National Audit Office

**Report**
by the Comptroller
and Auditor General

**Department for Business, Energy & Industrial Strategy**

# Cross-government funding of research and development

**HC 564 SESSION 2017–2019 15 NOVEMBER 2017**

Our vision is to help the nation spend wisely.

Our public audit perspective helps Parliament hold government to account and improve public services.

The National Audit Office scrutinises public spending for Parliament and is independent of government. The Comptroller and Auditor General (C&AG), Sir Amyas Morse KCB, is an Officer of the House of Commons and leads the NAO. The C&AG certifies the accounts of all government departments and many other public sector bodies. He has statutory authority to examine and report to Parliament on whether departments and the bodies they fund have used their resources efficiently, effectively, and with economy. Our studies evaluate the value for money of public spending, nationally and locally. Our recommendations and reports on good practice help government improve public services, and our work led to audited savings of £734 million in 2016.

National Audit Office

Department for Business, Energy & Industrial Strategy

# Cross-government funding of research and development

Report by the Comptroller and Auditor General

Ordered by the House of Commons
to be printed on 14 November 2017

This report has been prepared under Section 6 of the National Audit Act 1983 for presentation to the House of Commons in accordance with Section 9 of the Act

Sir Amyas Morse KCB
Comptroller and Auditor General
National Audit Office

10 November 2017

HC 564 | £10.00

This report examines the effectiveness of government's arrangements for coordinating research activity and maximising the value of government's investment in research and development.



11505 11/17 NAO

# Contents



The National Audit Office study team consisted of:
Heather Thompson, Rachel Kift, Naseef Huda and Sarah Hipkiss, under the direction of Siân Jones.

This report can be found on the National Audit Office website at www.nao.org.uk

For further information about the National Audit Office please contact:

National Audit Office
Press Office
157–197 Buckingham Palace Road
Victoria
London
SW1W 9SP

Tel: 020 7798 7400

Enquiries: www.nao.org.uk/contact-us

Website: www.nao.org.uk

Twitter: @NAOorguk

# Key facts

**£8.75bn**

total expenditure on research and development by UK government departments, the research councils and the Higher Education funding councils in 2015

**1.7%**

total UK expenditure on research and development in 2015 as a proportion of GDP

**£4.7bn**

additional government investment in research and development by 2021

| | |
|---|---|
| **Around £3 billion** | total estimated expenditure on research in 2015-16 by the Ministry of Defence, the Department of Health, the Department for International Development and the Department for Environment, Food & Rural Affairs. |
| **6** | research areas we examined in detail in this report: human health, animal and plant health, climate, energy, robotics and autonomous systems, and advanced materials. |
| **Above £3 billion** | total estimated annual expenditure in these six research areas |

# Summary

## The research and development environment

**1** Research and development is important for a number of reasons. It promotes economic prosperity, it assists in tackling challenges to our society and it helps to expand human knowledge. Research can encompass basic research to acquire new scientific knowledge, applied research to solve specific problems, and translational research aimed at exploiting technologies to develop new products or processes.

**2** In 2015, the UK spent £31.6 billion on research and development. Around half of this total investment was funded by the business sector, while government funding of research, including spending by UK government departments, the research councils and higher education funding councils, totalled £8.75 billion. Most of the remaining funding came from overseas funders or not-for-profit organisations.

**3** The Department for Business, Energy & Industrial Strategy (BEIS) has responsibility for the majority of government investment in science. It funds research and development principally through its partner organisations, the research councils, Innovate UK and the Higher Education Funding Council for England (HEFCE). In addition, around a third of public funding of research and development comes from other government departments, including the Department for Environment, Food & Rural Affairs (Defra), the Ministry of Defence (MoD), the Department for International Development (DFID) and the Department of Health, who fund research specific to their own policy areas.

**4** The UK research environment is undergoing significant change. In 2015, Sir Paul Nurse's review of the research councils recommended better coordination of the research landscape and new cross-government arrangements to facilitate strategic research priorities.[1] A new body, UK Research and Innovation (UKRI), will bring together the research councils, Innovate UK and Research England (HEFCE's research funding functions). UKRI will be in place from April 2018, and is intended to create an integrated research and innovation system. In January 2017, the government published its Industrial Strategy green paper which highlighted the importance of research for economic growth.

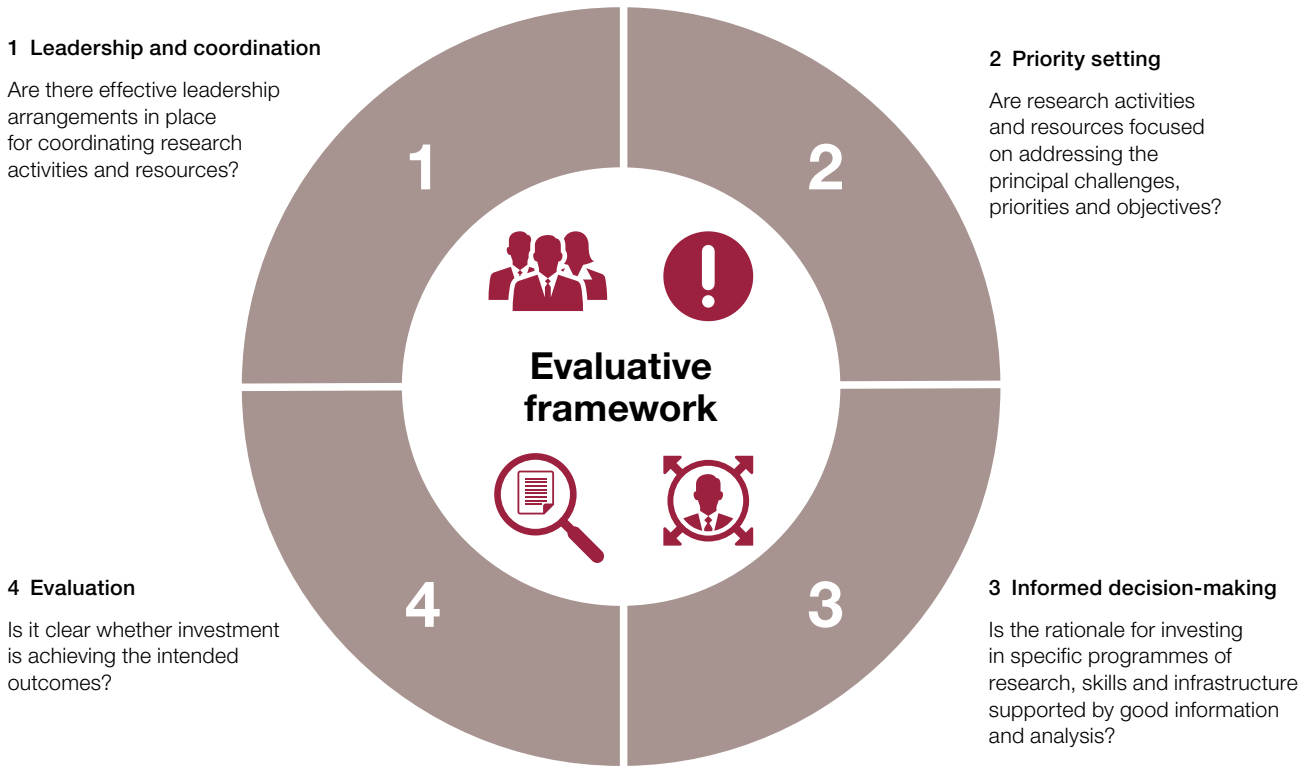
1 Sir Paul Nurse, A review of the UK research councils, *Ensuring a successful UK research endeavour*, November 2015.

## Focus of our report

**5** Research and development activity receives multiple sources of public funding, including from government departments, research councils, higher education funding councils and international funds. This cross-government activity requires strategic vision and clear information about how funding is used. Funding decisions need to be supported by a good understanding of past, current and planned research investment by all funders to ensure that investment is targeted where it is most needed, and that the risks of overlap or duplication of research activity are avoided.

**6** In response to this challenge, we developed a set of principles which bring together the features of well-coordinated funding of research and development (**Figure 1**). We drew on frameworks for evaluating research used by other organisations, as well as existing frameworks developed by the National Audit Office.[2] We also consulted on the principles with government departments that fund research and with the Government Office for Science.

**Figure 1**
Evaluative framework: Principles for evaluating coordination arrangements




Source: National Audit Office

2 Comptroller and Auditor General, *Government's management of its performance: progress with single departmental plans*, Session 2016-17, HC 872, National Audit Office, July 2016.

**7** We used these principles as an evaluative framework to assess the effectiveness of arrangements for coordinating research activity and maximising the value of government's investment in research. Our work focused on six areas of research involving multiple government departments, agencies and research councils, and substantial public funding. We compared arrangements across the six research areas in order to highlight good practice and identify where improvements could be made. The six research areas are:

- human health;
- animal and plant health;
- climate;
- energy;
- robotics and autonomous systems; and
- advanced materials.

**8** The report includes an introductory chapter providing background and context to research and development (Part One), and is then structured according to the set of principles (Figure 1):

- leadership and coordination (Part Two);
- priority setting (Part Three);
- informed decision-making (Part Four); and
- evaluating the impact of investing in research (Part Five).

**9** We set out our audit approach in Appendix One and our evidence base in Appendix Two. In addition, we have published our evaluative framework and a range of case studies covering the areas we examined, available at: www.nao.org.uk/report/cross-government-funding-of-research-and-development/

**10** This report builds on existing work by the National Audit Office on science and research which aims to improve accountability and transparency, disseminate good practice and influence future changes to the science and research landscape. In 2016, we published a report which examined the former Department for Business, Innovation & Skills' (BIS) approach to investing in science infrastructure projects.[3]

**11** The funding of research and development is a broad and wide ranging topic, and our focus was restricted to examining six areas of research against the key principles we identify in Figure 1. As a result, there are issues that this report does not directly address, such as the mechanisms by which individual departments manage their research budgets, the balance between public and private funding of research, and government's investment in translational research to support innovation. Such topics may be considered in future NAO work in this area.

3 Comptroller and Auditor General, *BIS's capital investment in science projects*, Session 2015-16, HC 885, National Audit Office, March 2016.

## Government funding of research and development

**12 As a percentage of Gross Domestic Product (GDP), the UK spends less on research and development than the average for European Union (EU) and Organisation for Economic Co-operation and Development (OECD) countries.** The EU has set a target to increase combined public and private investment in research and development to 3% of GDP by 2020. In 2015, the UK (the second largest EU economy, accounting for 16% of the EU's total GDP in 2016) spent a total of £31.6 billion on research, 1.68% of UK GDP, an increase from 1.66% in 2014. This compares with an average of 2.03% across all EU countries and an OECD average of 2.4%. The UK spends less on translating research into commercial applications than some other countries including Israel and China (paragraphs 1.4 to 1.6).

**13 Since 2015, the government has made various commitments to increase research funding.** In 2015 spending by UK government totalled £8.75 billion. Recent commitments include the £1.5 billion Global Challenges Research Fund, and an additional £4.7 billion spending on research by 2021 (paragraphs 1.4 and 1.9).

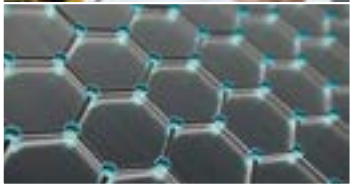
**14 The UK's withdrawal from the EU could affect how UK research is funded in future.** The UK is a net receiver of competitive EU funding for research. Between 2007 and 2013, the UK contributed €5.4 billion and received €8.8 billion. In August 2016, the government guaranteed future funding for grants won by British businesses and universities while the UK remains a member of the EU, and encouraged UK researchers to continue to bid for EU funding. However the longer-term implications for funding, freedom of movement and collaborative research projects will depend on the outcome of the UK's negotiations with the EU and future UK Government decisions (paragraphs 1.10 and 1.11).

## Key findings

### NAO assessment

**15** Given this context, we assessed the six research areas against the set of principles in our evaluative framework. Our overall assessment (**Figure 2**) brings together our findings across the key principles of leadership and coordination, priority setting, informed decision-making, and evaluating the impact of investing in research and development.

