NATURAL ENVIRONMENT RESEARCH COUNCIL

Organisational Theme Reports
NERC Strategy 2007 – 2012
Next Generation Science for Planet Earth

Research Facilities and Equipment
November 2007

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Organisational Theme Report

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Research facilities and equipment

Essential infrastructure for environmental science

1. Introduction

1.1 Approach

1.1.1 Theme reports are the core of NERC strategy for 2007 – 2012 *Next Generation Science for Planet Earth*. The Reports are the culmination of consultation, advice and decision-making that took place over 2006 and 2007. They are working documents that provide the basis for implementation, informing Theme Action Plans. The corresponding sections of the published NERC strategy document are a summary of the information in the reports.

1.1.2 The reports were produced by Strategy Development Panels in 2006 and underwent further development in 2007 to incorporate changes to the strategy resulting from a public consultation. The overall process for development of the Research Facilities and Equipment report is summarised below

1.1.3 The NERC Chief Executive was delegated by NERC Council to establish the Research Facilities and Equipment Strategy Development Panel ('Facilities and Equipment panel') to identify the major 'infrastructure' issues NERC needs to address, and develop options and recommendations for consideration at the November 2006 Council Meeting. Panel members were selected for their knowledge and experience, not as representatives from particular institutions or organisations. In addition there has been input from senior managers across NERC.

1.1.4 The Research Facilities and Equipment panel met twice, on 9 May and 9 June 2006. Two panel meetings were held supplemented by email discussions. Both meetings took the form of debate and brainstorming sessions. These addressed the nature of environmental science, the especially wide range of infrastructure required to support it, NERC's existing infrastructure and how this could and should be matched to current and future needs. A classification of necessary infrastructure was developed and a process was outlined for its future development.

1.1.5 Further information on the scope of the panel and the analysis they undertook is provided below, in sections 1.3 and 2, respectively.

1.1.6 The panel's report was presented to the NERC Executive Board (NEB) on 21 September 2006. A revised version, incorporating the conclusions from NEB was presented to Council on 30 November 2006. Subsequently, the report was further updated to reflect the overall priorities agreed at Council for the theme

1.1.7 A draft NERC Strategy Document was developed from the panel reports and was opened for public consultation in February – April 2007. A final version of the Strategy, incorporating recommendations from the consultation, was approved by Council in June

2007 and published in November 2007. In October 2007 the theme reports were updated again to reflect this evolution of the strategy document.

1.2 Background

1.2.1 The Earth is very large and complicated. To establish its nature and to understand how it functions requires the *capability*, within the limits of practicability, to access any part of it for the following purposes:

(i) To make measurements *in situ.*
(ii) To use the location as a vantage point for remote measurements of another location.
(iii) To obtain and retrieve samples for analysis on site or elsewhere.

1.2.2 The types of measurements and samples cover the gamut of the natural sciences, ranging across physics, chemistry, biology and the geosciences. The nature of the locations addressed encompasses physical, chemical and biological conditions that present major challenges for humans and instruments alike. The time-scales of relevance range from fractions of a second to billions of years, with a need to be able to sustain contemporary time-series measurements for periods up to decades or even centuries.

1.2.3 Such geographical access requires a safe and cost effective transport and life-support system for humans, or a robotic alternative. In addition specific equipment and instruments are required to make the desired measurements, and/or to extract samples, to carry out analysis on site, and/or to preserve and return samples or data to a place of analysis.

1.2.4 Once returned, samples require apparatus for their analysis ranging from that found in a "well-found" laboratory to highly sophisticated large-scale facilities. They may also need to be stored and archived in controlled environments for their long-term preservation.

1.2.5 The analysis of retrieved data, as well as modelling and simulation activities, require digital computing facilities ranging from desktops to the most-powerful supercomputers available.

1.2.6 NERC's roles as a funding agency for the UK academic environmental community, as an employer of staff, and as an owner of research institutes and infrastructure, result in its being a highly complex organisation requiring the full range of modern management infrastructure, such as business systems and communication facilities.

1.2.7 Thus to fulfil its purpose, NERC has to provide and operate a great range and variety of infrastructure, arguably more so than for any other scientific enterprise. This places especial importance for NERC on the enabling function of existing and new technology.

