STFC Physical Sciences and Engineering Advisory Panel (PS&EAP)

Response to BIS exercise entitled "Creating the future: a 2020 vision for science and research - a consultation on proposals for long-term capital investment in science and research".

Report to Large Facilities Coordinator of STFC Science Board

KEY QUESTIONS:

Q4: 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?

- It is vital that UK scientists and engineers have access to state-of-the-art facilities at all levels, ranging from departmental (university-based) to regional, national and international scale capabilities. Investment in existing or proposed large facilities must be fully assessed in terms of impact and tensioned against investment at regional and institutional levels, so that UK advances in science and technology disciplines can be maintained at its currently internationally excellent level. Keeping these considerations in mind:
- Capital investment is needed in new large facilities that give access to exciting new techniques and opportunities;
- A programme of upgrades to existing large facilities must be planned and maintained to enable them to run efficiently and cost-effectively at an internationally excellent level, fully exploit the capital investments already made, and take advantage of new science and technology developments;
- Large facilities users need access to local infrastructure in order to fully develop their underpinning science and measurement methods and make best use of the beamtime they are awarded in the context of wide-ranging programmes;
- Science roadmaps should be developed across different areas of established and emerging science and technology so that the above factors are appropriately balanced between communities with different impact assessments and outcomes;
- In all cases, it is essential that funds for capital and resource (including infrastructure as well as maintenance, staffing etc) are matched, to avoid the so-called "batteries not included" position that makes least efficient use of any major capital investment;
- It is widely felt throughout all the communities that far too much pressure is placed on University finances as a result of the requirement for cost-sharing instrument purchases. While this practice can be useful to ensure investment is linked with University priorities, the institutional budgets are now far too stretched for this to be a sustainable position. It is clearly inefficient, ineffective and is leading to a crisis involving substantial downgrading of the UK university-based instrument park that is a key resource contributing equally with large facilities to our international excellence in science and technology.

Q8: What should be the UK's priorities for large scale capital investments in the national interest, including where appropriate collaborating in international projects? (1000 words maximum)

Main capital investments managed by STFC and considered by the PS&E AP centred around neutrons and photon science, including synchrotron and large laser facilities

extending to discussion of planned and proposed free electron laser capabilities. The AP first concluded that (a) the UK badly needs to develop a coherent strategy for planning and managing its portfolio of current and projected neutron and photon beam capabilities. The AP then agreed that (b) a coherent plan must be established to develop the Harwell Science and Innovation Campus infrastructure (potentially linked to developments on the Culham site) in the context of updating, revising and incorporating new elements within the current HSIC masterplan. Individual elements of both are developed below:

A. Neutron capability

1. ISIS has long been the envy of the international community as the world's brightest neutron spallation source linked to unique UK ideas and concepts leading to ground-breaking science and technology discoveries over a wide range of fields. Although it is now overtaken in actual power by large-scale projects such as SNS (USA), it retains the lead in major areas of neutron technology, experimental design and cutting-edge science envisaged and delivered. With its second target station (TS-2) it has entered a new realm of experimental conception and with the first phase of instruments delivered and in operation is set to lead the world for a next generation of scientific experiments.

- Completing the full complement of instrumentation to fill the experimental hall at ISIS TS-2 that has been delayed/halted due to budget constraints. The new instruments designed and approved in consultation with the neutron user community and with international scientific oversight would unleash the full potential of the new target station and allow the UK to capitalise on its already significant investment in the new neutron source. Completing the TS-2 instrument base with updated designs and experimental target strategies will confirm the UK as the world's leading centre for neutron research. *Recommendation: support completion of ISIS TS-2 instrument suite.*
- TS-1 target/moderator upgrade. This is needed to maintain ISIS's core activities as described within the Programmatic Review report already submitted to Council.

2. ILL. Continue with current/projected investment level (Endurance) up to *ca*. 2020, when ESS's capability will be better understood. Longer range considerations of an 'ESS-West' facility based on world-leading experience and innovation in neutron science at ISIS can also be considered at that juncture.

Recommendation: The UK must engage with the ESS project, whilst concurrently <u>fully supporting</u> ISIS and maintaining a one third shareholding in the ILL.

3. Developing a European <u>short pulse MW facility</u> within the UK. The AP believe that the ongoing neutron review will highlight this as a requirement and that the precise needs and configuration of such a facility will depend on ESS outcomes (to be reviewed ca. 2020).

Recommendation: the UK should maintain enabling work as part of our neutron vision and strategy.

B. Synchrotron capability

1. <u>Diamond Light Source</u>. Since opening in 2007 it has now developed a full complement of beamlines delivering cutting edge science and technology innovations over a wide range of disciplines including biomedical research. Latest innovations added include a nanoscale imaging capability with high-resolution electron microscopy linked to the synchrotron facility as a user-accessible "beamline". A further innovation is construction of an immediately adjacent "Research Complex" facility housing research teams and instruments working on key projects linked to Diamond beamline experiments. Possible extension of these capabilities is developed further below. For Diamond itself the actual beamline complement

is just now completed and must be allowed to reach and demonstrate its full potential. However capital investment must be planned for over a 5-10 year horizon to take advantages of new developments in technology and science objectives.