## Figure 2
Overall assessment

| Overall assessment | Research area (and indicative level of public funding) | |
|---|---|---|
| Well established<br>Coordination mechanisms and leadership arrangements are well established and functioning, consolidated data on funding and capability is used to support decision-making, and steps are being taken towards consolidated evaluation of research outcomes. | **Human health** (£2.3 billion in 2015) |  |
| Progressing<br>There is broad consensus of a need for coordination and leadership; mechanisms for setting strategy and sharing information are in development. | **Animal and plant health** (above £0.2 billion per annum) |  |
| | **Energy** (£0.38 billion in 2014) |  |
| In early development<br>Some evidence of coordination mechanisms but strategic leadership and coordination, and consolidated information to inform decisions and evaluation, are not yet sufficiently developed. | **Climate** (above £0.09 billion per annum) |  |
| | **Robotics and autonomous systems** (£0.38 billion incurred or planned between 2012 and 2020) |  |
| | **Advanced materials** (above £0.6 billion invested in current research programmes) |  |

**Note**

1 Total funding for each research area is not reported on a consistent basis or in one place. The data is not presented here for the purpose of comparison but to give an indication of the estimated scale of funding. Further details including sources, at Figure 9.

Source: National Audit Office

## Leadership and coordination

**16 While there are examples of well-coordinated research and development, or areas of progress, some important areas of science lack sufficiently developed leadership.** Our examination has demonstrated that strong leadership is the driving force for coordination and making everything else happen – this includes setting priorities, and having good information to make decisions and evaluate the impact of investment. In human health, various forums play a role in ensuring a strategically coherent approach to funding research and funders of energy and animal and plant health research are currently developing leadership arrangements. Other areas are less developed. Despite consensus that it is needed, BEIS has not yet established government leadership and a strategy for investing in robotics. Government has faced challenges in establishing stable leadership in advanced materials research. The Advanced Materials Leadership Council was dissolved in December 2016 and it was not clear at that time what would replace it. It was reconvened in June 2017 as a smaller industry-led group that aims to be more responsive than its predecessor (paragraphs 2.3 to 2.13 and Figure 10).

**17 Key features of effective coordination include involvement of the right participants, clarity around participants' objectives, production of tangible outputs, clear roles and responsibilities and effective incentives for staying involved.** Furthermore, the costs associated with leadership and coordination can be minimal compared to the level of investment in research and the value to funders (paragraph 2.3 and Figure 11).

**18 BEIS and UKRI have an important role to play to incentivise and enable effective leadership arrangements across research areas.** The creation of UKRI offers an ideal opportunity to encourage and support research areas to develop effective arrangements, using good practice examples to inform changes (paragraphs 2.1 and 2.2).

## Priority setting

**19 Where there is effective leadership, funders work together to prioritise research investment.** We found that investment priorities are well coordinated in one research area (human health) where funders use opportunities provided by forums such as the Office for Strategic Coordination of Health Research (OSCHR), to discuss and align research priorities. OSCHR was established in 2007 to ensure a more strategically coherent approach to publicly-funded health research. Two research areas (animal and plant health and energy) are in the early stages of developing new arrangements to align priorities. Some individual funders have well-developed arrangements for setting priorities that others could learn from. For example, following a review by the Government Office for Science, the Ministry of Defence has developed a process for consolidating and aligning its research priorities (paragraphs 3.2 to 3.4 and Figures 12 and 13).

**20 However, collective action is needed to prioritise investment in three research areas we examined, to ensure efforts are focused on addressing the principal challenges.** For research on the global climate, funders have identified a need for a strategic core climate plan to direct research efforts and discussions are under way to consider how research councils and government funders can contribute to delivery of a national climate capability. In robotics and autonomous systems, and advanced materials, key players have identified strategic themes for investment but a top-down strategy would help reach consensus on priorities (paragraphs 3.1, 3.3 and Figure 12).

## Informed decision-making

**21 We found that most research areas we examined lacked coherent and complete information on funding of research, skills and infrastructure.** Funders recognised the importance of having data on what activities are being funded and the results of research, and have made efforts to improve shared information. However, collecting and analysing data is challenging. For example, funders found exercises to map funding information in animal and plant health and climate research time-consuming and resource intensive, particularly where data from different funders is not recorded consistently. In robotics, or advanced materials, where funders and other stakeholders are still emerging, research activity is not tracked or analysed. (paragraphs 4.5, 4.7 and Figure 14)

**22 The UK needs good information on funding, skills and infrastructure to establish which research programmes and facilities are potentially affected by the UK leaving the EU to inform future priorities for UK investment in science.** BEIS told us that it has collected data on which specific research disciplines have majority funding from the EU, worked with its partner organisations to understand the impact of leaving the EU on research infrastructure, and is involved in wider cross-government work to assess the impact of migration on skills. This information will support the UK's ongoing EU exit negotiations (paragraph 4.11).

## Evaluation

**23 Most research areas we examined lack consolidated analysis of the impact of research and development.** Where leadership arrangements are established or developing, funders have taken steps to evaluate the collective impact of research funded by different organisations. In human health, funders have undertaken detailed assessments of the impacts of research funded by government and charities, and Defra has made a broad estimate of the value to society of healthy animals and plants, taking into account research funded by multiple parties. In other areas, the absence of consolidated data makes it difficult for funders to evaluate the collective impact of research (paragraphs 5.1 to 5.5 and Figure 17).

## Conclusion

**24** Government needs a coherent view of the UK's research strengths relative to other nations and analysis of funding in key areas of research, so that it can prioritise areas where activity is lagging behind and ensure the UK is investing in the right areas. While some of the more mature areas of research we examined have well-established arrangements to support coordination and collaboration between public-sector funders, some newer areas, including important emerging technologies and areas of national importance currently require more effective leadership. As a result, there is a risk that funders do not have coherent data across research areas on capability, funding gaps, or outcomes of research and development to inform decisions on national priorities and strategic direction.

**25** The UK research landscape is set for major changes, including the formation of UKRI, the UK's withdrawal from the EU, the prominent role of science in the government's industrial strategy, and the additional funding committed to research. Given these changes, BEIS and UKRI have a significant opportunity to work with funders of research across government to continue to address the main challenges we set out in this report.

## Recommendations

**26** Since our fieldwork concluded in March 2017, strategic arrangements for government-funded research have developed in a number of areas. UKRI is being developed in shadow format, building on the roles played by individual research councils in coordinating research in their individual areas. In addition, arrangements for coordinating energy and animal and plant health are continuing to progress, a new Strategic Coherence of Official Development Assistance funded research board has been created to coordinate international development research, and the Advanced Materials Leadership Council has been reconvened. The BEIS/UKRI-led Industrial Strategy Challenge Fund is also providing increased oversight by, for example, coordinating future investments from a range of funders on research into robotics in extreme environments.

**27** UKRI will not be formally established until April 2018, therefore the precise arrangements by which it will undertake its pivotal role of maintaining the health of UK research are still to be determined. Given this, our recommendations are designed to support the evolving UKRI to make sure that it is well placed to deliver stronger collaboration between research councils and other government departments, as recommended by Sir Paul Nurse in his 2015 review.[4] We recognise that UKRI is one of many bodies that fund UK research, so our recommendations are directed collectively at UKRI, BEIS and government departments, with the understanding that UKRI will play a significant role in taking them forward.

4 See footnote 1.

## Leadership and coordination

**a** **UKRI and BEIS:** UKRI has an important role to play in setting the tone at the top by providing strategic leadership, promoting collaboration, and enabling the funders of research across government to work together. By April 2018, UKRI and BEIS should build on the coordinating roles played by the research councils and begin work with other government departments and the Government Office for Science to identify the areas of research that need strategic leadership and coordination. They should bring key players together, coordinate activity where possible, and promote collective working. BEIS and UKRI should also work actively with departments to assess pre-existing leadership mechanisms and identify improvements needed to strengthen translation of research and secure benefits.

**b** **Funders:** Once leadership arrangements have been established and the purpose and anticipated benefits of participation clearly articulated, funders should identify opportunities and risks, address barriers to collaboration, and take collective action in response to the most significant challenges.

## Priority setting

**c** **UKRI:** Following its establishment in April 2018, UKRI should work with BEIS, the Government Office for Science and other government departments to ensure that best use is made of the government's investment in research and development. Through its engagement with research communities, government and business, UKRI can lead efforts to join up the research landscape and address cross-cutting challenges such as robotics.

**d** **Funders:** Should ensure that they anticipate future challenges, use information on the results of existing research as well as current gaps to inform and shape priority setting, and make the case for where investment is required.

## Informed decision-making

**e** **Funders:** Should put arrangements in place to collect data and make them accessible to other funders. This will aid and inform others' understanding of funding gaps, skills needs and infrastructure requirements, and help inform investment decisions. Funders should consider approaches that avoid data collection and analysis becoming a resource-intensive exercise that quickly becomes out of date: for example, by automating and standardising data collection, or by categorising types of activity at point of funding.

**f** **UKRI:** Improving the quality of evidence on the UK's research and innovation landscape should be one of the benefits of UKRI. We see potential for UKRI to play an important oversight role in bringing together and analysing data on publicly-funded research, and in raising awareness of gaps or overlaps in research programmes, skills, capability or infrastructure requirements.

g **UKRI and BEIS:** Working with other government departments, UKRI and BEIS should ensure that data on funding and potential skills gaps which may result from the UK's exit of the EU are used to establish the position across research areas and whether key capabilities are at risk. Once decisions on EU exit have been reached, this information should be used to inform future spending priorities across government.

## Evaluating the impact of investing in research

h **UKRI and BEIS:** Should clearly articulate their expectations as to how the impact of a whole programme of investment across a research area should be collectively evaluated. Although the long-term outcomes of investment in research can take many years to establish, the results of early evaluations should prompt discussions and help inform views on what research requires ongoing investment or where resources may be better directed elsewhere.

i **Funders:** Should plan at the outset how they will evaluate the impact of investment and how they will address challenges. For example, funders should record the results of all relevant research in a way that allows outcomes to be collated and analysed across the piece. Funders should also plan how they will deal with time lags so that they can assess the short- or medium-term benefits of investment in individual programmes, as well as evaluate the outcomes of long-term investment across research areas.

# Part One

## Government funding of research and development

### Why fund research and development?

**1.1** Government invests in research and development across the spectrum of basic, applied and translational research (**Figure 3** overleaf).[5] Its objectives are to:

- **promote economic prosperity and growth:** transformation of cutting edge science into new products and services will create high quality jobs, develop and attract skilled people, increase productivity and help the UK take the lead in new markets. In the 2017 Industrial Strategy green paper, the government emphasises the importance of research to economic growth;[6]
- **tackle challenges to our society:** such as anti-microbial resistance, obesity and climate change; and
- **expand human knowledge:** to answer big questions in fields such as particle physics and space exploration.

### Research and development across government

**1.2** The Department for Business, Energy & Industrial Strategy (BEIS) has responsibility for the majority of government's investment in science. BEIS's funding is directed at a wide range of scientific disciplines, and aims to develop and maintain the UK's science and research capability. In 2015-16, BEIS's predecessor, the Department for Business, Innovation & Skills and its partner organisations (including research councils, the Higher Education Funding Council for England, and Innovate UK) funded some £5 billion of research and development.[7] Other government departments also fund research and development to meet their own policy objectives (**Figure 4** on page 17).

**1.3** The UK Government Chief Scientific Adviser (GCSA) plays a role in coordinating research and development across government. The GCSA provides scientific advice to the Prime Minister and engages with government ministers, their officials and departmental chief scientific advisers (**Figure 5** on page 18).

5 In this report, we use the Organisation for Economic Co-operation and Development's (OECD's) definition of research and development (see Appendix One).
6 HM Government, *Building our industrial strategy*, green paper, January 2017.
7 Based on data collected by the Office for National Statistics for its *UK gross domestic expenditure on research and development: 2015* Statistical bulletin, March 2017.

## Figure 3
Research spectrum

**Basic research**

To discover new scientific knowledge. Basic, or fundamental, research forms the bedrock of applied and translational research.

**Applied research**

To seek solutions to specific problems or answers to specific questions. Applied research is needed before scientists can advance to translational research.

**Translational research**

Experimental development focused on creating new products, patents or processes.

Source: National Audit Office

## Expenditure on research and development

**1.4** In 2015, the UK's gross domestic expenditure on research and development was £31.6 billion.[8] The business sector was the largest funder, funding £15.5 billion (49%) of all research and development performed in the UK (**Figure 6** on page 19). Government funding (including government departments, the research councils and the higher education funding councils) totalled £8.75 billion.[9] Most of the remaining funding came from overseas funders or not-for-profit organisations.

