business, Innovation and Skills

### Executive Summary

The Royal Society of Edinburgh welcomes the opportunity to respond to this consultation, and the commitment to additional long-term investment in science and research which it makes. The lists of possible projects set out in the consultation span a wide range of costs, from £15m to £420m, (leaving aside one much larger, but “scalable” programme). In considering our response we have sought to avoid being unduly influenced by the kudos of leading on large international projects and have focused on how to develop investment programmes, large or small, that make a difference at the UK level.

Our response focuses on what we think are the key areas of consideration for capital investment in science and research:

#### University-based centres and facilities

It is the view of the RSE that universities have proven excellence at driving innovation. Academic critical mass and interdisciplinarity are unique features of University environments. There are many examples of universities creating centres of excellence. We would argue that, whilst National Centres of Excellence have an important role in capacity provision, this cannot replace, or be at the expense of, investment that is directed by Universities, acting either alone or in consortia.

#### Collaboration

Scotland has a good record of collaboration between institutions, as evidenced by the Scottish “Pooling” initiatives. Scotland also hosts a number of UK collaborations.

A lesson from the Scottish experience is that collaborations must be open, not restricted by exclusive or inclusive requirements. Competitive pressures for a share of resources can move the enterprise towards the lowest common denominator. Geographical boundaries, reinforced by differences in funding channels, can lead to exclusion of otherwise apt partners.

Capital investment made at university level can attract ongoing investments and valuable links with industry. In order for collaborations with industry to be successful, there is a need for large-scale manufacturing scale-up facilities to be placed within universities, in addition to research facilities.

Internationally, there are additional opportunities for collaborations which could raise the international profile of UK research, provide access to international funding opportunities and bring new skills to the UK. We consider Horizon 2020 [the new EU Programme for Research and Innovation] to be vitally important. Investment should be structured to maximise Horizon 2020 returns.

#### Revenue and capital

Whilst capital investment is vital to the research capabilities of higher education institutions, this is the case only if there is a sufficient revenue stream to support the maintenance and upgrading of the infrastructure invested in. The maintenance and regular up-grading of facilities is vital. Capital investments should come with whole-life business models in mind.

**> KEY QUESTION: What balance should we strike between meeting capital requirements at the individual research project and institution level, relative to the need for large-scale investments at national and international levels?**

This response reflects the position of the RSE in two respects:

- i. Our Fellowship encompasses not only STEM but also Social Sciences, Arts and Humanities, Business and the Public Sector. The Working Group that prepared this response reflects that diversity.
- ii. Our Fellowship embodies Scotland's excellence in research, built on a history of educational excellence and investment in programmes and facilities over many years by successive Administrations in the UK and Scotland, the UK Research Councils and major UK charities. Crucial to this excellence has been collaborative access to major UK and international facilities.

The pattern of investment that has built up comprises facilities that are primarily focused on Scotland (whilst increasingly accessed collaboratively by several institutions and industry), UK-level resources (accessed by researchers throughout the UK) and international resources, wherever located (accessed by those from Scotland and elsewhere in the UK whose research is relevant). We welcome the commitment to provide additional resources and are clear that it should be an objective of policy for this integrated, balanced and highly-effective investment pattern to continue.

### General

This consultation appears at first sight to contrast large-scale, one-off investments (national or international) with what may seem more run-of-the-mill investments at individual research programme and institution level. In fact, the lists of possible projects set out in the consultation span a wide range of costs, from £15m to £420m, (leaving aside one much larger, but "scalable" programme) and might in some cases involve a range of institutions in the investment. So in considering our response, we have sought to avoid being unduly influenced by the *kudos* of leading on large international projects and have sought to put into the balance how to develop investment programmes, large or small, that make a difference at the UK level. This is particularly important, as we consider later the investment needed in Social Science, Arts and Humanities (SSAH), where scale is increasingly, but not always, an issue and where recognition of the significance, leverage and reputational gains from small to medium investments, strategically made, is vital.