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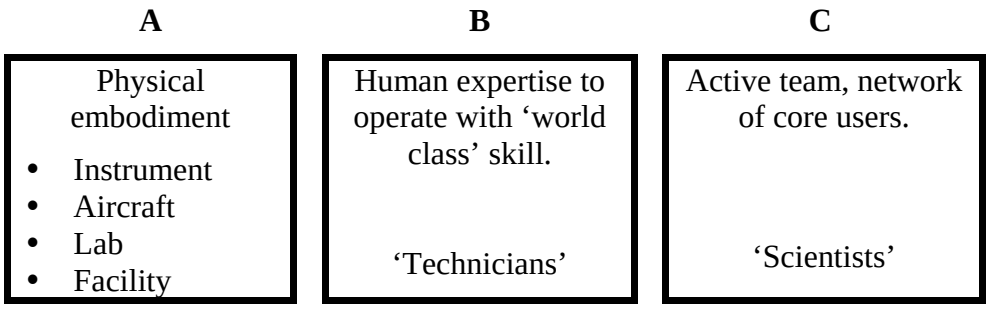
1.3 Scope of the Panel

1.3.1 The panel noted that owning or having access to the physical embodiment of a piece of infrastructure, however fit-for-purpose, is a necessary but insufficient condition for its successful use. Also required are expert technical and scientific staff to develop, operate, maintain and exploit the equipment. The panel thus defined infrastructure in the broader sense of "capability", as indicated in the figure, and adopted this definition in its considerations, noting, in passing, that the people encompassed by this definition cut across the NERC Funding categories (i.e. categories 1, 2, 3 and 5 all involved).



A + B + C = Infrastructure Capability

2. Analysis

2.1 Assessment of the inputs to the panel

2.1.1 The panel considered the range of types of infrastructure required by NERC (consistent with the definition above) and how this may be procured and managed.

2.2 An Infrastructure Taxonomy

2.2.1 Given the complex and wide ranging nature of NERC infrastructure, in order to structure its discussions the Panel defined subsets based on a taxonomy of uses as follows:

Type I: Obtaining the data or samples

(a) *Transporting scientist and equipment to and from investigation site;*

(b) *Access to measurement point directly or remotely;*

(c) *Transporting samples and data back to base.*

(a) *Transporting scientist and equipment to and from investigation site*

2.2.2 A scientist was defined as any researcher funded by NERC in support of NERC science.

Transport provides the safe and economic access between the scientist's home base and the point of investigation, for people equipment, samples and data. Transport of people may be commercial, by air, land or water; or bespoke, either NERC owned or acquired by barter or through a bilateral or multi-lateral collaborative arrangement. Similarly for equipment, with additional means including space launchers, and autonomous vehicles and platforms of all types. Commands to and data from equipment may be transmitted electronically or via wireless. Equipment may be bespoke from scientist's own lab; general from a loan pool, or purchased commercially. On-site, scientists will require life support (shelter – ranging from a tent to a base, plus sustenance, medical facilities, etc), communications, security, and possibly local guides. Pre-trip specialist survival training may be necessary.

(b) ***Access to measurement point directly or remotely***

2.2.3 This can be provided by Remote Platforms including satellites, unmanned drones or aircraft, balloons, and unmanned vessels, buoys or vehicles (rovers), plus an enormous range of standard or specialist instruments.

(c) ***Transporting samples and data back to base***

2.2.4 Some samples may need pre-transport preparation, e.g. drying, crushing, preservation, boxing etc. Sample transport may be specialised (e.g. ice cores in frozen storage). Data may require telemetry.

Type II: Analysis of samples, data once returned to home base

2.2.5 Infrastructure which needs to be provided at the scientist's home base includes "well-found laboratory" which requires buildings (sometimes specialist), and related equipment, plus specialist facilities and services.

Type III: Production of scientific output and outcomes

2.2.6 The processing of electronic information and the analysis and publishing of data requires the gamut of modern Information Technology from microprocessors to supercomputers, with specialist facilities and teams such as drawing offices, mapping units, PR teams, and experts in commercialisation and spin-out. Also required is the capability to link NERC scientists electronically and physically to facilitate joint working (e.g. Access Grid, remote control of field facilities).

Type IV: Archive and Storage

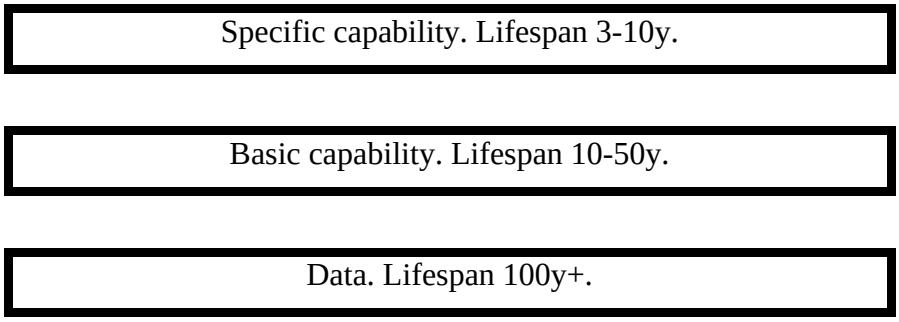
2.2.7 Other facilities are required for storage, either of physical, geological or biological samples (e.g. ice cores, marine sediment cores, rocks, biological specimens), and data. These may need to satisfy international standards.