**1.5** As a percentage of Gross Domestic Product (GDP), the UK spends less on research than the average for EU and Organisation for Economic Co-operation and Development (OECD) countries. The EU has set a target to increase combined public and private investment in research and development to 3% of GDP by 2020. In 2015, the UK (the second largest EU economy, accounting for 16% of the EU's total GDP in 2016) spent 1.68% of GDP on research, an increase from 1.66% in 2014. This compares with an average of 2.03% across all EU countries and an OECD average of 2.4%.[10]

**1.6** Furthermore, the UK spends less on experimental development (translational research) than leading innovation nations such as Israel and China (**Figure 7** on page 20), and there have been concerns about the UK's ability to exploit the results of research through new products and patents. For example, the House of Commons Science and Technology Committee has emphasised the need for more engagement with industry and better mechanisms to secure the economic benefits from research.[11] The Government's 2017 Industrial Strategy green paper recognises that government needs to do more to support commercialisation of research.[12]

8 Office for National Statistics, *UK gross domestic expenditure on research and development: 2015* Statistical bulletin, March 2017.
9 Calculated from data published by the Office for National Statistics (see footnote 8). Includes funding by government departments, research councils and higher education funding councils but not additional funding by higher education institutions.
10 Office for National Statistics (see footnote 8) and HM Government, *Building our Industrial Strategy*, green paper, January 2017.
11 HC Science and Technology Committee, *Bridging the valley of death: improving the commercialisation of research*, Eighth Report of Session 2012-13, HC 348, March 2013.
12 HM Government, *Building our industrial strategy*, green paper, January 2017.

## Figure 4

Other government departments' expenditure on research and development

| Department and investment (2015-16) | Areas of research | |
|---|---|---|
| Ministry of Defence (£1.71 billion) | Research to maintain capability to support its front-line commands and ensure it is well positioned to exploit future opportunities. |  |
| Department of Health (£1.13 billion) | Research into the prevention, detection and diagnosis and the development of new interventions, products or treatments to improve patient care and outcomes. |  |
| Department of Energy & Climate Change[1] (£0.04 billion) | Energy research and research conducted by the Met Office's Hadley Centre for Climate Science and Services. |  |
| Department for International Development (£0.31 billion) | Research into major global challenges: population growth; climate change; urbanisation and migration. |  |
| Department for Environment, Food & Rural Affairs (£0.10 billion) | Research into animal and plant health, environment quality and the natural environment, and food and farming.<br>Defra is also a customer of the Met Office's Hadley Centre. |  |

**Total:[2] £3.31 billion**

**Notes**

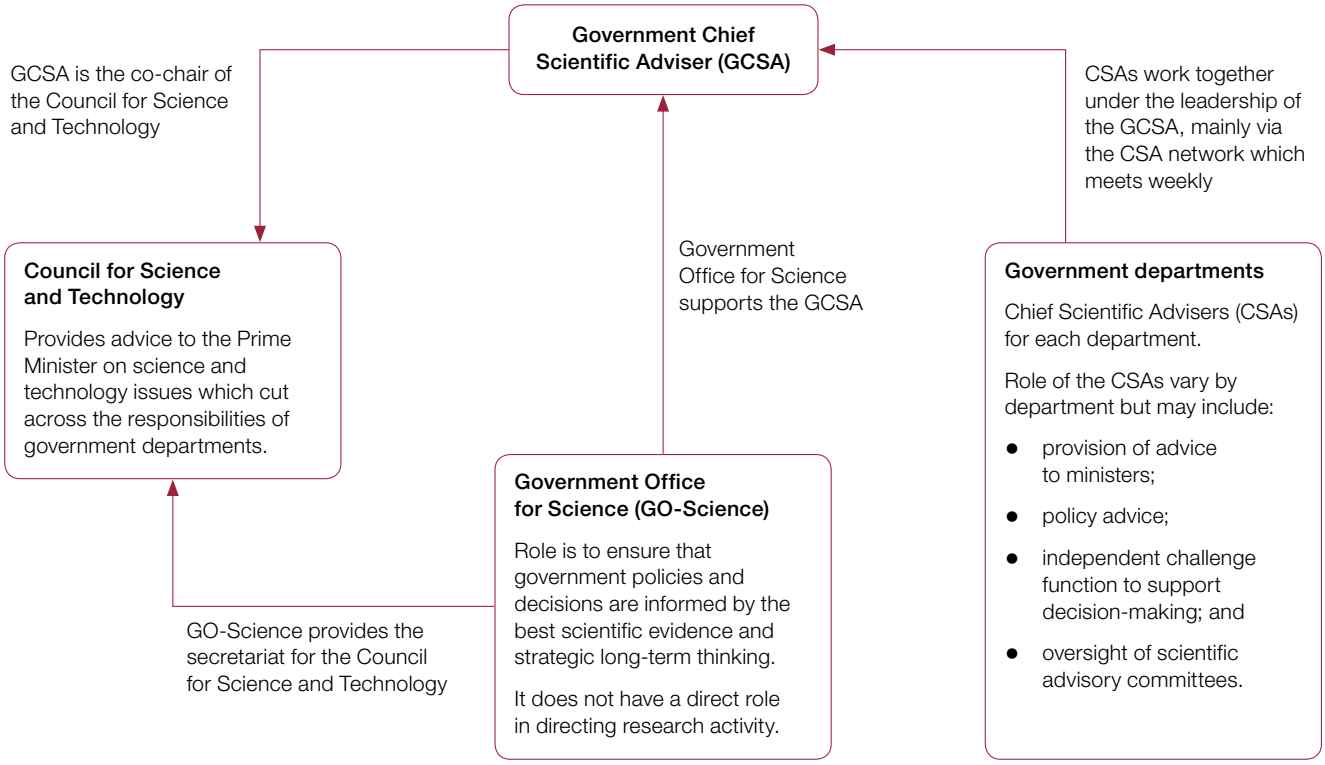
1 Research previously funded by the former Department of Energy & Climate Change is now funded by the Department for Business, Energy & Industrial Strategy.

2 Data does not sum exactly due to rounding differences.

3 Data are not adjusted for inflation.

Source: All data is from individual department survey submissions to the Office for National Statistics (ONS) for inclusion in its statistical bulletin, *UK gross domestic expenditure on research and development 2015*, with the exception of the former Department of Energy & Climate Change for which data was taken from the ONS science, engineering and technology reference tables (2015)

## Figure 5
Role of the Government Chief Scientific Adviser




Source: National Audit Office

## Key developments in the research and development landscape

### Nurse review

**1.7** In 2015, the government commissioned Sir Paul Nurse's review of the research councils to explore how the research councils could support research most effectively.[13] It recommended:

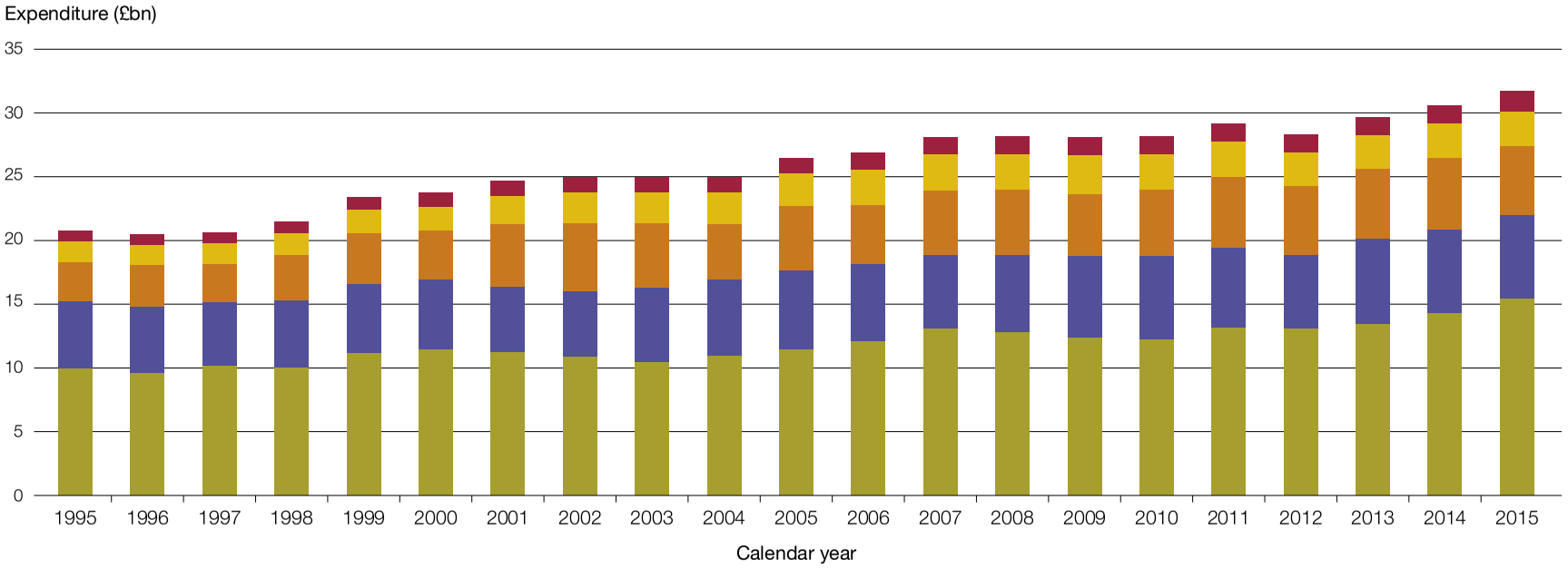
- the establishment of a partnership of the seven research councils, with the aim of strengthening them in the formulation of strategy, promotion of research, and engagement with their communities, and strengthening the collective voice of the research councils within government; and
- the development of new cross-government arrangements to facilitate the discussion of strategic research priorities and funding of research.

13 Sir Paul Nurse, A review of the UK research councils, *Ensuring a successful UK research endeavour*, November 2015.

## Figure 6

Trends in expenditure on research and development in the UK, 2015

**In 2015, the UK's gross domestic expenditure on research and development was £31.6 billion**




**Note**

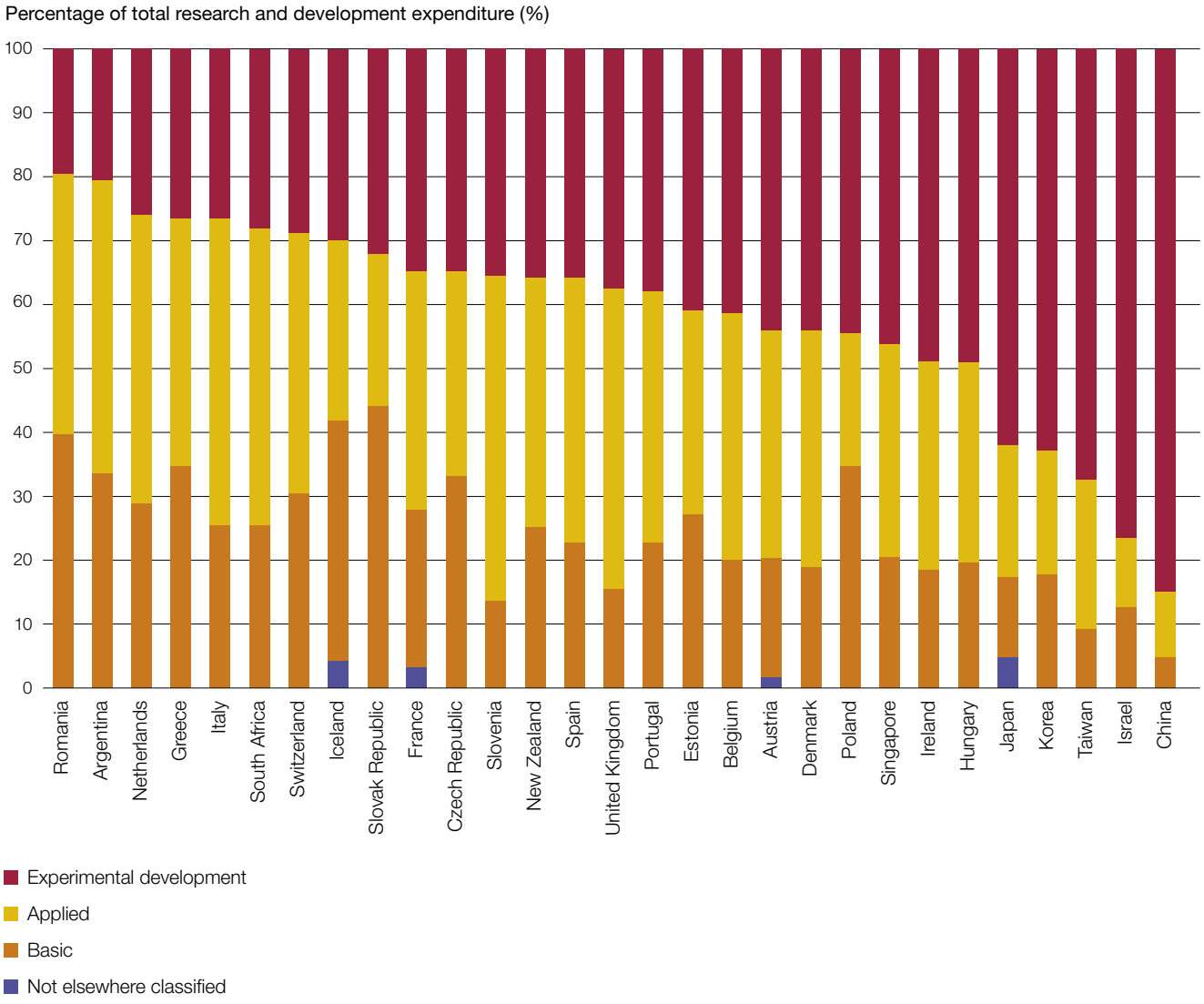
1 The Office for National Statistics has adjusted the expenditure data for inflation.