We warmly welcome the recognition of the importance of revenue resources keeping in step with capital investments; there is no point in having a wonderful facility that you cannot afford, nor have the capacity to use. Similarly, future plans should allow for the relatively modest capital upgrades necessary over time to maintain a state-of-the-art facility.

The last few years have seen difficulties in this respect, and the present imaginative approach to looking ahead offers the chance to get the balance right.

The RSE believes it is important for the UK to be at the leading edge of investment in a good range of the big projects proposed in the consultation document. It is crucial that the UK has access to big research facilities, and for that reason the UK should be a leading investor in these technologies. It is vital that whether or not UK investment secures such projects for the UK, the process of realising the investment and accessing/using it should be as collaborative as possible. This will be particularly important where it is decided that investment will be directed towards particular pieces of infrastructure based at particular organisations or institutions that may be in competition.

### Project and institutional level

The RSE, however, wants to stress the importance of investing adequately at project and institution level. The traditionally recognised importance of investment captured by the phrase the "well found" laboratory, but which also applies to SSAH, should not be underestimated. Investment in facilities at local, regional and national levels is essential for skills development. We can produce world-class researchers only if they are trained on world-class facilities. Without a pipeline of world-class researchers, we cannot expect to play leading roles in the big international projects.

The rationale for such investment is strong:

- Up-to-date equipment can greatly increase the speed, accuracy and efficiency with which work is carried out;
- It should not always be assumed that this is a plea for the best and latest equipment, but modernisation is essential;
- Scale matters – if relatively modest capital investment, sometimes of £1–2 million, or perhaps less, is lost, a lot of research centres would not be able to continue doing the work they do;
- The funding that was provided through SRIF (Science Research Investment Fund) was referred to within the Working Group meeting as exemplary of the type of small-scale funding that is vital to universities and research labs. SRIF was highly valuable because it provided small-scale funding year-by-year, allowing for upgrades to be carried out as and when they were needed;
- Experience in Scotland demonstrates the importance of this type of investment for SSAH, for example:
  - o various rounds of funding opportunities for secondary data analysis;
  - o the Research Methods Programme (2002–07)
- Investment in local and regional infrastructure helps to develop the engagement of social scientists and business researchers in STEM areas and provides opportunities for collaboration.

## University focus needed

Leaving aside the really large-scale 'one off' projects, there is a challenge in relation to the balance that should be struck between university-based investment and investment in national research centres (the consultation uses the term 'campus' to refer to the latter). It is the view of the RSE that universities have proven excellence at driving innovation. This is because universities are populated by academics whose very rationale is to think in innovative ways. The value of that should not be taken for granted; reaping the benefits of this innovative thinking requires facilities and time. Universities are also populated by students and post-doctoral researchers, who are seeking to learn how to use and exploit facilities as part of their research and training. Their teaching is informed by the research being carried out. If equipment and facilities are not based in universities, then students cannot readily access them to gain training and experience. We need to address weaknesses in the talent base of graduating students by ensuring that they can access and be trained in the use of facilities and equipment whilst at university. This is vital if they are to have the relevant skills to work in industry following their study and training. Thus, whilst we recognise that decisions must be taken case by case, we believe that there should be a presumption towards investment being directed to universities rather than towards national centres.

Academic critical mass and interdisciplinarity are unique features of University environments. There are many examples of universities creating centres of excellence. One area that has been recognised in the consultation document (page 87) is a Centre for Excellence for Sustainability and Resilience of National Infrastructure, which would look at low loss electrical conductors, amongst other things. At the UK level, excellence in this area is centred at Newcastle University. We would argue that, whilst National Centres of Excellence have an important role in capacity provision, this cannot replace, or be at the expense of investment, that is directed by universities, acting either alone or in consortia.

The RSE believes this is exemplary of why investment is best focussed on universities, where the intellectual capital is already in place. However, we acknowledge that there is a balance to be struck, and that there are some projects which, for various reasons, may need to be based off-campus. Facilities such as CERN and the Diamond Light Source, for example, define themselves, and so do not need to be university-based.

## Balance of the Programme

Of the three possible scenarios presented within the consultation document (page 35), the RSE favours something on the lines of scenario two as providing the optimum levels of large and small/intermediate investment. It will be very important to ensure there is investment directed at the international, UK and Scotland/UK regional levels.

