House of Lords Science and Technology Committee inquiry into Scientific Infrastructure: response from the Royal Astronomical Society

Introduction

With around 3750 members (Fellows), the Royal Astronomical Society (RAS) is the leading learned society representing the interests of astronomers, space scientists, planetary scientists and geophysicists.

This submission is the official response from the RAS. The RAS has no financial interest in the projects and organisations discussed herein, but many of our Fellows have either formal or informal involvement in them through universities and research establishments.

The Society also contributed to the submission from the Science Council, which covers many of the broader issues not included in this response. This document in contrast concentrates on specific issues that affect the communities we represent.

What scientific infrastructure is currently available in the UK, do UK researchers have sufficient access to cutting edge scientific infrastructure and how does this situation compare to that of other countries?

In astronomy, the UK has excellent access to facilities through international collaborations, particularly through our membership of the European Southern Observatory (ESO). This however provides access only to the southern hemisphere and there is an unresolved issue about access to optical telescopes in the north, as budget pressures are forcing some facilities to close.

The situation is more difficult for space-based facilities. Important parts of that infra-structure are provided by the European Space Agency (ESA), but the relatively small number of large missions does not fully cover the needs of the science community. Unlike ground-based facilities space equipment does not seem to be covered by capital allocations.

Within geophysics, researchers have access to the equipment pool of the NERC Geophysical Equipment Facility (GEF)[1] which provides short to medium term loans of larger numbers of instruments than could be obtained by an individual grant or institution. Related support is available from the NERC Airborne Research and Survey Facility[2] and the NERC Field Spectroscopy Facility[3].

Comparable or better infrastructure exists e.g. in the USA for Global Positioning System / Global Navigation Satellite System geodesy and airborne laser scanning, and in Germany for seismology, but the UK is unique in having an integrated facility. However the GEF continually operates at near-full capacity and a substantial increase in funding would significantly improve the number and scale of projects that could be supported.

Is sufficient provision made for operational costs and upgrades to enable best use to be made of the UK's existing scientific infrastructure? Is it used to full capacity; and, if not, what steps could be taken to address this?

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[1] http://gef.nerc.ac.uk/
[2] http://arsf.nerc.ac.uk/
[3] http://fsf.nerc.ac.uk/

Scientists in both the astronomy and geophysics communities fully support the development of new facilities, but feel very strongly that the support for the exploitation of those facilities and projects needs to be in place from the start. Capital for existing and new projects has to be supported by additional grant funding, including support for post-doctoral research associates (the number supported by STFC has declined by 50% since 2008) that is sufficient to utilise new infrastructure to the full.

The outcome of not providing adequate funds for support is that new facilities are either under-utilised or that they absorb a disproportionate share of the grants budgets in the relevant research councils and thus damage existing projects.

What substantial increases in scale would allow new areas or domains of science to be explored (analogous to Large Hadron Collider and Higgs boson)?

There is no shortage of scientific ambition in both the astronomy and geophysics communities. Examples of potentially ground-breaking new projects include:

- A new large ultraviolet/optical space telescope to replace Hubble

  The Hubble Space Telescope is possibly the best known of all astronomical facilities. However, it is coming to the end of its life in orbit and cannot be repaired again. The outstanding scientific results of the mission have clearly demonstrated the need for this kind of facility. A large space telescope operating in the ultraviolet and visible bands will have the goal of studying the conditions for the evolution of life in the Universe. It would enable observation of the key atmospheric ingredients of Earth-like exoplanets (carbon, oxygen, ozone) and lead to detection of biologically active worlds outside the Solar System, if they exist.

- A new large orbiting X-ray observatory

  The next decade will see the European Extremely Large Telescope (E-ELT) and Square Kilometre Array (SKA) radio telescope begin operations. There is however no plan for an X-ray observatory (of necessity these are sited in space) to replace the current generation of telescopes that began service more than a decade ago. E-ELT and SKA will undoubtedly make new discoveries and a new X-ray observatory would allow scientists to follow these up in that region of the spectrum, inaccessible to facilities on the ground.

- A robotic space mission to Mars to retrieve a sample from the surface and return it to Earth

  This mission is a key goal in the exploration of the Solar System. Using a robot spacecraft to return a sample from the surface of the red planet to laboratories on Earth would help establish whether Mars has ever hosted life. This mission would capture the imagination of the public and there would be numerous scientific opportunities opened by the development of the programme.

- A new gravitational wave observatory

This would address one of the long-standing problems in modern physics, namely the incompatibility of the theories of general relativity (which describes gravity) and quantum mechanics. The proposed Einstein Observatory[4] would be a pan-European project, probably sited underground in the Alps that would test general relativity at a fundamental level. Wider applications from this could include a step change in the precision of GPS systems.

- Renewed commitment to the Global Exploration Strategy

In 2009 the then British National Space Centre recommended that the UK take part in the Global Exploration Strategy[5] and aim to deliver the goals set out in the Global Exploration Roadmap[6]. Examples include the exploration of a nearby asteroid and ultimately Mars. Participation at this level would deliver major opportunities in planetary science, microgravity research and space-based astronomy.

- EUROARRAY

The proposed EUROARRAY would be a pan-European initiative to explore the 3D structure and physical processes that characterise the mantle and crust of Europe and the selected parts of the nearby ocean. It would consist of a large array (2800 instruments) of onshore and ocean bottom seismometers deployed in five sectors across the continent, enabling scientists to record seismic and environmental data and establish how these change when major geological events take place. These are fundamental to understanding the processes that take place at the boundary between the mantle and core of the Earth and how these relate to seismic hazards on the surface. EUROARRAY would complement the USarray now in operation in North America.