Type V: Business Systems and Back Office.

2.2.8 Finally, given that NERC constitutes a £400m/y "business", Back Office and business systems facilities are required including financial management, Video conferencing, Mail communications networks/mailing lists and a wide variety of data bases. This area is notorious for expensive project failures and requires especially close attention.

3. What defines the specifics of NERC's needs?

3.1 The NERC Science strategy, and in particular the specific science objectives of its portfolio of funded research activities, define the infrastructure needs. Science strategy tends to turn over with a shorter life span than major infrastructure (or at least, the basic capability component, e.g. ships, aircraft, specialist laboratories), which in turn will generally have a shorter lifespan than data.



3.2 Section 2 above illustrates the kaleidoscopic variety of infrastructure required by NERC to fulfil its mission. To carry out a "zero baseline" review and build up a list from scratch would be an overwhelming and impracticable task. The panel's recommendation, therefore, is that the management approach should be to list the major part of the historically contingent set of infrastructure that NERC owns or has access to already, and to develop a process by which this is adjusted in an evolutionary fashion. A strategic checklist of desired characteristics could be developed to guide decision-making (e.g. what we are good at, new opportunities opened up by technology or new forms of collaboration, the need to sunset facilities and equipment that are no longer value for money, or are simply out of date, general affordability, perceived national needs). This could take the form of a rolling review looking across all infrastructure – down to a level of detail, probably best determined by a financial cut off.

3.3 Once it has been decided what should be provided, how should that be implemented?

3.4 Ownership options include commercial contract, NERC owned and operated (via Swindon Office, Research Centres, Collaborative Centres, HEIs), HEI owned and managed (at FEC), NERC owned and HEI managed, bartering/alliances, international 'clubs' or subscriptions (e.g. ESA; EPICA; IODP), or via national or international collaborative arrangements. The decisions on the mode of ownership will need to be addressed on a case-by-case basis, balancing issues such as the technical complexity and delivery quality of the infrastructure against value for money (for example).

What do we have now?

Strengths	Weaknesses

• Does the job
• Diversity, hence flexibility, of support
• UK lead in specific areas
• Successful at obtaining large facility support
• Cost effective
• High reputation
• Bartering record
	• Investment/running costs blocks ability to take new opportunities
	• Time to respond to new science requirements
	• Long cost and experience time constants
	• Lack overview information:
	  ▫ What do we have?
	  ▫ What does it cost?
	  ▫ How is it used?
	  ▫ How useful is it?

Opportunities	**Threats**

• More informed investment decisions
• Partnerships
  ▫ National
  ▫ International
• Reputation
	• Fail to take decisions to terminate support
	• Asset register
	• Science and Technology Facilities Council may seek to take over NERC infrastructure
	• Funds dry up

4. Challenges

4.1 Challenge 1: Maintain a Distributed Portfolio – ensuring that it is flexible and responsive, to the extent practicable, to the needs of the NERC science programme

4.1.1. The infrastructure must meet the needs of current science challenges, both internal (to NERC) and external, and be able to adapt quickly to emerging science priorities

4.1.2. The panel identified the longer lifespan of infrastructure compared with science objectives, therefore a key challenge is anticipating the portfolio of infrastructure that future science priorities will demand. A further challenge is ensuring the right ownership model for different types of infrastructure, ensuring appropriate balance of flexibility, reliability and stability

4.1.3. NERC can contribute to this challenge by anticipating the need for infrastructure, managing the overall infrastructure portfolio while devolving individual management tasks as appropriate, and regularly reviewing the quality of and need for infrastructure.

4.1.4 We need to minimise the extent to which science challenges are limited by infrastructure. This will be achieved by introducing processes for delivering the portfolio of infrastructure so that it can respond to changing science priorities.

4.1.5 The strategic objective is to maintain a distributed portfolio that is flexible and responsive to the needs of the NERC science programme.

4.1.6 The current portfolio of infrastructure is more or less appropriate for the current science priorities. In future we recommend a process that allows greater flexibility (see Challenges 2 and 4).

4.1.7 This challenge is strongly linked with both the People and Delivery strategy themes. Infrastructure needs to be responsive to the changing needs of the science themes, and people are a key part of infrastructure as we have defined it.

4.2 Challenge 2: Establish an organisational framework for oversight of science infrastructure

4.2.1 The framework should ensure optimum value for money and efficacy from infrastructure, identify opportunities and future needs. It should set priorities, including which areas are no longer needed, and do so on a rolling basis, using a life cycle approach, recognising range of life spans of infrastructure. We need to identify new science opportunities arising from newly emerging technology, and manage our assets effectively.