## > How can we maximise collaboration, equipment sharing and access to industry to ensure we make the most of this investment?

### Scottish experience of collaboration

Scotland has a good record of collaboration between institutions, as evidenced by the Scottish "Pooling" initiatives. The path was beaten by SUPA (Scottish Universities Physics Alliance) and several other successful collaborations have followed the same model since. An example would be Sinapse, which was created around brain-scanning facilities that were in place in Aberdeen, Dundee, Edinburgh and Glasgow. For each institution, there was a clear challenge in terms of running and maintaining these facilities, which provided a compelling argument for the universities to work together in a coordinated fashion. This has allowed them to share facilities, so that rather than all buying the same basic brain-scanner, they have been able to decide which type of scanner they need for different types of research. This has provided a choice for the research community within Scotland in relation to the type of facility available and also enables more intensive utilisation of facilities. The facilities are embedded in universities, where there is the academic critical mass to support the work being done.

The opportunity taken here was to optimise the use of support from the Funding Council; the challenge was to collaborate in a credible way, making choices on priorities that could involve some sacrifices by individual academic groups.

Scotland also hosts a number of UK collaborations. Leading examples are the high-performance computing facilities at the Edinburgh Parallel Computing Centre (EPCC), hosting, amongst other things, the ARCHER national supercomputing centre; and the BIS grant for research into robotics awarded jointly to Edinburgh and Heriot-Watt Universities. In the field of SSAH, examples would be:

- Applied Quantitative Methods Network – involving eight partner universities in its first phase of funding (2009–2012);
- Administrative Data Liaison Service;
- Scottish Graduate Programme in Economics;
- The Scottish Graduate School of Social Science;
- Scottish Graduate School for Arts and Humanities.

A further lesson from the Scottish experience is that collaborations must be open, not restricted by exclusive or inclusive requirements. Competitive pressures for a share of resources can move the enterprise towards the lowest common denominator. It is arguable that the difficulty of ruling out an institution within what is otherwise regarded as a group of equals can impair the effectiveness of a collaboration. Geographical boundaries, reinforced by differences in funding channels, can lead to the exclusion of otherwise apt partners.

## **Collaboration: interdisciplinary and with industry and the public sector**

Capital investment made at university level, where there is the academic critical mass to support the work being done, can attract ongoing investments and valuable links with industry. It is, therefore, vitally important to look at the translation of science research funding into commercial application. There are already positive examples of this in Scotland. We draw on a number of examples that we believe should be built on and replicated:

Examples from the SSAH include:

- using research to underpin teaching resources for schools;
- evaluating policy impact;
- contributing to policy development;
- advising parliamentary committees, thus contributing to the quality of public debate;
- Providing CPD for professionals in various public services.

An example from the natural sciences is the creation of an academic Drug Discovery Unit at the University of Dundee. It was supported by Scottish and UK public funds and a range of national and international charities. The Unit allows Dundee to engage with large pharmaceutical companies, who are quite happy to 'de-risk', their activities by off-shoring early target identification and early molecule screening. They then come in at a later stage, having saved the start-up investment. The capital infrastructure is moderately large, and it probably does have to be within an institution, because the academic critical mass to exploit it and service the facility is essential. A further example is the Advanced Forming Research Centre (see <http://www.strath.ac.uk/afrc/>), which provides themed, industry demand-led R&D programmes and facilities and is an example of industrial-scale research equipment that can deliver solutions which can readily transition into industry.

In order for collaborations with industry to be successful, there is a need for large-scale manufacturing scale-up facilities to be placed within universities, in addition to research facilities. There are good cases for the co-funding of these facilities by Government and industry, and this process of scaling-up should be more widespread.

An example is the Centre for Continuous Manufacturing and Crystallisation, which is headquartered at Strathclyde but involves six other universities, and has been funded through a combination of the Funding Councils, Government and Industry.