Source: Office for National Statistics, *UK gross expenditure on research and development: 2015 Statistical bulletin*, March 2017

## Figure 7

Research and development spending at different stages of research, by country

**The UK spends a lower proportion of its research and development expenditure on experimental development than leading innovation nations such as Israel and China**




**Notes**

1 HM Government produced this chart using data from the Organisation for Economic Co-operation and Developments's 2015 research and development database.

2 Research and development spending is shown as a percentage of total research and development expenditure in 2013.

Source: HM Government, *Building our industrial strategy*, green paper, January 2017

## Organisational changes

**1.8** In 2016, in response to the Nurse review, the government introduced a reform bill (the Higher Education and Research Bill) to create UK Research and Innovation (UKRI), a new organisation bringing together the research councils, Research England (the research funding arm of the Higher Education Funding Council for England), and Innovate UK. The government aims to improve strategic direction, cross-cutting decision-making and the balance of funding across areas of research. The bill received Royal Assent in April 2017 and UKRI will be established in April 2018.

## UK Government research funding priorities

**1.9** Since 2014, the government has committed additional funding for science. In particular:

- In 2016, the government announced that it would provide an additional £4.7 billion of research and development funding between 2016 and 2021. The additional funding is to increase research capacity and business innovation across the UK's research base and to create a new cross-disciplinary Industrial Strategy Challenge Fund (ISCF) to support collaborations with business.
- In January 2017, the government published its Industrial Strategy green paper, highlighting the importance of robotics, clean energy, and biotechnology for economic growth. In March 2017, the government announced initial investments totalling £536 million to be invested in healthcare and medicine, clean and flexible energy, and robotics and artificial intelligence. The government is consulting on priorities for further ISCF investments.
- Government has also committed to funding research to address the challenges faced by developing countries. Since 2014, it has allocated £735 million to the Newton Fund to promote economic development and social welfare in partner countries.
- In 2015, the government announced a £1.5 billion Global Challenges Research Fund funded by BEIS and a £1 billion Ross Fund to tackle infectious diseases jointly managed by the Department for International Development (DFID) and the Department of Health. These funds form part of the UK's Official Development Assistance Commitment (overseas aid). In addition, in October 2016, DFID launched its Research Review, setting out how it would invest an average of £390 million per year over the next four years.

### UK withdrawal from the European Union

**1.10** The UK is a net receiver of EU funding for research and development. Between 2007 and 2013, the UK contributed €5.4 billion to EU science and received €8.8 billion.[14] In respect of the Horizon 2020 programme, the EU's flagship science programme running from 2014 to 2020, by 2015, the UK had received the highest number of grants issued (approximately 15%).[15]

**1.11** In August 2016, the government guaranteed future funding for grants won by British businesses and universities while the UK remains a member of the EU, and encouraged UK researchers to continue to bid for EU funding. The extent to which the UK will be able to access EU funding in the future depends on the outcome of its negotiations for withdrawal. In addition, withdrawal could affect the UK's access to skills and the freedom of movement of researchers, as well as access to EU facilities and research programmes.

## Our approach to examining cross-government funding of research and development

**1.12** Given the organisational changes and further government investment in research, we positioned our work to examine how BEIS and other public bodies which fund research and development (referred to in this report as 'funders') coordinate their research activity to maximise the impact of investment. We developed an evaluative framework to examine arrangements in six major areas of research (**Figure 8**).

**1.13** We selected areas of research (**Figure 9** on page 24) that:

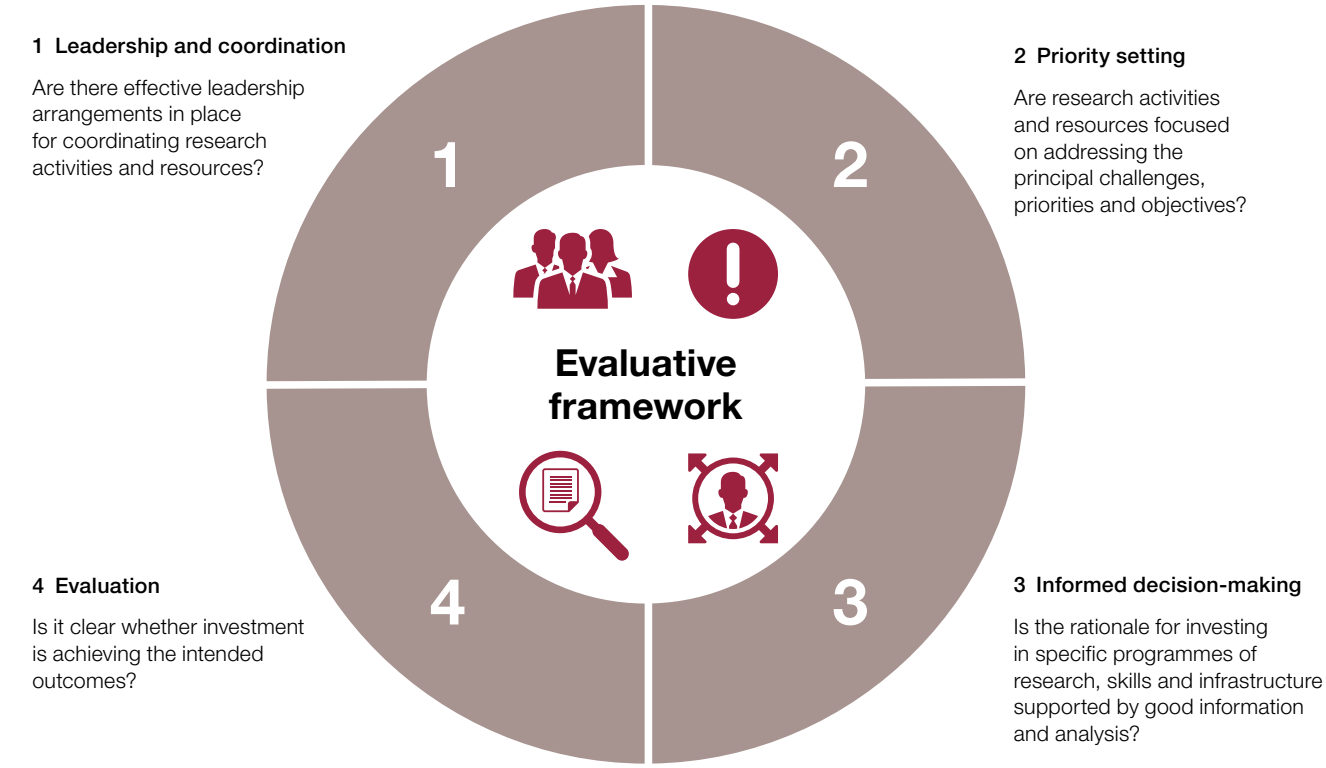
- cover a significant level of investment: while it is difficult to establish full annual expenditure in each area, available data suggest that the total across these areas is above £3 billion;
- involve multiple government departments, agencies and research councils, as well as varying levels of not-for-profit sector and industry funding; and
- cover a range of different types of subject disciplines and research activity.

14 HL Science and Technology Select Committee, *EU membership and UK science*, Second Report of Session 2015-16, HL Paper 127, April 2016.

15 Comptroller and Auditor General, *Financial management of the European Union budget in 2014: a briefing for the Committee of Public Accounts*, Session 2015-16, HC 799, National Audit Office, February 2016.

## Figure 8

Evaluative framework: our approach to examining arrangements




**Note**

1 For more detail, see Appendix 2 and www.nao.org.uk/report/cross-government-funding-of-research-and-development/

Source: National Audit Office

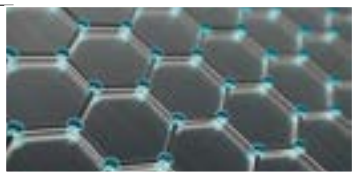
**1.14** The following parts of this report cover the key principles in the evaluative framework. Each part explains the importance of each principle, assesses the arrangements in the areas of research we examined, and comments on the practices we observed and the challenges to improving arrangements:

- Part Two examines leadership and coordination;
- Part Three examines priority setting;
- Part Four examines informed decision-making; and
- Part Five examines the impact of investing in research.

Full details of our methodology are at Appendix One.

## Figure 9

The six areas of research we examined in this report

| Research area | Funders and estimated public funding[1] | |
|---|---|---|
| Human health | **£2.3 billion** in 2015.[2] Funders include the National Institute for Health Research, the Medical Research Council, the Department for International Development (DFID), Innovate UK, other research councils and the devolved administrations. |  |
| Animal and plant health | **Above £0.2 billion** per annum.[4] Funders include the Department for Environment, Food & Rural Affairs (Defra), the Biotechnology and Biological Sciences Research Council, Innovate UK and DFID. We focus on research into pests and diseases of plants and animals, while recognising that plant and animal health sits within the broader context of agricultural research. However, agriculture and food security are not the focus of this report. |  |
| Energy | **£0.38 billion** in 2014.[3] Funders include the Department for Business, Energy & Industrial Strategy (BEIS), the Engineering and Physical Sciences Research Council (EPSRC), Innovate UK, DFID and the devolved administrations. |  |
| Climate | Above **£0.09 billion** per annum.[7] Funders include the Natural Environment Research Council, Defra, BEIS, and DFID. We have considered both research on the global climate and research into the impact of climate change. |  |
| Robotics and autonomous systems (RAS) | BEIS has reported **£0.3 billion** of incurred or planned expenditure between 2012 and 2020.[5] Funders include Engineering and Physical Sciences Research Council (EPSRC), BEIS, Innovate UK and other research councils. The Ministry of Defence (MoD) estimates its investment into RAS at **£0.08 billion** between 2014 and 2017. |  |
| Advanced materials | Above **£0.6 billion** invested in current EPSRC grants, Innovate UK and MoD research programmes.[6] |  |

**Note**

1 Total funding for these research areas is not reported on a consistent basis or in one place. The data are not presented here for the purposes of comparison but to give an indication of the estimated scale of the funding in each case.

2 Source: Association of Medical Research Charities, *Medical research charities: our impact at a glance* (2015 infographic), September 2016; UK Clinical Research Collaboration, UK Health Research Analysis 2014, Medical Research Council, 2015.

3 Source: House of Lords Select Committee on Economic Affairs, *The Price of Power: Reforming the Electricity Market*, Second Report of Session 2016-17, HL 113, February 2017.

4 Source: Government Office for Science and Department for Environment Food & Rural Affairs, *Animal and Plant Health in the UK: Building our science capability*, December 2014.

5 Source: Department for Business, Energy & Industrial Strategy, *Written evidence to House of Commons Science and Technology Committee robotics and artificial intelligence inquiry*, September 2016.

6 Source: EPSRC research database; Ministry of Defence; Innovate UK, *Delivery Plan financial year 2016-17*, April 2016.

7 Estimate includes 2015-16 commitments by BEIS and Defra for the Met Office Hadley Centre (£18 million), DFID (around £25 million) and Natural Environment Research Council (£48 million).

Source: National Audit Office analysis

# Part Two

## Leadership and coordination

### Why it is important

Understanding the environment and context for research activity, and identifying the key organisations and people involved, will help funders identify opportunities for collaboration and address barriers. Strong leadership arrangements will help ensure that efforts to address research priorities are coherent and coordinated.