4.2.2 The framework should also ensure that researchers have access to cutting edge facilities and safeguard national capability such as long-term monitoring.

4.2.3 In establishing the framework, the key challenges will be overcoming resistance to change, implementing review procedures responsive to the science needs/drivers but independent of the infrastructure itself, and introducing management structures that are appropriate to the investment, rather than a one-size-fits-all approach.

4.2.4 NERC owns the organisational structure, but does not own all the infrastructure or facilities. We will need to implement effective “horizon scanning” through coordination of in-house and external expertise.

4.2.5 The organisational structure must ensure flexibility, value for money and responsiveness to evolving science needs.

4.2.6 The organisational framework will allow one body to have an overview of all NERC’s investments in infrastructure. This will enable the appropriate infrastructure being available to match the strategic science objectives.

4.2.7 This fits well with the evolution of the current Services Review Group, which is taking a more proactive approach to portfolio management. The stronger drive from NERC’s science priorities will also be reflected in the new organisational framework.

4.2.8 The organisational framework will have links to NERC’s Capital Strategy and the Technology Strategy. It will need to interact with the Large Facilities Capital Fund and

be aware of the changes taking place with the formation of the Science and Technology Facilities Council.

4.3 Challenge 3: Develop a joined-up approach to infrastructure, sharing skills and knowledge of what is available

4.3.1 We should ensure that skills, knowledge and infrastructure are shared effectively across the UK and internationally. Sharing should be encouraged whether the infrastructure is purchased by NERC or by other means. It should take place across NERC, the Research Councils UK and funding agencies in other countries, and across HEI communities in the UK and abroad. There should be strong links between existing and new technology.

4.3.2 Developing a joined-up approach is strongly connected to Challenge 2, the establishment of an organisational framework. A key to success will be effective communication across all sectors (NERC, other Research Councils, HEIs).

4.3.3 To meet this challenge, NERC will provide coordination and leadership and facilitate communication.

4.3.4 The desired deliverables will be a more strongly coordinated approach to infrastructure than at present, ensuring a better fit to science priorities and improved value for money.

4.3.5 The strategic objective is to take a holistic view of infrastructure, drawing on the available skills and knowledge within and outside the NERC community.

4.3.6 Establishing a joined-up approach to infrastructure is a natural progression from the changes being considered for the Services Review Group. We recognise the need for stronger management and coordination of the overall infrastructure strategy.

4.3.7 Implementing an effective joined-up policy depends heavily on motivation, and therefore links to the People theme. Implementing a new management framework links to the Delivery theme.

4.4 Challenge 4: Develop and maintain a range of ownership models that is responsive to NERC needs and science priorities

4.4.1 We need to ensure the ownership models are appropriate to infrastructure needs. NERC should have the flexibility to change management of individual facilities as appropriate.

4.4.2 NERC Services and Facilities employ the ‘NERC owned, HEI operated’ model, but this is not generally applied for equipment bought via grants. This ownership model should be applied where appropriate.

4.4.3 NERC will supply coordination and leadership to encourage and facilitate a range of ownership models.

4.4.4 The desired deliverables will be a range of ownership models covering widely ranging requirements of services, facilities and other infrastructure.

4.4.5 The strategic objective is a range of ownership models that is responsive to NERC needs and science priorities.

4.4.6 NERC is currently reviewing the management and coordination of its science infrastructure, so this fits with the current review.

4.4.7 This challenge is linked to Challenge 2 and the Delivery theme.

5. Meeting the Challenges

5.1 The published NERC Strategy highlights some of the ways in which the NERC will be "Meeting the Challenges" for the Research Facilities and Equipment Theme. These are essentially some of the potential key deliverables. They often cut across several of the Theme's challenges. For consistency, we have included them below against the key challenges that they most strongly relate to. They are not exclusive and may evolve during the Strategy's lifetime.

"Meeting the Challenges" (from the NERC Strategy)	**Research Facilities and Equipment Challenges**			
	1	**2**	**3**	**4**
Develop a framework of scientific infrastructure for UK environmental science that is set in an international context	X	X	X	X
Identify the facilities and equipment that the environmental community will need in the future to meet its scientific challenges	X	X	X	
Strengthen the scientific community by developing networks for sharing skills and knowledge of science facilities and equipment			X	
Improve the efficiency of research infrastructure by exploiting new technological advances emerging from the technologies theme		X		

6. Conclusions and Recommendations

6.1 NERC needs to establish a strong oversight structure and process capable of relating infrastructure needs to science needs, identifying new requirements and components for sun-setting. The natural starting point should be the existing Services Review Group, which does an effective job on a smaller remit. The management of specific components of infrastructure needs to be delegated to local levels (details of which vary across the portfolio). The overall outcome must be responsive to evolving priorities.