Further positive examples of collaboration between academia and industry are provided by the recent creation of eight Scottish Innovation Centres<sup>1</sup>. These centres are designed to establish long-term partnerships to better exploit academic knowledge and expertise via a combination of public and industry funding. Each takes an interdisciplinary approach to address solutions to a range of challenges, including digital health delivery; off-site production and low-carbon building technologies; and increasing oil and gas production at reduced cost in the UK Continental Shelf. The Stratified Medicine Scotland Innovation Centre, based at the University of Glasgow, combines cutting-edge biomedicine and electronic health records, two areas where Scotland leads world-wide, in order to create more personalised and effective forms of treatment.

## **Collaboration involving the Social Sciences, Arts and Humanities**

Collaboration and investment that support the economy are an increasing feature of the Social Science and Arts and Humanities research area. At the level of the UK economy, the creative sector accounts for around 8% of GDP and contributes around £102 billion GVA each year. The increasing number of collaborations between research in STEM and SSAH creates a welcome blurring of boundaries between them, as witnessed by research in topics such as Medical Humanities and Product Design Engineering, and with this comes a growing need for capital investment in SSAH. Other collaborative research and engagement with the Creative Economy involves partnership with organisations, including cultural institutions such as museums and libraries, the Technology Strategy Board, the Design Council, NESTA, Creative Scotland, etc. A point frequently made to us has been that, particularly in the field of Arts and Humanities, salaries and other costs constitute the major part of many projects and are, in reality, capital investments, and we believe they should be categorised accordingly.

Of the projects mentioned in the consultation document, we see particular advantage in digital transformative and large digitisation projects. Examples include **Digital Transformations**, which investigates the potential of digital technologies to transform research in the arts and humanities. This project includes topics such as intellectual property, cultural memory and identity, and communication and creativity in the digital age. Similarly, **Science in Culture**

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<sup>1</sup>**Digital Health Institute (DHI)**: technologies and solutions for future health care delivery; **Stratified Medicine Scotland**: next-generation sequencing for future health care delivery; **CENSIS**: Sensor and Imaging Systems (SIS) as a key enabling technology impacting on a wide range of industry sectors; **Industrial Biotechnology Innovation Centre**: as a key enabling technology with a particular focus on Scotland's low-carbon economy; **Oil and Gas Innovation Centre**: with a particular focus on increasing production and reducing costs in the UK Continental Shelf; **Scottish Aquaculture Innovation Centre**: solutions for sustainable and more efficient fish production; **Construction Scotland Innovation Centre**: connecting the construction industry for future growth in areas such as off-site production and low-carbon building technologies; **Big Data Innovation Centre**: with a focus on digital technology, energy, financial services, healthcare and public sector markets.

explores cross-disciplinary relationships between sciences and the Arts and Humanities; whilst **Connected Communities** is a cross-Council programme led by the AHRC, working with EPSRC, ESRC, MRC and NERC, plus external partners. In this project, arts and humanities researchers lead on creativity, sustainability, culture and belief frameworks.

Examples of large digitisation projects include the **Urban Big Data Centre**, led by the University of Glasgow. This is a unique UK ESRC-funded research centre which addresses social, economic and environmental issues in cities, such as transport, employment, migration, housing, education and social exclusion. The AHRC and ESRC-funded Big Data projects **Lexicography** (an Historical Thesaurus of Scots), and **Dialectology** (a project which will reveal language complexities to aid phonetic training) are further examples.

Further investment is needed in Big Data projects in SSAH in the areas of archival content (both objects and text, visual and sound), such as proposed by the National Library of Scotland. Corporate Archives, many untapped, also have a wealth of significant information on business and industry, as well as on cultural heritage.

Internationally, there are additional opportunities for collaborations which could raise the international profile of UK research, provide access to international funding opportunities and bring new skills to the UK. We consider Horizon 2020 [the new EU Programme for Research and Innovation] to be vitally important. Investment should be structured to maximise Horizon 2020 returns.