### Overall view

**2.1 Clearer accountability and stronger leadership are required in some important emerging areas of science to maximise the value of government investment.** Most of the research areas we examined recognise the need for effective leadership. This assists with the development of aligned research strategies, and the coherent oversight of funding and capability across the area of research. Strong leadership also helps funders gain visibility of the collective outcomes of their investment (**Figure 10** overleaf).

**2.2** The leadership arrangements needed to support and guide an area of research will vary depending on the number of key players, whether there is a responsible body whose role it is to provide direction, and the level of involvement from non-public funders such as industry and charities. For example, in some research areas there may be a clear strategic fit with a government department's policy objectives, in which case that department will be well placed to provide leadership. In cases where it is less clear, the Department for Business, Energy & Industrial Strategy (BEIS) or, once in place, UK Research and Innovation have roles to play in ensuring that leadership is established and functioning.

## Figure 10
Assessment of leadership arrangements

| Assessment | Research area |
|---|---|
| There is a broad consensus on the need for coordination; coordination mechanisms are well established and functioning. | **Human health:** The Office for Strategic Coordination of Health Research (OSCHR) was established in 2007. Its function and approach are well established. Alongside the NAO's 2013 review *Integration across government*, we examined coordination of publicly-funded health research.[1] The review concluded that OSCHR has had a positive impact on the health funding landscape. |
| There is a broad consensus on the need for coordination; mechanisms for setting strategy and sharing information are in development. | **Animal and plant health:** Although there are existing coordination mechanisms for research into agriculture and food security, funders of animal and plant health have identified a need for leadership in this specific area. UK Science Partnership for Animal and Plant Health was proposed in December 2014 and met for the first time in December 2016.<br><br>**Energy:** Energy and Innovation Board was established in 2016. It had met four times by the end of 2016. |
| Some evidence of coordination mechanisms but strategic leadership is still in the early stages of development. | **Climate:** Government recognises the need for better coordination of research on the global climate and developing existing mechanisms such as the Interdepartmental Met Office Strategy Group. Coordinating research into the impact of climate change is more challenging as there are multiple funders and no single responsible body.<br><br>**Robotics and autonomous systems:** While the Robotics and Autonomous Systems Special Interest Group has played an important role, there has been consensus since 2014 that national leadership is needed.<br><br>**Advanced materials:** Government has faced challenges in establishing stable leadership arrangements in advanced materials. The Advanced Materials Leadership Council was dissolved in December 2016 without producing a strategy, and it was not clear at that time what would replace it. It reformed with industry leadership in June 2017 as a smaller group that aims to be more responsive than its predecessor. |

**Note**

1 Comptroller and Auditor General, *Integration across government*, Session 2012-13, HC 1041, National Audit Office, March 2013.

Source: National Audit Office analysis

## Well-established or developing leadership arrangements

**2.3** There are well-established arrangements for the coordination of human health research, while energy research and animal and plant health are in the early stages of developing new arrangements. There are various groups and forums coordinating activities within human health research including the Office for Strategic Coordination of Health Research (OSCHR), established in 2007 to ensure a more strategically coherent approach to publicly-funded health research. While the early running costs associated with establishing the OSCHR function were in the region of £0.5 million per annum, annual costs have now decreased to around £46,000, this is minimal compared to some £2 billion invested by government in health research annually.

**2.4** While the specifics of the OSCHR model may not be appropriate in every research field, emerging areas of research may find it useful to draw on the OSCHR example when developing their own arrangements. For example, the Government Office for Science and the Department for Environment, Food & Rural Affairs (Defra) have considered how elements of the OSCHR model could be applied to animal and plant health.[16]

**2.5** The House of Lords Select Committee on Science and Technology also referred to the OSCHR model when it recommended that government give careful consideration to how it can ensure a cross-government approach to funding international development research.[17] In response, the main funders are establishing a new Strategic Coherence of Official Development Assistance funded Research Board to develop a coordinated approach to international development research. The chair of the board was announced in October 2017.

**2.6** When we reviewed leadership arrangements we identified common features that can lead to success (**Figure 11** overleaf).

## Challenges in developing leadership arrangements

**2.7** Three areas of research we looked at (climate, robotics and autonomous systems, and advanced materials) are not yet supported by clear or established leadership arrangements (Figure 10). They have each experienced different challenges, and their progress has varied.

### Emerging science with no single responsible body

#### Robotics and autonomous systems

**2.8** Stakeholders have told us that the cross-cutting nature of robotics and autonomous systems makes coordination difficult as there is no single responsible department. In 2014, the Robotics and Autonomous Systems Special Interest Group (RAS SIG – an expert group funded and managed by Innovate UK's Knowledge Transfer Network) published a strategy recommending establishment of a leadership council to bring funders together and engage with leaders across industry, academia and government.[18] In response, BEIS (at that point the Department for Business, Innovation & Skills) agreed to set up leadership arrangements.[19]

16 Government Office for Science and Department for Environment, Food & Rural Affairs, *Animal and Plant Health in the UK: Building our science capability*, December 2014.
17 House of Lords Committee Office, *Letter to the Secretary of State for International Development*, July 2016.
18 Robotics and Autonomous Systems Special Interest Group, *RAS 2020 Robotics and Autonomous Systems,* July 2020.
19 Cabinet Office and Department for Business, Innovation & Skills, *Response to the robotics and autonomous systems strategy*, March 2015.

## Figure 11
The features of successful leadership

| Feature | Example |
|---|---|
| The right participants are involved to fit with the aim of the group | Office for Strategic Coordination of Health Research (OSCHR): membership is restricted to public funders of health research. Independent board members from industry, NHS and third sector ensure that the focus remains on what is being funded and what gaps need to be addressed. The importance of the OSCHR chair's leadership and the continuity and stability this has provided for health research was widely acknowledged by those we spoke to. |
| There is clarity about participants' objectives | The Low Carbon Innovation Coordination Group was established to address weaknesses in the coordination of public funding for the development of renewable energy technology. However, it faced challenges from members' conflicting policy objectives over nuclear energy. In 2016, the group was replaced by the Energy Innovation Board. |
| Leadership and coordination has a clear purpose and leads to something tangible | The purpose of a leadership group could be problem-solving, building critical mass, making the case for funding, etc.<br>For example:<br>● the Robotics and Autonomous Systems Special Interest Group produced an outline strategy;<br>● OSCHR told us that its regular meetings facilitate understanding of where evidence gaps are; and<br>● the Energy Innovation Board is currently mapping activity to build its understanding of who is funding what. |
| The participants have clear roles and responsibilities | One approach is to give individual board members specific responsibility for action. Alternatively, the approach in human health research is to convene subcommittees when a need arises for action in specific areas. |
| There are clear incentives for staying involved | Incentives and benefits of participating may include:<br>● enhanced knowledge and insight into developments in the research area, giving coherence to individual funding bids;<br>● opportunities to network: for example the OSCHR Chair is also the Life Sciences Champion and in regular contact with various parts of government; and<br>● for industry or not-for-profit sector partners, insight into government's focus and strategic direction. |

Source: National Audit Office

**2.9** However, these arrangements have not yet been established. In October 2016, the House of Commons Science and Technology Committee published a report on robotics and autonomous systems which raised concerns about the continuing lack of leadership and absence of a strategy for developing skills and securing the investment needed for further growth.[20] Also in October 2016, the Council for Science and Technology urged the government to build on the efforts of the RAS SIG to improve coordination and build momentum.[21]

**2.10** In its response to the select committee's report, BEIS agreed that robotics is an area requiring improved coordination. BEIS said that funding from the new Industrial Strategy Challenge Fund would be available to support priorities such as robotics, and that it would consider the best model of leadership for robotics as it develops its industrial strategy. However, BEIS has not yet confirmed the arrangements for ensuring strategic oversight and coordination.[22]

### Advanced materials

**2.11** In common with robotics, advanced materials is not an easily defined area of research as it cuts across research fields and technological applications and there is no single department to provide direction. A Council for Science and Technology seminar on advanced materials concluded that the sector must speak with a coherent voice to allow industry to invest with confidence.[23]

**2.12** Government has made efforts to improve leadership. The Advanced Materials Leadership Council was established in December 2014 to coordinate research at a national level and was jointly chaired by the Minister of State for Universities and Science and a representative from industry. It aimed to bring together leaders from industry, academia, government and skills providers to inform government policy and ensure that investment in advanced materials applications benefits the UK economy. The Leadership Council developed a strategic vision for advanced materials, and published papers on areas where it identified specific opportunities for new investment, but it did not produce a detailed strategy for growing capability.[24] The Council observed that, while there have been advances in a wide range of materials applications, there are few examples of successful exploitation, and an absence of clear direction to capitalise on the full potential of UK industry.

20 HC Science and Technology Committee, *Robotics and artificial intelligence*, Fifth Special Report of Session 2016-17, HC 145, October 2016.
21 Council for Science and Technology, *Letter to the Prime Minister on opportunities in robotics, automation, and artificial intelligence for the UK*, October 2016.
22 HC Science and Technology Committee, *Robotics and artificial intelligence: Government Response to the Committee's Fifth Report of Session 2016-17,* Fifth Special Report of Session 2016-17, January 2017.
23 Council for Science and Technology, Science Landscape Seminar Reports: Advanced materials, June 2015.
24 Advanced Materials Leadership Council, *A vision for a new industrial revolution*, 2016.

**2.13** However, the Leadership Council was dissolved in December 2016 and it was not clear at that time what would replace it. It was then reconvened in June 2017 as a smaller group chaired solely by a representative from industry. The new group aims to be more responsive and flexible than its predecessor and its specific task is to advise on where financial interventions will have most impact. The Leadership Council will have an initial lifetime of 12 months after which it will be reviewed for impact.

## Multiple priorities

### Climate

**2.14** Climate research has two distinct strands:

- **Research into the global climate** covers basic research including predicting future climate change. Key public funders include BEIS (covering the remit of the former Department of Energy & Climate Change), the Natural Environment Research Council (NERC), and Defra. The Met Office and NERC's research institutes carry out research to meet government's research requirements.
- **Research into the impact of climate change** requires input from a wider range of funders. Defra is a lead partner with responsibility for delivering the requirements of the Climate Change Act including undertaking a five-yearly risk assessment, but it does not fund research in isolation. A range of government departments are responsible for understanding climate risks to the delivery of their objectives (for example, the Department for Transport needs to understand the impact of rising summer temperatures on railway tracks, while BEIS assesses the impact of water shortages on cooling for energy production). In addition, the Department for International Development funds research to reduce the impacts of climate change in developing countries.

While we have considered leadership arrangements in both strands of climate research, we recognise that government faces particular challenges in coordinating research into the impact of climate change, because there are multiple funders and stakeholders, and no single responsible body.

**2.15** There are various mechanisms in place to coordinate climate research, each with different roles that cut across both strands. These include:

- The **Joint Weather and Climate Research Programme** coordinates underpinning research conducted by the Met Office and NERC's research institutes.
- The **Met Office Hadley Centre Climate Programme Board**, with BEIS and Defra representation, coordinates the content, funding and oversight of the climate modelling work programme.
- The **Interdepartmental Met Office Strategy Group** was set up in 2015-16 in response to a review by BEIS. Its role is to provide a single voice for government and set out strategic priorities for the Met Office.
- Various cross-government coordination groups focusing on specific thematic areas including the **UK Collaborative on Development Sciences Disaster Recovery Group** which coordinates research on climate and natural disasters. **Research and Innovation for Our Dynamic Environment (RIDE)**, hosted by NERC, was established in 2016 to draw together key funders of research, set priorities and identify interdisciplinary partnership opportunities. RIDE has a smaller secretariat and fewer resources than the Living With Environmental Change Network, the group it replaced.
- At a global level, the **Intergovernmental Panel on Climate Change** plays a role in driving research activity. The **International Climate Fund** approves Overseas Development Assistance (ODA) climate projects across DFID, BEIS and Defra.

**2.16** While initiatives such as the Joint Weather and Climate Research Programme have helped improve leadership of global climate research, coordinating research into the impact of climate change is more complex. To fulfil its role in assessing the risk of climate change to the UK, Defra needs access to a robust evidence base. In 2017, the Committee on Climate Change identified areas of climate change risk where coordinated action is needed, and some evidence gaps identified in 2012 remain. The Committee told us that the lack of an overarching strategy for climate science research may have led to evidence gaps such as the absence of routine data collection to assess if policies are meeting their goals. In February 2017, the Committee wrote to the research councils to highlight these evidence gaps and to identify ways that the research councils could work together, along with government departments and the new UKRI, to inform policy on adaptation to climate change.[25]

25 Lord Krebs, *Letter to chief executives of the research councils*, February 2017.

**2.17** BEIS acknowledges that action is needed to fill evidence gaps. In 2017, it agreed a statement of climate science research need with other government departments. It is also considering how the creation of the UKRI will enable a more coordinated approach to delivering climate science capability. BEIS told us that it recognises the need for greater cross-government engagement and governance on climate research and suggested that this could be achieved through, for example, creation of a Climate Science Board.