Recommendation: maintain current level of support for DLS and plan for new injections of funds on 5-10 year horizon.

2. ESRF UK contribution/commitment. Since opening in 1992 the ESRF has been the world's leading centre for high-energy synchrotron X-ray research. It has led to many transformative science and technology discoveries in a wide range of fields, ranging from molecular and materials science to biomedical research. The UK remains a main partner in the project. The ESRF has high energy capabilities that cannot be matched by DLS for critical experiments in materials science and biotechnology. Recently ESRF has undertaken a major upgrade programme, resulting in unprecedented new capabilities in nanoscience and imaging that are central to key UK research programmes. The UK must maintain our ESRF investment in Phase 2 of the upgrade programme incorporating the lattice upgrade.

Recommendation: Support Phase 2 of the ESRF upgrade.

C. Lasers

The Central Laser Facility is a world-class centre for laser-based research and provides access to unique high-power and ultrafast laser experiments. Its suite of microscopy instruments complements the imaging capabilities offered by Diamond and ISIS and a planned national TEM facility, with the Harwell Campus developing as a premier international location for imaging science across disciplines. To maintain its position at the forefront of laser-based science, the following investments are required:

- Upgrade of the Vulcan laser system to the Vulcan 20:20 (20 PW power, 20 KJ long pulse) in a new building as a flexible facility to address the most diverse range of scientific users.
- Extension of the Gemini facility target stations and further development of the DiPOLE technology;
- Co-location of the ULTRA and Artemis laser systems in the current (or second phase) Research Complex at Harwell (RCaH) building to integrate the two systems into a single major facility for dynamics and spectroscopy. This unique combination will provide THz – soft X-ray spectral coverage, attosecond to microsecond time resolution, multi-user operation and 100 kHz repetition rates;
- Development of a hub for Interdisciplinary Research in Imaging Science (IRIS) to encompass imaging activity at Octopus, Diamond, ISIS and the new national TEM facility and to apply "big data" techniques for image archiving and analysis.

Recommendation: support the Vulcan 20:20 upgrade to maintain UK lead in high power laser science.

D. Free Electron Laser (FEL)

A strategy to build a community, identify key areas to benefit UK science and industry, and define source requirements is required to make the optimal case for a UK X-ray FEL. Working towards a UK FEL in the 2020s, decisions about technology and parameters such as repetition rate, maximum photon energy and operation mode should be deferred until more is known about the performances of the machines currently under construction.

Recommendation - support engagement with X-FEL. Assess benefits over 5 year period and enunciate as part of a coherent UK strategy for photons and neutrons.

E. Harwell Campus

The AP strongly recommends that discussions concerning facilities and their associated infrastructure inform and be integrated with the development of the Harwell Campus Concept Masterplan. That includes, but is not limited to, development of a student village, expansion of the RCaH and development of regional and national institutes and campus extensions. The AP particularly highlights support for the following initiatives, which are listed in the BIS document (Creating the Future: A 2020 Vision for Science & Research):

- A Centre for Research in Imaging and Spectroscopy (CRIS); other Centres in Energy and Materials Science, developed in partnership between the large facilities, academic institutions and industry consortia;
- A major extension to the RCUK research complex at Harwell, following the recommendations of the recent RCaH review, highlighting wider engagement with the community and stronger interaction with industry. *Phased development is recommended rather than a single large investment;*
- An extension to the existing Science Hostel (Ridgway House) that is dedicated to hosting short- to medium-term visits by facility users.
- Establishment of a Student Village is also strongly supported but this should be incorporated in and integrated with larger scale plans for development of the HSIC area and masterplan.

A WORLD-CLASS RESEARCH ENVIRONMENT

Q5:How can we maximise collaboration, equipment sharing, and access to industry to ensure we make the most of this investment? (1000 words maximum)

- Collaboration has to occur at the correct level for the value and purpose of the investment being made;
- Incentivise co-operative bids including industrial and academic partners;
- Incentivise institutions hosting mid-level kit to demonstrate widespread use among academic as well as industry uners;
- Ensure co-ordination at a governmental level on areas of common interest (i.e., between ministries) to facilitate and incentivise academic/industrial collaboration;
- Ensure capital equipment investment is always underpinned by funding for and establishment of training programmes for scientific and technical personnel. This will ensure renewal of the UK workforce and provide input for next-generation facility developments to maximise the investment return;
- To maximise economic impact, consultation with industry (SMEs upwards) at the earliest stages should be encouraged in facility development project schemes.

