

#### A new UK research funding agency

House of Commons Science and Technology Select Committee

Submission from the Royal Academy of Engineering

30 June 2020

#### Summary

- The new funding agency should address the radical innovation gap in the 'development' part of UK R&D funding landscape. It should deliver innovative answers to solve ambitious real-world challenges where innovation is the only solution. It should bring together breakthrough research, at proof of concept and prototype level, and develop technology solutions with strategic alliances between industry and public sector agencies, in close collaboration with end-users.
- The new funding agency should draw on the key characteristics of DARPA, namely ambitious challenges at the edge of possibility, with a defined customer, high calibre programme managers with flexibility and autonomy, ample funding with a high-risk appetite and the freedom to fail.
- As a first step a pilot programme should initiated from which lessons can be learned.
- At this time of crisis and uncertainty for the existing research and innovation landscape due to the COVID-19 pandemic, a new agency should not happen at the detriment of existing structures.

#### Introduction

1. The Royal Academy of Engineering welcomes the opportunity to submit evidence to the House of Commons Science and Technology Committee's inquiry into a new UK research funding agency. The Academy's submission has been informed by the expertise of its Fellowship, which represents some of the nation's best practicing engineers, including leading researchers, industrialists, innovators and entrepreneurs.

2. Following the announcement of a 'new approach to funding emerging fields of research and technology, broadly modelled on the US Advanced Research Projects Agency' in the Queen's Speech in October 2019<sup>1</sup>, the Academy hosted a roundtable on the topic on 31 October. The discussion included individuals who had participated in

<sup>&</sup>lt;sup>1</sup> Queen's Speech 2019: <u>background briefing notes</u>, 14/10/2019.

Defense Advanced Research Projects Agency (DARPA) or similar programmes and informed the Academy's briefing <u>Radical Innovation: a blueprint for a new UK</u> research and technology funding agency, published in March 2020<sup>2</sup>.

3. The COVID-19 crisis has severely impacted UK research and innovation sector. Universities are facing serious financial difficulties due to the shortfall in international students<sup>3</sup>. Businesses are at risk of reducing or halting R&D activities as cost saving measures in the economic downturn<sup>4</sup>. The fast-approaching end of the transition period to exit from the European Union is another potential shock to the UK research and innovation sector. The urgent need to stabilise the sector, meet the ambitions of the expected government R&D roadmap and any lasting impact of the COVID-19 pandemic will need to be considered to assess where a new funding agency best fits into this changed landscape, what it should deliver, and its first priorities.

# • What gaps in the current UK research and development system might be addressed by an ARPA style approach?

4. The engineering community believes an ARPA-inspired agency could bring most value to the UK by supporting radical innovation<sup>5</sup>. The Academy has produced a briefing<sup>6</sup> outlining 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. Support for radical innovation is a gap in the UK's R&D system.

5. The UK research base is a clear national asset and its strength underpins much radical innovation. This high quality of research, the access to skilled people and the ability to collaborate with universities are key factors in attracting business R&D investment to the UK<sup>7</sup>. However, while being a global leader in research, the UK has a less successful track-record in exploiting innovation and delivering research driven by industry strategic needs<sup>8</sup>.

6. The UK has historically under-invested in innovation and the 'D' of R&D. The case for continued investment in our research base as a means of fuelling future prosperity is compelling and has been widely articulated. However, this is necessary but not sufficient to safeguard our ability to compete globally: a concomitant focus on our innovation investment and performance is essential to ensure that we benefit from the potential in our research base. Investment to turn research into real world solutions and successful

<sup>&</sup>lt;sup>2</sup> Royal Academy of Engineering, <u>Radical innovation: a blueprint for a new UK research and</u> <u>technology funding agency</u>, 2020.

<sup>&</sup>lt;sup>3</sup> London Economic for the University and College Union, <u>Impact of the Covid-19 pandemic on</u> <u>university finances</u>, April 2020.

<sup>&</sup>lt;sup>4</sup> Royal Academy of Engineer, <u>Stimulating R&D for a faster and better recovery</u>, June 2020. <sup>5</sup> Royal Academy of Engineering, Radical innovation: a blueprint for a new UK research and

technology funding agency, 2020.

<sup>&</sup>lt;sup>6</sup> Ibid.

<sup>&</sup>lt;sup>7</sup> Royal Academy of Engineering, <u>Increasing R&D investment: business perspectives</u>, 2018.

<sup>&</sup>lt;sup>8</sup> Royal Academy of Engineering, <u>Engineering priorities for our future economy and society</u>, 2019.

businesses, should be valued just as much as the publication of scientific papers and winning of Nobel prizes.

7. The Technology Readiness Levels (TRL), describing stages in R&D from idea (TRL 1) to full commercial application (TRL 9) are a useful tool in guiding discussions on R&D funding, and are used throughout this paper, although we acknowledge their well-known limitations in capturing the diversity and non-linearity in innovation. UK Research and Innovation (UKRI) had a £7.4 billion budget in  $2019/2020^9$ , of which £2.68 billion was allocated through the Research Councils, generally on projects covering basic research, through technological formulation, applied research and small-scale prototypes within TRL 1 to 3.