**2.18** In addition, departments are working to resolve issues in how climate research is funded across government. Science funding in departmental budgets is not ring-fenced so is susceptible to erosion as departments face budgetary pressures. For example, BEIS told us that there is a mismatch between who funds the Met Office's research facilities and who uses them. It is working with other departments to resolve issues about how the Met Office's research infrastructure is funded in future.

# Part Three

## Priority setting

### Why it is important

Funders need to be clear about principal priorities, opportunities and challenges across the area of research. This will enable them to work together to ensure that efforts are aligned and directed towards common goals.

### Overall view

**3.1 Some funders work together to prioritise research investment, but in other areas there are risks that efforts are not focused on addressing the principal challenges.** We found that investment priorities are well-coordinated in human health. Funders of animal and plant health, and energy research recognise the need for a clear strategy and are in the early stages of developing new arrangements to align priorities. In the other three research areas where coherent leadership arrangements are not in place, or have been slow to develop, there is no collective effort to prioritise investments (**Figure 12** overleaf).

### Well-established or developing arrangements for setting priorities

**3.2** In human health research, there are long-standing arrangements and a good understanding of who does what, leading to clarity about the roles and priorities of funders. There is no single strategy for human health research but the many coordinating mechanisms support a culture in which funders have a good awareness of each other's priorities.

**3.3** In energy and animal and plant health research, funders are working to establish who does what, and where individual interests lie, to provide a better understanding of priorities for investment. The establishment of appropriate leadership mechanisms may help more fragmented research areas gain a top-down view on priorities and provide a forum for collective action to address challenges.

**3.4** Some individual funders have well-developed arrangements for setting priorities that others could learn from. For example, following a review by the Government Chief Scientific Adviser, the Ministry of Defence (MoD) has developed a process for consolidating and aligning its research priorities (**Figure 13** on page 35).

## Figure 12
Assessment of arrangements to prioritise investment

| Assessment | Research area |
|---|---|
| Mechanisms to align investment priorities are well established. | **Human health:** The Office for the Strategic Coordination of Health Research facilitates discussions on research priorities and availability of funding. Funders ensure that their strategies are aligned and resources are used in a coherent way. |
| There is broad consensus on the need to align priorities and an approach is being developed. | **Animal and plant health:** The UK Science Partnership for Animal and Plant Health has identified priority areas for improved coordination and is developing a detailed action plan to address challenges within a five-year time frame.<br><br>**Energy:** The new Energy Innovation Board aims to align the strategic approaches of partner organisations into common priorities and outcomes through 'deep dives' across 10 thematic areas. |
| Mechanisms for aligning and coordinating investment priorities are not yet developed. | **Climate:** There is scope for funders of research on the global climate to align strategic priorities. The Met Office has identified a need for a strategic core climate science plan and discussions are under way to consider how research councils and government funders can contribute to delivery of a national climate capability.<br><br>**Robotics and autonomous systems:** The Robotics and Autonomous Systems Special Interest Group has identified strategic themes, but a top-down strategy would help reach consensus on priorities.<br><br>**Advanced materials:** One of the conclusions of a seminar on the advanced materials funding landscape, convened by the Council for Science and Technology, was that a clear strategy should be developed to enable and facilitate effective funding decisions.[1] In 2016, the Advanced Materials Leadership Council published short 'vision papers' on four areas (energy, health, electronics and demanding environments) identifying specific opportunities for new investment. However, an approach for aligning priorities has not yet been developed. |

**Note**

1 Council for Science and Technology, Science Landscape Seminar Reports: Advanced Materials, June 2015.

Source: National Audit Office analysis

## Challenges in setting priorities

**3.5** In some research areas, the breadth of activity or even the challenges of defining and grouping the activity into a research area make it difficult to clearly articulate priorities. For example, in robotics, research underpins and supports scientific advances in a range of technologies, so a joined-up approach across government to set cross-cutting priorities is important. While funders may have differences in focus, the establishment of a leadership group can provide a focal point for discussion, and improve understanding of others operating in the same space, thus helping to better direct investment.

## Figure 13
How the Ministry of Defence sets priorities

In 2015, the Government Chief Scientific Adviser conducted a review of defence capability which identified the need for a clearer distinction between delivery of research and how customer requirements were identified and prioritised. In response, MoD designed a new, staged, customer-focused process for determining research requirements and assessing relative priorities. MoD used this approach to set and plan its research programme in 2016. Six customer groups include: the three armed forces, Joint Forces Command, Ministry of Defence Head Office and wider government.

**Stage 1: Capture user requirements**

Customers are asked to produce Statements of User Needs.

In the most recent exercise, around 300 statements were produced across the MoD's front-line commands.

**Stage 2: Ranking**

Customers are asked to rank their Statements of User Needs.

**Stage 3: Translation**

MoD's science and technology community translate the user requirements into research requirements.

**Stage 4: Assessment of the research requirements**

Criteria include:

- importance to user;
- strategic fit; and
- affordability.

**Stage 5: User views**

Customers provide their views on the research requirement assessment.

**Stage 6: Develop research programme**

The requirements are developed into a research programme with two main elements:

- User driven – using science to solve well-understood problems.
- Opportunity driven – using science to advance capability.

**Stage 7: Allocation of funding**

Allocation of funding will take into account opportunities to collaborate internationally or with other government departments.

**Stage 8: Commissioning**

Detailed planning and costing.

Source: National Audit Office

# Part Four

## Informed decision-making

### Why it is important

Maximising the value of public investment in research requires accessible, comprehensive, and coherent information on what and where others are investing, and a strategic approach to allocating resources. Funders need comprehensive and sufficiently granular information and analysis on current and past activity to help identify funding gaps or duplication, inform and direct investment decisions, and strengthen the rationale for investment.

### Overall view

**4.1 Data collection and analysis of funding and capability are inconsistent.** Our examination revealed a mixed picture. Funders in most of the research areas we examined recognised the need for comprehensive information on who was funding what to identify gaps and prioritise investment. For example, the UK Clinical Research Collaboration (UKCRC) has developed a systematic approach to analysing funding activity across human health. In other cases funders aimed to create an overview or database of funding activity but have faced challenges bringing information together efficiently and keeping it up to date (**Figure 14**).

**4.2** Despite concerns about skills gaps in most of the research areas we examined, we identified relatively few examples of a systematic approach to assessing current and projected supply and demand for specific research skills (Figure 14). Similarly, we did not see examples of funders taking a systematic approach to assessing current and future infrastructure requirements across research areas.

## Figure 14

Assessment of the availability and use of consolidated information

| Assessment | Research area |
|---|---|
| There is a well-established approach to sharing information between key funders. | **Human health:**<br>● The UK Clinical Research Collaboration conducts a five-yearly analysis of health research spending, systematically bringing together data from government and not-for-profit funders. Research is categorised at the point of funding. Analysis allows funders to identify gaps and opportunities for investment and can support prioritisation.<br>● The National Cancer Research Institute analyses cancer research funding data to highlight relative strengths and weaknesses within the research programme. The data have enabled the research community to target research gaps.<br>● The Medical Research Council's (MRC's) Training and Careers Group (TCG) examines future skills needs and coordinates with other organisations including the National Institute for Health Research, industry, professional organisations and the other research councils to inform the MRC's training and skills strategy. |
| There is a recognised need for coherent information and developing approaches. | **Animal and plant health:**<br>● The Department for Environment, Food & Rural Affairs (Defra) led efforts to categorise and analyse the spending distribution of the main funding partners. This informed strategy development and Defra's spending review bid.<br>● A joint Government Office for Science-Defra review of science capability identified strategically-important areas where there are current skills shortages or potential future gaps. Action is under way to develop career pathways to target skills gaps.<br><br>**Energy:**<br>● The new Energy Innovation Board is carrying out 'deep dives' on thematic areas to review and challenge individual programmes and to identify gaps and overlaps.<br>● The government and the Nuclear Industry Council published a skills strategy for nuclear energy which sets out current and future skills requirements and the interventions needed. |
| These research areas are facing challenges or at an early stage of development. | **Climate:** The Living with Environmental Change Partnership developed a database of funded research.[1] However, it was not used and ultimately discontinued because of the challenges of keeping it up to date.<br><br>**Robotics and autonomous systems:**<br>● The Robotics and Autonomous Systems Special Interest Group mapped out public sector research investment activity across the spectrum from basic research through to commercialisation, to highlight gaps and supporting implementation of an innovation pipeline. Quantification of this analysis could support decision-making.<br>● The Transport Systems Catapult has published an Intelligent Mobility Skills Strategy which quantifies skills needed by 2025 and assesses UK capability relative to the rest of the world.<br><br>**Advanced materials:** We have not seen evidence of action to build coherent information on funding and capability. |

**Note**

1 The Living with Environmental Change Partnership was succeeded by Research and Innovation for Our Dynamic Environment in 2016.

Source: National Audit Office analysis

## Well-established or developing arrangements for informed decision-making

**4.3** We identified good examples of where funders have categorised research activities, developed a coherent picture of the funding landscape and used this to direct their investment (**Figure 15**). In these cases, funders have acted to ensure that public funding is targeted at bridging funding gaps and solving problems not being addressed by other funders, whether at the basic, clinical, or translational stage of research.

**4.4** In some cases, skills capability assessments have informed decision-making. For example, the *Intelligent Mobility Skills Strategy* indicates where government interventions could meet projected skills gaps.[26] The government's skills strategy for nuclear sector is targeted at ensuring that skilled individuals are available to meet future requirements (**Figure 16**).

### Figure 15

Case study: Using a coding system to inform investment in health research

The UK Clinical Research Collaboration (UKCRC) developed a unified approach, the Health Research Classification System (HRCS), to categorise funding. A dual-coding system, capturing both area of health and disease and type of research, was intended to help funders make decisions about future investment.

Using the HRCS, the first health research analysis report was produced in 2006. It captured data from the 11 largest public and charitable funders, providing an overview of spending across areas of health research as well as detailed assessments of individual areas.

This first analysis showed low levels of spend on primary disease prevention and promotion of well-being. In response, government departments, research councils and medical charities established the National Prevention Research Initiative to increase funding in this area, collectively investing £34 million between 2005 and 2014 through a series of initiatives.

The UKCRC published two further health research analysis reports in 2012 and 2014. These were used to inform strategy discussions and prompt joint funding initiatives.

Funders have explored automated approaches and expect that these approaches should reduce the resource and time required to code health research funding for the next analysis. Reductions in cost may encourage more funders to participate.

Source: National Audit Office

26 Transport Systems Catapult, *Intelligent Mobility Skills Strategy, Growing new markets in smarter transport*, October 2016.

## Figure 16

Case study: Developing a skills strategy for the nuclear sector

**Background**

In 2015, the government published *Sustaining our Nuclear Skills* which assessed current skills provision as part of the nuclear industrial strategy. Plans to build new nuclear power stations mean that the UK needs more highly-skilled people to build and operate the fleet, run existing stations, decommission older stations, process nuclear waste and maintain the nuclear defence programme.

**Strategy development**

In response, the Nuclear Skills Strategy Group launched a Strategic Plan in December 2016 to ensure that employers can "recruit skilled people at the required rate to meet the sector's ambitious forward programme".

Features of the plan include training infrastructure and provision, training standards and qualifications, a skills delivery model and an agreed timeline. Actions include training requirements for apprentices, new bursary schemes, a clear national curriculum, and regional skills initiatives.

Source: National Audit Office

## Challenges in consolidating information

### Bringing information together

**4.5** Collecting and sharing coherent information on who funds what is challenging. While there are some shared systems for capturing information about research projects (such as Gateway to Research which includes information on projects the research councils have funded, and Researchfish, a private online facility which brings together information about research outputs[27]), there is no single database capturing all government-funded research. An exercise to develop a database of environmental science research (including climate research) was discontinued because of the difficulty of collecting and maintaining data from multiple sources. Funders of animal and plant health have faced similar challenges in bringing information together.