### > **What factors should we consider when determining the research and capital requirement of the higher education estate?**

#### **Revenue streams**

A crucial factor for consideration is that whilst capital investment is vital to the research capabilities of higher education institutions, this is the case only if there is a sufficient revenue stream to support the maintenance and upgrading of the infrastructure invested in. Finding the revenue to maintain facilities purchased through capital investment is a real challenge for universities, but having experienced personnel to manage these facilities is crucial. Capital infrastructure, as soon as it goes into an institution, actually costs that institution money in maintenance and running costs. Capital investments without revenue to support them can be disastrous to organisations. The maintenance and regular upgrading of facilities is vital, and capital investments should come with whole-life business models in mind.

The notion of well-founded laboratories – with wider revenue mentioned above – is crucial to ensuring the quality of the talent base leaving university; if the facilities available to students are not well maintained and operating

effectively, then students will not gain adequate training or experience of utilising these facilities.

#### **Connections with industry**

We have offered comments in the previous section.

#### **Interdisciplinary working**

There are a lot of research areas where the solutions to big problems will come through an interdisciplinary route. It is, therefore, essential that the investments made, at whatever scale, should be structured so as to create a research environment and culture that allows different disciplines to work together on the big issues, whether they are from the same institutions or different ones. This requires Government to take a lead in rewarding, through investment, those organisations that embrace the need to build bridges between disciplines and sectors, rather than an insular focus on building empires. Increasingly, RCUK, the ERC and Horizon 2020 stress the paramount need for interdisciplinarity and that the embedding of SSAH is essential for maximising the returns to society from investment in science and technology.

### > **Should – subject to State aids and other considerations – science and research capital be extended to Research and Technology Organisations and Independent Research Organisations when there are wider benefits for doing so?**

This question presumes a positive answer, because it assumes that extending eligibility will lead to 'wider benefits'; however, what these are or who will derive the benefit from such changes needs to be better understood. The present arrangements are part of a complex, but delicate, ecosystem. The effect of introducing new players into it, and their impact on existing players, needs careful consideration before any significant changes are implemented.

The present pattern of coverage is patchy and arguably inconsistent, and it would seem sensible to simplify it if possible. One benefit this would have would be avoiding arbitrarily ruling certain organisations out of engagement with collaborative projects, whilst leaving decisions on funding to be taken on merits.

In the Social Sciences, a particular question which arises is the role of independent survey–research organisations, and also – in small numbers – independent research organisations. The best-known example of the latter in the UK is the Institute for Fiscal Studies. The former – organisations which conduct social surveys – are essential to the maintenance of high-quality quantitative research, especially in the form of longitudinal studies, in many social science disciplines.

> **KEY QUESTION: What should be the UK's priorities for large-scale capital investment in the national interest, including, where appropriate, collaborating in international projects?**

> **What should the criteria for prioritising projects look like?**

> **Are there new potential high-priority projects which are not identified in this document?**

In considering the long list of possible projects in pages 54–58 of the consultation, and things that might be added to it, the RSE did not set out to offer judgements or make detailed bids on behalf of Scotland. That is the responsibility of individual institutions and funding bodies. Instead, the RSE sought to identify some general principles to guide priority setting and to apply these with reference to Scotland.

### **Responding to challenges**

First, it will be essential to take account of the extent to which particular investments will contribute to understanding and tackling some of the challenges the world currently faces; for example, in human health, nutrition, energy security, water supply and the environment, as well as a range of societal and economic pressures. These needs should rank at least as important as the need to have “the next big thing” in a particular field of experimental science; though the two will not necessarily be at odds.

### **Building on strengths**

Secondly, the choice of priorities should build on strengths. As argued earlier, this must include programmes of investment at project and institution level, to maintain capacity as well as to tackle new things; noting, for example, the increasing need for data-handling capacity across the board, including SSAH. Within existing campuses and institutions across the UK, there is expertise that could be developed and enhanced, and which could attract new international talent, with the right capital investment and revenue. The RSE believes that investments should focus on areas in which the UK already has pockets of expertise and research excellence. It seems less efficient and effective to build entirely new campus structures or national research centres from scratch.

### **Collaboration and efficiency**

Thirdly, they should be projects that maximise opportunities for collaboration and interdisciplinarity and efficiency.