Q6:What factors should we consider when determining the research capital requirement of the higher education estate? (1000 words maximum)

- The primary driver has to be the quality and impact of research enabled by the equipment;
- Step-changes in scientific discovery that the equipment will make possible;
- The training of research personnel and the next generation of scientists;

- Optimum use of capital equipment so that a large number of scientists benefit;
- Provision of technical support for optimum use – and to facilitate use by non-experts;
- Access for external users – industry and SMEs;
- Demonstrated international momentum in the area;
- A potential to engage the public;
- For each discipline, common core techniques should be identified that are essential at departmental (University) level for research and skills training for young researchers;
- Regional level – support from groups of universities;
- At both local and regional levels there is a need to consider infrastructure that will support LFs and industrial engagement.*

* Physics and Chemistry Departments in the UK have recently estimated that the combined capital cost of replacing major equipment that is often of multi-use/multi-user capability is approx £100M per annum. Comparable costs are expected among Engineering and other related science/technology disciplines. The AP notes that additional "hidden" capital costs including provision of infrastructure (e.g., new building or remodelling to account for improved structural stability and environmental control) approximately double the equipment estimates, to yield ~£200M per annum for these two disciplines surveyed (i.e., Physics and Chemistry). These costs were previously made accessible to Universities within the context of the JIF and SRIF (I-III) programmes that have now disappeared. The burden of acquiring, maintaining and upgrading the University-based instrumentation park has now been placed back with the Research Councils targeted to provide investigator-led science and the Universities themselves via the 50% cost-sharing rule. Those considerations are now tensioned against investment in UK-based large facilities and UK participation in international capabilities. That situation is not tenable if the UK wishes to maintain an international lead across key science/technology disciplines.

Q7: 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? (1000 words maximum)

In principle, science capital could be extended to RTOs and IROs e.g. Natural History Museum, British library, and potentially industry, but this should only be done if they offer unique capabilities outside those offered by Research Councils and Universities, and that it is possible to ensure there will be long-term open access to the research community in a sustainable manner.

SCIENCE STRATEGY FOR MAJOR NEW PROJECTS

Q9: What should the criteria for prioritising projects look like? (1000 words maximum)

The criteria should be:

- Scientific excellence;
- Economic and societal impact including development of skills;
- UK leadership;

- Need to consider risk in proportion to benefit (e.g. some projects with high risk/high benefit)?
- Industrial and wider applications.

Q10: Are there new potential high priority projects which are not identified in this document? (1000 word maximum)

The present modest engagement with XFEL is a first step in what a growing community across several scientific disciplines believe is the right direction and will enable the UK community to have some access to this emerging and exciting new technology.

A full engagement with the XFEL project, to broaden access and give UK science a strategic voice in the XFEL project, must be one of the priority topics to be considered under the UK photon/neutron strategy review that is one of the main points agreed upon as necessary by this AP. That review will be of value in defining the best possible option regarding the construction of a UK-XFEL.

It is essential that we now take enabling steps in that direction so that, if we do decide to go ahead with a UK-XFEL instrument, we will have assembled sufficient knowledge and assembled national expertise to implement it rapidly and efficiently as a world-class instrument.

The FEL user community in the UK is scientifically active at emerging frontiers of the new science enabled by the instrumentation. It is presently small but growing and attention must be paid to the potentially significant high-impact outcomes that the UK might make by establishing its own instrument, in addition to investing more substantially in EU capabilities.

The AP felt that the future impact of such a large financial investment must be balanced against the needs of both other existing and projected large facility user communities as well as institutional/regional level research. It was recognised that co-location of a UK XFEL on the HSIC site along with the high-energy Vulcan 20:20 laser capability would provide a unique facility worldwide.

Q11: Should we maintain a proportion of unallocated capital funding to respond to emerging priorities in the second half of this decade? (1000 word maximum)

Absloutely yes. We have to retain sufficient flexibility to respond to new scientific opportunities and breakthroughs. But serious discussion has to be undertaken about the amount of such "hold-back" : not enough and it wouldn't make any difference to any future capital investment/instrument technology; too little and it would take away from current investment potential. The AP suggests that some scenarios are envisaged with possible funding envelopes to assign a "useful" hold-back amount, along with strategies and timelines for spending this if projects are not developed as projected, or new opportunities become available.

Q12: 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? (1000 words maximum)

Broadly, yes the major international projects identified are the right priorities. We must maintain our presence within and support for ESRF and ILL. In the case of ESRF support for the Phase II upgrade should be conveyed clearly to the ESRF management who have

expressed uncertainty about UK committment to the international project, and this has had an impact un UK facility users and beamtime access submission and proposal acceptance rates. That is mainly a "morale" issue that could be alleviated relatively readily, as these consultation documents are assembled.

Dr David Lennon (Chair), School of Chemistry, University of Glasgow;
Professor Andrew Orr-Ewing, School of Chemistry, University of Bristol;
Professor Sarah Hainsworth, Department of Engineering, University of Leicester;
Professor Andrew Randewich, Atomic Weapons Establishment, Aldermaston, Reading;
Professor Jon Marangos, Department of Physics, Imperial College, London;
Professor Paul McMillan, Department of Chemistry, University College London;
Profesor Paolo Radaelli, Department of Physics, University of Oxford.

Thursday 12th June 2014