**4.6** While there are examples of effective forums for spreading awareness of research activity (such as the Ministry of Defence's Defence Materials Forum), consolidated information on what research is currently funded, and has been funded in the past, is needed to inform decisions to invest. Funders told us that they rely on peer reviewers to apply their knowledge and expertise to research proposals, spot duplication, and advise on whether the research is truly novel and should be funded. Peer reviewers would be better supported if the information available to them had wider coverage. The Medical Research Council and the Biotechnology and Biological Sciences Research Council told us that they do not have enough information on research funded by other government departments.

27 www.researchfish.com

## Cross-cutting technologies

**4.7** For cross-cutting technologies like robotics, where funders and other stakeholders are still emerging, there are additional challenges in establishing who is involved and what research they are funding. For example, robotics has many applications but no main sponsoring department, making it difficult to track and classify research activity. Funding may only be classified as robotics research at the point when the technology has become an end product.

**4.8** While there is a need for more coherent information, initial work by the Robotics and Autonomous Systems Special Interest Group has produced analysis illustrating how robotics can lead to benefits at multiple points in a process.[28] The analysis showed that robotics and autonomous systems could have a potential impact in three types of processes: producing goods; providing services; and delivering goods and resources. Quantification of benefits and outcomes in this type of process analysis could help make the case for further investment in translational research.

## Assessment of infrastructure capability

**4.9** There is little evidence of a coordinated approach to consolidate information on infrastructure within research areas. An exercise by the Council for Science and Technology identified the main facilities in specific research areas, providing decision-makers with clearer information to support better strategic decisions. However, we have seen no evidence of this analysis being developed further.[29] As part of this exercise, the research community expressed concern about a lack of testing facilities in the UK, specifically in the advanced materials, energy, and robotics and autonomous systems research areas, with corresponding concerns about difficulties for researchers in accessing facilities located overseas. Future productivity may be hindered by the absence of action to address gaps, making it more difficult to research and test products and get them to market.

**4.10** A joint Government Office for Science-Defra review of animal and plant health research capability highlighted concern about fragmentation of infrastructure and found that there was too much scope for duplication and gaps.[30] The report recommended balancing financial efficiency with structural resilience by rationalising gaps and overlaps in infrastructure, capabilities and evidence generation across the UK, and by renewing ageing infrastructure using a strategic, planned approach to sustain national capability and evidence generation.

28 Robotics and Autonomous Systems Special Interest Group, *The UK landscape for robotics and autonomous systems*, 2015.
29 Council of Science & Technology review of the knowledge landscape.
30 Government Office for Science and Department for Environment, Food & Rural Affairs, *Animal and Plant Health in the UK: Building our science capability*, December 2014.

## UK exit of the European Union

**4.11** The UK needs good information on funding, skills and infrastructure to establish which research programmes and facilities may be affected by the UK exiting the EU, in order to support negotiations and to inform future priorities for UK investment in science. The Department for Business, Energy and Industrial Strategy (BEIS) told us about the action it is taking to address these issues:

- BEIS monitors levels of participation and funding for UK organisations participating in EU science and innovation programmes by analysing data and applications to Horizon 2020, the EU science and innovation programme. BEIS told us that this allows it to monitor EU funding at a sub-programme level and track the role of EU funding across research fields.
- In 2017, the Science and Technology Research Council (STFC) reviewed all UK-based and international research facilities that rely on UK public funds. It identified issues affecting these facilities that may arise from the UK's exit from the EU and options for addressing these issues. BEIS and its partner organisations plan to develop a research infrastructure roadmap to improve strategic planning within the UK and with international partners.
- The Home Secretary has commissioned the independent Migration Advisory Committee to provide advice and evidence to support alignment of the UK immigration system and the industrial strategy, including the impact of immigration on skills. BEIS's role includes working with the Department for Education to develop the evidence base on science and research skills within UK higher education institutions.

# Part Five

## Evaluating the impact of investing in research

### Why it is important

Evaluating the impact of investing in research is challenging. The scientific, societal and economic returns are often long term and it is difficult to put a value on ground-breaking research. There are also costs associated with in-depth assessments.

Funders need to know whether investment in research is securing the desired outcomes and achieving strategic objectives. By taking a systematic approach to evaluating impact funders are able to assess whether investment in research is delivering what was expected, learn lessons, and collect valuable information which can direct future spending decisions. Evaluations can highlight opportunities or gaps such as whether investment in pure research is translating into commercial applications. This will make the case for continued investment or prompt decisions about whether resources would be better directed elsewhere.

### Overall view

**5.1 Most research areas we examined have not yet carried out consolidated analysis of the impact of research.** We found that research areas with established or developing leadership arrangements have a more coordinated approach to evaluating the results of a programme of research funded by different organisations (**Figure 17**). In other areas there was less evidence of a coordinated approach, although some funders had developed systematic processes for evaluating the impact of their individual projects.

### Well-established or developing arrangements for evaluation

**5.2** Funders of human health research, including government, academia, and the third sector, have developed a coordinated approach to estimating the benefits of research and using this evidence to support the case for continued investment (**Figure 18**). In human health research, funders have long recognised the importance of having good data and have taken steps over time to develop datasets to support a joined-up approach.

## Figure 17
Assessment of arrangements to evaluate the impact of investment

| Assessment | Research area |
|---|---|
| There is evidence of a coordinated approach to evaluating the results of research funded by different bodies and demonstrating the impact and contribution of investing in research | **Human health:** Funders have aimed to understand a range of impacts arising from public and charitable funding for medical research, including the resulting economic benefits. A series of quantitative assessments – the 'What's it worth' series – have been made of the benefits of investing in health research. |
| There is a broad consensus on the need to do more collectively to demonstrate the impact and contribution of investing in research; some work has been attempted or is in development | **Animal and plant health:** In support of the creation of the Animal and Plant Health Partnership, the Department for Environment, Food & Rural Affairs led efforts to estimate the value to UK society of healthy animals and plants. The estimate combined the annual economic contribution of directly dependent sectors with estimates of the social and environmental value of woodlands. |
| There is less evidence of coordinated evaluation | **Advanced materials, climate, energy, robotics and autonomous systems:** These have less mature coordinated approaches, although some individual funders have developed systematic approaches for evaluating their own investments. |

Source: National Audit Office analysis

## Figure 18
Case study: Developing a coordinated approach to estimating the benefits of health research

### Background

In 2004, the Academy of Medical Sciences, the Medical Research Council and the Wellcome Trust established the UK Evaluation Forum to determine the collective socioeconomic benefits of medical research in the UK.

### Methodology

Work focused on mapping evaluation practices in member organisations, discussing stakeholders' evaluation needs and expectations, and examining other countries approaches to demonstrating the socioeconomic impact of health research. The Forum recommended that UK funders should support research to assess the economic impact of UK medical research.[1]

### Results

Funders subsequently commissioned work to estimate the economic returns from health research and to inform methodologies for future assessments. They estimated rates of return for two specific areas: cardiovascular disease and mental health. Later studies in the 'What's it worth' series have focused on estimating the rates of return of public and not-for-profit funding in cancer research and in musculoskeletal research.

**Note**

1 UK Evaluation Forum, Medical Research: assessing the benefits to society, May 2006.

Source: National Audit Office

**5.3** While our examination did not highlight many examples of coordinated approaches to evaluation, there are examples of funders developing systematic approaches for evaluating the impact of their own research projects:

- The Natural Environment Research Council (NERC) periodically commissions analysis of the impacts of its research activities on the UK economy and society. These reports have quantified the health, economic and social benefits arising from NERC's research on issues ranging from skin cancer to crop yields.
- The Engineering and Physical Sciences Research Council (EPSRC) evaluated its investment into the Supergen programme to inform decisions on its future investment strategy for renewable energy research.[31]
- The Department for International Development (DFID) conducts annual reviews of its research programmes. Research programmes may also be subject to independent evaluation and review. For example, the Independent Commission for Aid Impact (ICAI) reviews the impact of DFID's investment in research.

## Challenges in taking a coordinated approach to evaluation

**5.4** In many research areas, the absence of consistent and comprehensive data on the outcomes of research may act as a barrier to a coordinated approach to evaluation. For example, we found a lack of consolidated information on climate research, robotics and autonomous systems, and advanced materials so it is perhaps unsurprising that there is less evidence of a coordinated approach to evaluation in these areas.

**5.5** Human health research funders have encountered challenges in making evaluations and have taken steps over time to address limitations. For example, developing and bringing into use a standardised way of classifying research funding (Figure 15) and working together to develop methodologies (Figure 18). There is an opportunity for funders in other research areas to draw on their experience, and on the first steps to addressing the challenges we set out, when developing coordinated approaches to evaluation (**Figure 19**).

31 One of the UK Government's largest single investments in fundamental research on low carbon energy generation and sustainable distribution.

## Figure 19

A coordinated approach to evaluation: challenges and first steps

| The challenge | First steps |
|---|---|
| Ensuring availability of data and coverage of research funded by the main players. | Developing a standardised classification system to enable a systematic approach to identifying the results of research by all funders. |
| Systematically capturing wider economic benefits and spillover effects. | Undertaking a review of economic literature to identify data on new products and patents, and business start-ups. |
| Dealing with time lags and measuring costs and benefits over a sufficiently long period of time. | Ensuring data are collected across the whole period by making a plan at the outset for how the outcomes of investment will be measured. |
| Attaching a financial value to benefits and costs. | Using proxies such as opportunity costs or willingness to pay in the absence of more robust data. |
| Dealing with uncertainty. | Using sensitivity analysis to test assumptions and estimate a range of returns. |

Source: National Audit Office

# Appendix One

## Our audit approach

**1** We examined the effectiveness of government's arrangements for coordinating research activity and maximising the value of government's investment in research and development. The Department for Business, Energy & Industrial Strategy (BEIS) is responsible for the majority of the government's spending on science, technology and engineering, but around a third of total government investment in science comes from other government departments which fund research to meet their own policy objectives.

### Scope

**2** Publicly-funded research and development in the UK includes funding from BEIS, its research councils and Innovate UK, other central government departments, the higher education funding councils in England, Wales, Scotland and Northern Ireland, and the devolved administrations in Scotland, Wales and Northern Ireland. While this report covers areas of research that may be funded by some or all of these bodies, the focus of the report is the oversight provided by BEIS, its research councils and Innovate UK, and the other major departmental funders of research and development; the Department of Health, the Department for Environment, Food & Rural Affairs, the Department for International Development and the Ministry of Defence.

**3** The report does not cover the higher education funding councils' oversight arrangements of funding it grants to higher education institutions, or the devolved administrations' oversight of research they fund.

**4** For the purposes of our work and this report, we have relied upon the Organisation for Economic Co-operation and Development's (OECD)'s Frascati Manual definition of research and development as "creative and systematic work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications".[32] The Frascati definition includes:

- basic research – experimental or theoretical work undertaken to acquire new knowledge without any particular application or use in view;
- applied research – also original investigation but directed towards a specific practical aim or objective; and
- experimental development – systematic work directed to producing new materials or products, new processes or systems, or to improving substantially those already produced or installed.

**5** The Office for National Statistics also uses the OECD's definition to collect and report data.

## Evaluative framework

**6** We developed a set of principles (evaluative framework) which bring together the features of well-coordinated funding of research and development. We drew on frameworks for evaluating research used by other organisations, as well as existing frameworks developed by the National Audit Office.[33] We also consulted on the principles with government departments that fund research, and with the Government Office for Science.