- 3D marine and land seismic acquisition

No oil company will drill a prospective oilfield now without three-dimensional (3D) seismic images, because the detail in them allows the expensive borehole to be guided to the most likely spot for finding oil. Consequently, seismic prospecting contractors have made big investments in specialist ships and land crews for acquiring 3D data, massive computing power to process the terabytes of data acquired, and cutting-edge research to improve the resolution of the images. At present, academic research is denied these capabilities unless the data happen to be there already; hence targets lacking oil have not been imaged. These might include the Gorringe Bank, possibly the origin of the 1755 Lisbon earthquake; the potentially earthquake-generating subduction zones off the shores of Japan and the Caribbean; methane gas seeps in Arctic seas that might be boosting global warming; and the spreading mid-ocean ridges where the Earth's crust is born and glimpses of the underlying mantle are seen. On land targets include earthquake-prone faults near cities such as

[4] http://www.et-gw.eu/
[5] https://www.globalspaceexploration.org/c/document_library/get_file?uuid=119c14c4-6f68-49dd-94fa-af08ecb0c4f6&groupId=10812
[6] http://www.nasa.gov/pdf/591067main_GER_2011_small_single.pdf

Christchurch and in China; the Ethiopian Rift where the continent is splitting; mountain-building zones such as the Alps and Himalayas; and old crust such as in northwest Scotland, where past academic two-dimensional surveys have shown tantalising signs of deep faults in the upper mantle.

What role should the Government play in ensuring that there is an effective long-term strategy for meeting future scientific infrastructure needs?

In astronomy, Government funding through the research councils is the only viable way of maintaining access to the largest facilities, channelled through international organisations such as ESO and ESA where appropriate.

Some members of the geophysics community argue that the funding of medium-level infrastructure should be given a higher priority and be protected within the science budget.

Is it more important to invest in large, national infrastructure or medium infrastructure?

Science research needs access to a range of facilities, but international competitiveness is essential so large infrastructure will always be required. Fulfilling research needs will often demand international collaboration, as large infrastructure projects are beyond the means of national programmes. Astronomical infrastructure such as telescopes has, necessarily, to be located abroad in suitable locations, but the UK should seek to host international facilities in areas where it has particular expertise.

Geophysics also depends on infrastructure at all scales. This community emphasises the need for medium –sized infrastructure so that the UK can maintain a broad research base and provide workforce training at doctoral and postdoctoral level.

Since the last Comprehensive Spending Review, a series of additional announcements have been made on investment in scientific infrastructure.

How were the decisions on investment reached and what have been the impacts of this approach to funding scientific infrastructure?

While this has been largely positive, many capital decisions seem to have been made at government (Ministerial) level rather than in the research councils, which represents a different strategic approach to that previously in place. The Committee should investigate whether these decisions were properly informed by consultation with the scientific community.

What impact has removing capital spend from the ring-fenced budget had on investment in scientific infrastructure and should the ring-fenced science budget be redefined to include an element of capital spend?

The decision to remove capital from the ring-fenced budget has had a serious impact, leading to a reduction of more than 50% in the funds available (see for example the evidence given by the Society to the earlier Commons Science and Technology Committee inquiry into Astronomy and Particle Physics[7]). This has mainly been through the reduction of available capital for new projects.

[7] http://www.publications.parliament.uk/pa/cm201012/cmselect/cmsctech/806/806we03.htm

Universities have been forced to find capital funding to match research grant support when they have no capital income. This in turn has led to redeployment of grant overheads into capital support and has increased the costs of all grants to Universities.

Members of the Society state that the current capital funding environment makes it impossible to plan ahead for replacement/upgrade costs as equipment becomes inoperative or obsolete, leading to its degradation.

If the current funding level is maintained or reduced, what would be the longer term impacts on scientific infrastructure in the UK?

There is a serious risk that capability will be undermined in the longer term, making the UK uncompetitive with its international peers. There is also a question as to whether recent capital decisions have been made in an appropriately strategic way. Rapid responses to short-term funding calls are not the best way to plan future infrastructure.

Does the UK have effective governance structures covering investment in scientific infrastructure, how do they compare to those of other countries, and are there alternatives which would better enable long-term planning and decision-making?

The research councils are effective in long term planning for future facilities. They provide an appropriate decision making structure in their respective scientific disciplines. However, these structures are weak when engaging with facilities that cover the disciplines of more than one research council. STFC runs such cross-council facilities effectively, but there are questions of intellectual ownership and funding for separate communities of users that need to be addressed.

In astronomy, space science and some aspects of geophysics (e.g. remote sensing) the UK Space Agency also plays an important role. The research councils (STFC and NERC) should provide strategic science advice to the Agency, which should then seek to deliver these goals through ESA or bilateral arrangements with other nations. These issues are explored more fully in the RAS response to the Commons Science and Technology Committee inquiry into the UK and European Space Agencies[8].

To what extent do funding structures in the UK help or hinder involvement in EU and international projects, and should the level of UK involvement be improved?

In general these structures do not hinder involvement, although the often long lead times for decisions and the element of perceived double jeopardy in applying for infrastructure usage separately from experimental operating costs can be problematic.

More generally, it is worth noting the difficulties in recruiting excellent overseas research students which result from a combination of the UK residency requirements for studentship funding, and (for non-EU students) the high tuition fees charged by universities.

There are of course good reasons for the government underwriting educational costs for UK students but not for internationals. However, postgraduate students are not just recipients of education but also are one of the main engines of our research. Within the global world of scientific research our capabilities are enhanced by having the best students wherever they come from. Even

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[8] http://data.parliament.uk/writtenevidence/WrittenEvidence.svc/EvidencePdf/587

if they leave the UK after their PhD, the international links which they represent are valuable to the UK research effort and to our future global influence.