From a Scottish perspective, the RSE sought to identify some of the items on the list that met these principles and to which it felt that Scotland and the Scottish institutions

could bring research expertise and excellence. The comments below also suggest possible further areas to consider.

A general theme of the list is ‘Big Data’. Edinburgh’s high-performance computer facilities make Scotland a natural location for investment in programmes that would exploit and utilise this capacity; ideally with use being possible on a collaborative and networked basis. In the field of the biomedical and life sciences, for example, the RSE believes that Scotland also has strengths and research expertise that are in line with the research proposed under *Bridging the Genotype to Phenotype Gap* (project 1.2).

Scotland could contribute to research in the human and animal fields under this research heading.

The fields of art, design and architecture increasingly require digital resources to handle data, to facilitate design work, and to enable the outputs to be transmitted and used. Design and architectural innovations now require advanced computational tools and access to emerging technologies; this will aid the capacity for optimising designs for economic and environmental goals and impact on research developments. Work in these fields is widely distributed and shared between practitioners (in academia and in business) and between institutions. Investment to support these collaborations is essential.

Scotland is already contributing to research in sustainable intensification relating to land use and food security, which takes an interdisciplinary approach.

Energy and human medicine are further examples of areas in which Scotland could lead in taking an interdisciplinary approach to campus-based research activity, on the basis of its strength in these disciplines.

Water security is an area of huge importance. Within its discussion of campus-based projects, the consultation document mentions a *Water Security and Innovation Centre* (6.5, page 94). This should be an area of high priority.

The marine environment is not well covered in the consultation. Scotland has an incredible stretch of coastline, and the RSE believes that this is something that Scotland, and the UK as a whole, should make the most of; be that in terms of marine oil, marine energy, coastal communities or other areas of marine science. Given Scotland’s unique geography, which includes highland, island and coastal areas, there is a lot of opportunity in Scotland for the creation of regional demonstration centres, providing access to wind and wave technology, amongst other things. These are areas in which industry is less likely to make large investments, so public money is likely to be essential. Scotland has excellence and expertise in energy security; for example, Heriot-Watt University is doing exciting work at the moment with regard to wave and tidal energy, which could have huge potential; whilst at Strathclyde, two of the recently-awarded EPSRC Centres for Doctoral Training were in Wind and

Marine Energy Systems, and Future Power Networks and Smart Grids. Another related area that could be addressed is environmental sustainability.

Scotland also has existing strengths in the social sciences, and there are already seven ESRC initiatives that are hosted in Edinburgh, most of which are collaborative projects involving other Scottish universities. Intermediate-level investment which supports and sustains the work coming out of these initiatives would grow these pockets of excellence and make them more accessible to other collaborators. A centre for the Social Sciences akin to the Isaac Newton Institute for Mathematical Sciences could build upon existing excellence to make it accessible to even more people. Possible fields of work would be:

- Big Data—collecting data sets and using these to derive information about different aspects of society and social behaviour;
- Administrative data sets, i.e., data sets that public organisations hold;
- Financial data;
- Creative industries;
- Medical data;
- Ethics and data protection;

**> Should we maintain a proportion of unallocated capital funding to respond to emerging priorities in the second half of this decade?**

We are sympathetic to this idea, on the basis that we cannot know now where the next big priorities might emerge. It would be sensible to retain some capital funding so that we can invest in new and emerging areas that are not yet on the radar, and also provide upgrades to maintain state-of-the-art facilities.

**> Are the major international projects identified in the consultation the right priorities for this scale of investment at the international level? Are there other opportunities for UK involvement in major global collaborations?**

**We have no further comments.**

### **Additional Information and References**

Advice Papers are produced on behalf of the RSE Council by an appropriately diverse working group in whose expertise and judgement the Council has confidence. This Advice Paper has been signed off by the General Secretary.

**Any enquiries about this Advice Paper should be addressed to RSE Policy Officer, Elizabeth Hemsley** (Email:[evidenceadvice@royalsoced.org.uk](mailto:evidenceadvice@royalsoced.org.uk)). Responses are published on the RSE website ([www.royalsoced.org.uk](http://www.royalsoced.org.uk)).

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