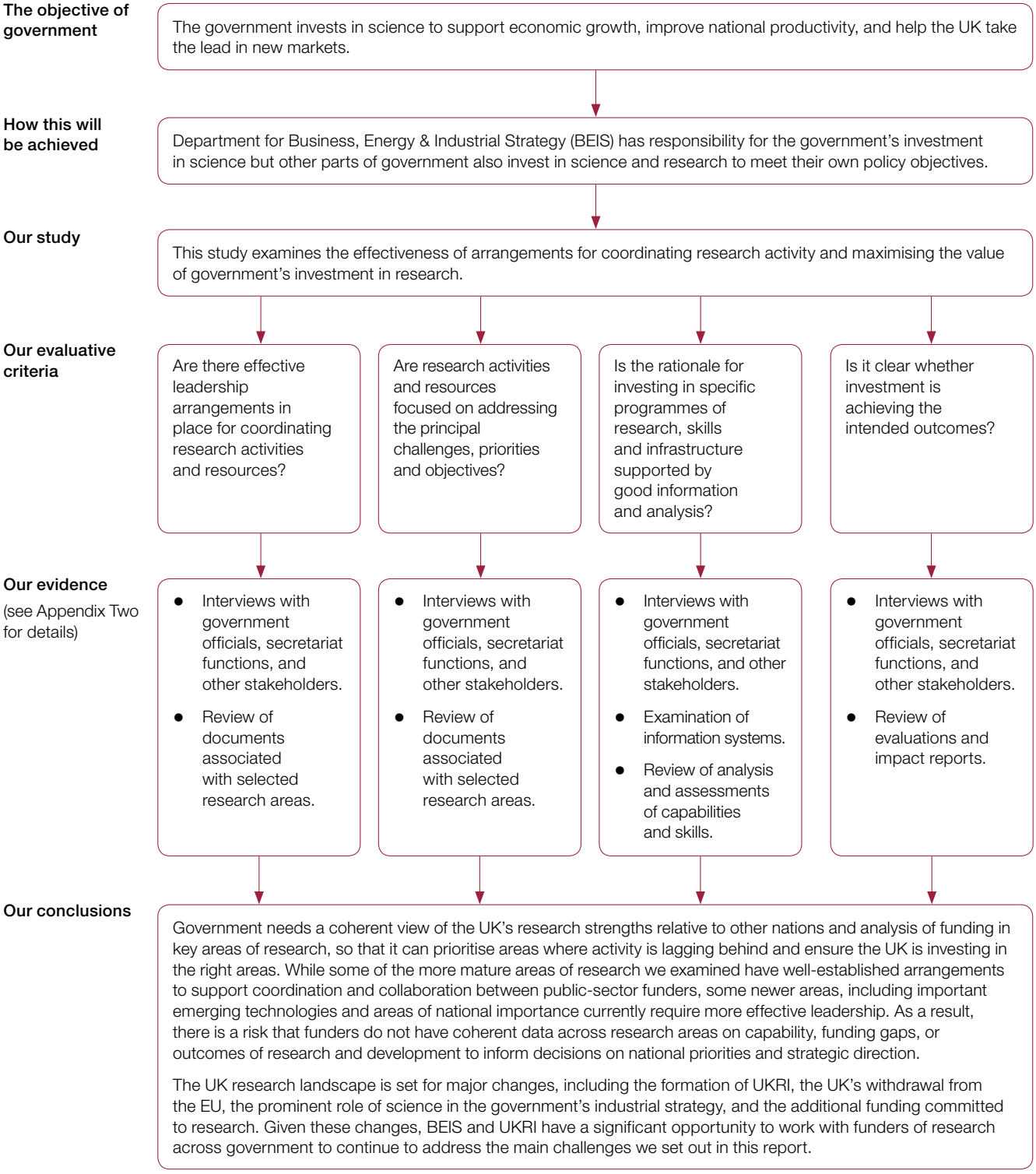
**7** We used the framework to direct and inform our examination of coordination and oversight arrangements in six areas of research (human health, animal and plant health, energy, climate, advanced materials and robotics and autonomous systems).

**8** The report structure corresponds to the principles set out in the evaluative framework: Leadership and coordination, Priority setting, Informed decision-making, and Evaluation.

**9** Our audit approach is summarised in **Figure 20** overleaf. Our evidence base is described in Appendix Two.

32 The Frascati Manual is the internationally recognised methodology for collecting and using R&D statistics.
33 Comptroller and Auditor General, *Government's management of its performance: progress with single departmental plans*, Session 2016-17, HC 872, National Audit Office, July 2016.

## Figure 20
Our audit approach



# Appendix Two

## Our evidence base

**1** We reached our independent conclusion on the effectiveness of arrangements for coordinating research activity and maximising the value of government's investment in research based on our assessment against the principles of effective coordination, as set out in our evaluative framework. Our audit approach is outlined at Appendix One.

**2** The fieldwork for this report was primarily carried out between June 2016 and March 2017. Due to the announcement of the June 2017 General Election, publication of the report was postponed to November 2017. The report has been updated to reflect any specific developments in the intervening period but broadly reflects the position we established during fieldwork.

**3** The evaluative framework includes a set of principles and questions which we sought to answer in order to inform our understanding of the arrangements in place in each of the six areas of research we examined. A summarised version of the framework is included at **Figure 21** on pages 50 and 51. A detailed version of the framework is available at www.nao.org.uk/report/cross-government-funding-of-research-and-development/. Using the framework, we assessed the effectiveness of coordination by asking questions grouped under four principles:

- Leadership and coordination
- Priority setting
- Informed decision-making
- Evaluation.

## Figure 21
The principles of effective coordination

| Key question | Why is it important? | What does good look like? |
|---|---|---|
| **1** Are there effective leadership arrangements in place for coordinating research activities and resources? | Understanding the environment and context for research activity, and identifying the key organisations and people involved, will help funders to identify opportunities for collaboration and address any barriers. Strong leadership arrangements will help to ensure that efforts to address research priorities are coherent and coordinated. | • Strong leadership and a culture of coordination and collaboration across the sector.<br>• Collective action is facilitated by various groups and forums who coordinate and align activities within the research area.<br>• Key players (including government, academia, industry and charities) come together to identify opportunities, tackle barriers to collaboration, coordinate activities, discuss future needs and developments, understand available resources, and develop partnerships. This may involve setting strategic direction for the sector as a whole or for particular areas. |
| **2** Are research activities and resources focused on addressing the principal challenges, priorities and objectives? | Funders need to be clear about principal priorities, opportunities and challenges across the area of research. This will enable them to work together to ensure that efforts are aligned and directed towards common goals. | • A common understanding of the principal challenges facing the sector.<br>• Clarity about the research priorities, opportunities, objectives and direction for the sector.<br>• Roles and contributions of key players in addressing objectives are understood and agreed.<br>• Outputs of horizon-scanning influence decisions about future priorities. |
| **3** Is the rationale for investing in specific programmes of research, skills and infrastructure supported by good information and analysis? | Maximising the value of public investment in research requires accessible, comprehensive, and coherent information on what and where others are investing, and a strategic approach to allocating resources. Funders need comprehensive information and analysis with sufficient granularity on current and past activity to help them identify funding gaps or duplication, inform and direct investment decisions, and strengthen the rationale and justification for investment. | • Data analysis of research investment has facilitated discussions on funding gaps and opportunities, improved coordination, and directed investment.<br>• Investment decisions take account of where others (eg industry, charities and other nations) are investing in research programmes, skills and infrastructure.<br>• Information on proposed research programmes and the results of completed research are shared across the sector to avoid duplication of effort.<br>• Funders use information and knowledge of the sector to coordinate and align priorities and submit joined-up funding bids, where appropriate. |

## **Figure 21** *continued*
The principles of effective coordination

| Key question | Why is it important? | What does good look like? |
|---|---|---|
| 4 Is it clear whether investment is achieving the intended outcomes? | Evaluating the impact of investing in research is challenging. The scientific, societal and economic returns from such investment are often long term and it is difficult to put a value on ground-breaking research. There are also costs associated with carrying out in-depth assessments of impacts achieved.<br><br>But funders need to know whether investment in research is securing the desired outcomes and whether strategic objectives are being achieved across an area of research. By taking a systematic approach to evaluating impact funders are able to assess whether investment in research is delivering what was expected, learn lessons, and collect valuable information which can direct future spending decisions. Evaluations will highlight opportunities or gaps such as whether investment in pure research is translating into commercial applications. This will make the case for continued investment or prompt decisions about whether resources would be better directed elsewhere. | • There is available data on research activity funded by the main players.<br><br>• Work is undertaken to bring together and evaluate the benefits of investing in the sector and to make the case for continued investment.<br><br>• A clear strategy for translating and exploiting the results of research, eg in terms of new innovations, products, services and wider public benefits. |

Source: National Audit Office

4 Research and development encompasses a broad range of subject disciplines and research activity. Our review focused on detailed examinations of six research areas to understand arrangements in place to coordinate research activity (human health, animal and plant health, energy, climate, robotics and autonomous systems, advanced materials). These six areas of research:

- cover above an estimated annual £3 billion of government funding;
- involve multiple government departments, agencies and research councils, as well as varying levels of not-for-profit sector and industry funding; and
- cover a range of different types of subject disciplines and research activity.

5 The six case studies provided us with sufficient variety to draw comparisons between research areas, highlight good practice and identify improvements. Our approach was not an extensive examination of all research areas. There will be examples of effective coordination in other research areas which are not identified by this review.

6 We consulted with BEIS, Research Councils UK and the Government Office for Science on our selection of research areas for examination: human health, animal and plant health, energy, climate, robotics and autonomous systems, and advanced materials. We selected research areas which cover a range of different types of research, benefit from a significant level of investment from multiple government departments, agencies and research councils, as well as varying levels of investment from other areas such as the not-for-profit sector and industry.

7 We interviewed a range of individuals to find out more about arrangements in each area of research. We shared our analytical framework with all interviewees in advance of meetings so that they had the opportunity to consider and reflect on our main lines of enquiry and tell us about arrangements and practices in their research areas. This approach enabled us to take on board their observations and influenced our thinking on good practice. We revised the framework to reflect the findings from our fieldwork and our learning from comparing arrangements in different research areas:

- We carried out semi-structured interviews with officials from the principal funding government departments and research councils, and the Government Office for Science, with the objective of understanding leadership, coordination, and priority-setting arrangements, and finding out about the underlying sources of information and analysis which inform and direct government's investment decisions.
- We spoke to representatives of the secretariat functions for the Office for Strategic Coordination of Health Research (OSCHR), the UK Clinical Research Collaboration, the UK Science Partnership for Animal and Plant Health, and the Advanced Materials Leadership Council to find out more about their roles and coordination arrangements in these research areas.
- We spoke to the OSCHR chair and to two members of the Robotics and Autonomous Systems Special Interest Group to find out more specifically about leadership and coordination in these research areas.

- We spoke to the Head of Policy at the Academy of Medical Sciences and the Head of Research and Impact at the Association of Medical Research Charities to better understand the roles of their organisations in the health research landscape, and to the Head of Adaptation at the Committee on Climate Change to seek views on leadership and coordination within applied climate research.

**8** We examined various relevant documents to understand more about both the wider research and development environment, and our selected areas of research:

- We examined published documents from government departments, the research councils, the National Institute for Health Research, the Government Office for Science, the Council for Science and Technology, the Office for National Statistics (ONS) and the Committee on Climate Change. Documents reviewed included strategic plans, evaluations of research investment, and impact reports.
- We examined reports published by the House of Commons Science and Technology Committee and the House of Lords Science and Technology Committee.
- We examined documents produced by leadership groups including terms of reference, vision and strategy papers, and minutes of meetings.
- We drew on evidence from our previous work, including our reports on the Department for Business, Innovation & Skills' capital investment in science projects, and Integration across government.[34,35]

**9** We examined information systems on research projects, reviewed analysis of research investment, and assessments of capabilities and skills to help us to assess the availability and quality of information supporting investment decisions.

**10** Data on research and development expenditure:

- We referred to the bulletin published by the ONS for statistical information on spending by different sectors of the UK economy on research and development.[36] ONS statistics on government and research councils spending are based on survey submissions by each government body that funds research and development. We obtained copies of the surveys government departments submitted to the ONS in order to provide a breakdown of spending by the main government departments that fund research and development (Figure 4).
- Public funding for areas of research is not reported on a consistent basis or in one place so we collated information from a range of published and unpublished sources in order to derive a broad estimate of the public funding associated with the six areas of research we examined (Figure 9). In some cases the estimates include expenditure by the devolved administrations. The estimates we produced are not presented for the purposes of comparison but to give an indication of the scale of the funding in each case.

34 Comptroller and Auditor General, Department for Business, Innovation & Skills, *BIS's capital investment in science projects*, Session 2015-16, HC 885, National Audit Office, March 2016.
35 Comptroller and Auditor General, Cabinet Office and HM Treasury, *Integration across government*, Session 2012-13, HC 1041, National Audit Office, March 2013.
36 Office for National Statistics, *UK gross domestic expenditure on research and development 2015*, March 2017.

This report has been printed on Evolution Digital Satin and contains material sourced from responsibly managed and sustainable forests certified in accordance with the FSC (Forest Stewardship Council).

The wood pulp is totally recyclable and acid-free. Our printers also have full ISO 14001 environmental accreditation, which ensures that they have effective procedures in place to manage waste and practices that may affect the environment.

National Audit Office

Design and Production by NAO External Relations
DP Ref: 11505-001

£10.00

ISBN 978-1-78604-152-4