ROYAL ACADEMY OF ENGINEERING

RADICAL INNOVATION

A blueprint for a new UK research and technology funding agency

The UK government has proposed the development of a new research and technology funding agency.[1,2,3] This agency is described as a new approach to funding high-risk, high-payoff emerging fields of research and technology, broadly modelled on the US Advanced Research Projects Agency (ARPA). For over 60 years, ARPA programmes have applied a specific funding model for technology development, credited with producing transformational technology. Examples include the precursors to the internet and GPS.

This briefing sets out a blueprint for an agency that supports radical innovation. This is how the engineering community believe an ARPA-inspired agency could bring most value to the UK.

1 Queen's Speech 2019: background briefing notes, 14/10/2019
2 Conservative Party Manifesto 2019
3 Queen's Speech 2019: background briefing notes, 19/12/2019

Engineering is crucial for radical innovation. It often forms a two-way connection between research and innovation to enable commercial breakthroughs. A new funding mechanism could address the UK's historic under-investment in innovation and unlock positive disruption and step changes in technology that reverberate far across society. The benefits can be far-reaching. By strengthening local economies, creating sustainable jobs and addressing global challenges, opportunities can be driven in every part of the UK and improve people's lives.

This briefing is based on discussions by our Fellows and a wider network of associates and partners of the Royal Academy of Engineering, including participants in ARPA or similar programmes.

CHAMPIONING RADICAL INNOVATION

The engineering proposal: a funding mechanism that delivers innovative answers to solve ambitious real-world challenges. Bringing together and developing breakthrough research and technology, it would provide ample funding, flexibility, skills, a high-risk appetite, close collaboration with end-users and deliver through strategic alliances between industry, academics and public sector agencies.

LEARNING FROM ARPA

- Challenges are set with **ambitious goals at the edge of possibility**, where innovation is the only solution. These are underpinned by clearly defined technical problems, which gradually push the boundaries of possibility in order to progress towards delivering solutions to the customer.
- The scale and nature of the challenges mean that government and public procurement are often the **customer**. The customer provides a pull as an end-user for the technological solution being developed and is prepared to try new innovative solutions in the early stages of development. The market is not the primary target, there are however means to exploit commercial opportunities as they arise.
- **High calibre programme managers**, with technical expertise and experience, are crucial to success. They are given the opportunity to apply their knowledge and abilities to solving ambitious challenges. The nature of the role maximises the use of their skills with full responsibility and freedom to define the programme, draw on leading capabilities in the public and private sectors, and to allocate funding to strategically drive the project forward at pace.
- **Independence and autonomy** facilitate fast decision-making, flexibility and the freedom to allocate and release funds. Programme managers are deliberately strictly time-limited in their posts to introduce new ideas and respond to developments in research and technology.
- **Focused on integration and driving development towards application**. Fundamental research is not viewed as the primary focus of the ARPA model, but act as a rich base to draw from. However, an ARPA model will not hesitate to commission or conduct risky fundamental research at pace where that is needed to solve problems on the path towards a technology solution.

A BRIEF HISTORY OF ARPA

The Advanced Research Projects Agency (ARPA) was created in 1958 by the US President in response to the launch of Sputnik by the Soviet Union.[4] The purpose of ARPA was to form and execute research and development projects to expand the frontiers of technology and science and to increase reach far beyond immediate military requirements. The ARPA operating model has remained and been applied to different sectors, for example the Defence Advanced Research Projects Agency (DARPA) for defence and ARPA-E for energy.

DARPA has grown to maintain an annual budget of $3.5 billion, with nearly 100 programme managers overseeing about 250 research and development programmes.[5,6] It is a flat organisation, with a director, a series of office managers and programme managers. The director sets the broad outlines of the research agenda and hires the programme managers. The programme managers typically come into the Agency with a very specific problem to develop, then spend around a year researching the technology and domain in which it lies. The programme manager has sole authority and responsibility for the technology development plan and proposal funding decisions.

4 Azoulay, P., Fuchs, E., Goldstein, A. P., & Kearney, M. (2019). Funding breakthrough research: promises and challenges of the "ARPA Model". Innovation Policy and the Economy, 19(1), 69-96.
5 About Us [Accessed January 2020]
6 Budget [Accessed January 2020]

SUCCESS IN THE UK CONTEXT

- **High risk - high reward**: ambitious projects require large amounts of funding with the freedom to fail. Project failure needs to be a recognised and accepted risk. If too many projects are successful, the ambition and risk-reward level of the challenge could be questioned. The funding is responsive and covers the entire project costs: available to encourage progress, willingly and quickly withdrawn if projects are not advancing. The beneficial outcomes of projects for wider society and consumers are often not measurable for 10 to 50 years. This is a significant shift in thinking compared to the current UK system based on value for money.
- To realise this vision, significant **culture change** will be needed. The UK has tried before to implement these principles for ambitious, autonomous and fast-paced innovation funding, with lessons learnt from the Industrial Strategy Challenge Fund. More autonomy, risk-taking, speed and independence from HM Treasury and ministerial control than is currently seen in research and innovation funding is critical. Consideration should also be given to the implications of the sudden withdrawal of project funding on staff and careers in universities.
- **A positive disruptor**: new funding providing positive disruption and encouraging healthy competition and collaboration would be welcome. Links to other organisations should be thought through, to avoid confusion for the user and disabling, unproductive rivalry with the existing components of the UK's research and innovation landscape, most notably UK Research and Innovation (UKRI), including Innovate UK.
- **A pilot programme, strategically scaled and focused on well-selected challenges, would be a valuable trial for this new framework for radical innovation in the UK. This would draw on the leading capabilities of the UK research and innovation community and demonstrate their technological application.**

CHAMPIONING RADICAL RESEARCH:

The UK research base is a clear national asset and its strength underpins much radical innovation. While being a global leader in research, the UK has a less successful track-record in exploiting innovation. The proposal above is to take full advantage of a new radical funding mechanism to bridge the gap and encourage the delivery of innovative answers. There is nevertheless a clear appetite in the engineering community for more support of radical research in the UK. The principles of **autonomy and risk-taking** should also be applied by UKRI and its Research Councils, with its existing capabilities, to **identify and fund more radical research**.

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UKRI

UK Research and Innovation (UKRI) was launched in April 2018.[7] UKRI was created to establish a strong, agile and joined-up funder of research and innovation for the UK. It brings together seven Research Councils focused on different fields of research, Innovate UK which works to de-risk and support innovation, and Research England supporting English Higher Education providers. The UKRI 2019/2020 budget was £7.4 billion.

INDUSTRIAL STRATEGY CHALLENGE FUND

The Industrial Strategy Challenge Fund (ISCF), now within UKRI, was set up in 2016 by the UK government.[8] It aims to bring together the UK's research base and businesses to transform how we live, work and move around the world. Four grand challenge areas were identified: artificial intelligence and data, clean growth, an ageing society and the future of mobility. For each challenge, missions were focused on a specific problem. The first two waves of funding supported 497 projects with £986 million government funding.

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We bring together the most successful and talented engineers from across the profession – our Fellows – to advance and promote excellence in engineering for the benefit of society.

We have three strategic priorities: make the UK the leading nation for engineering innovation and businesses, address the engineering skills crisis, and position engineering at the heart of society.

We are a national academy with a global outlook.

7 Academy of Medical Sciences, the British Academy, the Royal Academy of Engineering and the Royal Society, UK Research and Innovation, October 2019.
8 Industrial Strategy Challenge Fund [Accessed January 2020]