8. In contrast, Innovate UK, focused more towards development from TRL 4 to 7, beyond small scale prototype to larger scale development, prototype systems and demonstration, had a budget of £1.3 billion including £491 million for the Industrial Strategy Challenge Fund (ISCF). TRL 8 and 9 are focused on commercialisation and tend to be funded by the private sector. These funding programmes delivered by UKRI are excellent at supporting engineering research and innovation, including through facilitating collaborative R&D between universities and larger companies or supporting small innovative companies. Furthermore, only a very small proportion of funding for development is open and flexible, able to rapidly respond to market needs and innovation, with open programmes amounting to only 6% of Innovate UK's allocations in  $2017/2018^{10}$ .

9. It is appropriate that businesses contribute significantly towards R&D and innovation that will benefit them. However, government has a pivotal role to play in stimulating innovation. While innovation offers many potential benefits at the level of an individual firm, government support is often essential to encourage companies to engage in innovation. This is because innovation is an inherently risky process with an uncertain outcome, the benefits may only materialise over very long timescales and the innovator often accrues only a small proportion of the overall benefit generated<sup>11</sup>. Public investment in R&D has been shown to have so-called spill-over effects, with nearby businesses increasing innovation and productivity<sup>12</sup>.

10. Late-stage development and demonstration, TRL 5 to 9, is a crucial to bring new products and services into use, as most need to be extensively tested and demonstrated at scale in real-world environments before they can succeed in application<sup>13</sup>. However, it is also difficult and risky, both due the technical challenges and the time and level of capital investment that may be required. R&D is global and compared to competitor countries, the UK is poor at supporting this crucial stage of development. The Academy is pursuing work to gather evidence on late stage development and opportunities to increase private R&D investment in the UK.

<sup>&</sup>lt;sup>9</sup> BEIS, <u>The allocation of funding for research and innovation</u>, 2018.

<sup>&</sup>lt;sup>10</sup> Innovate UK, <u>Delivery Plan: Shaping the future 2017-2018</u>, 2017

<sup>&</sup>lt;sup>11</sup> Royal Academy of Engineering, <u>Investing in Innovation</u>, 2015.

<sup>&</sup>lt;sup>12</sup> NESTA, <u>The missing £4 billion</u>, 2020.

<sup>&</sup>lt;sup>13</sup> Royal Academy of Engineering, <u>Increasing R&D investment: business perspectives</u>, 2018.

11. The US ARPA/DARPA model operates in the development sphere, from proof of concept to demonstration<sup>14</sup>. This is equivalent to the TRL 3 to 7. In contrast with the UK funding landscape, the US ARPA/DARPA crosses inflexion points around TRL 3 and 4 where projects would move across from one funding programme to the next, for example from Research Councils funding to Innovate UK. DARPA programmes also benefit from flexibility in funding reflecting the non-linearity of innovation, with the ability to fund scientific research at the lowest end of the TRL scale when needed to gain crucial understanding.

12. Crucially the US ARPA/DARPA model generally includes a defined customer at the end, the US Department for Defence or a specific industrial sector, as a pull towards translation and application. The UK, in contrast, is considered poor at using procurement to drive innovation<sup>15,16</sup>.

13. The engineering proposal put forward by the Academy is a funding mechanism that delivers innovative answers to solve ambitious real-world challenges. It would bring together breakthrough research, at proof of concept and prototype level, and develop technology solutions with strategic alliances between industry and public sector agencies, in close collaboration with end-users. Research is not the focus but can be returned to if needed. Rather, the focus of this new funding agency would be to drive development and demonstration of solutions, to challenges where innovation is the only solution and the market is not the primary target<sup>17</sup>.

14. It is of paramount importance that evidence, expertise, and experience should inform the creation and purpose of the new agency, to conduct an informed intervention and equip the agency to deliver on its priorities.

## • What are the implications of the new funding agency for existing funding bodies and their approach?

15. New funding should provide positive disruption and encourage healthy competition and collaboration<sup>18</sup>. UKRI is still relatively young and establishing itself, although its Councils have a long history with established funding mechanisms. Links between a new funding agency and other organisations should be thought through to avoid confusion for the user in an already complex system and disabling, unproductive rivalry with the existing components of the UK's research and innovation landscape, including UKRI. At this time of crisis and uncertainty for the existing research and innovation landscape due to the COVID-19 pandemic, a new agency should not happen to the detriment of existing structures.

16. UKRI's response to the COVID-19 pandemic has shown it is capable of operating some of the key principles credited with the success of the US ARPA model (paragraph

<sup>&</sup>lt;sup>14</sup> Azoulay, P., Fuchs, E., Goldstein, A. P., & Kearney, M. (2019). <u>Funding breakthrough research:</u> <u>promises and challenges of the "ARPA Model".</u> Innovation Policy and the Economy, 19(1), 69–96. <sup>15</sup> Royal Academy of Engineering, <u>Increasing R&D investment: business perspectives</u>, 2018.

<sup>&</sup>lt;sup>16</sup> Royal Academy of Engineering, Public projects and procurement in the UK, 2014.

<sup>&</sup>lt;sup>17</sup> Royal Academy of Engineering, <u>Radical innovation: a blueprint for a new UK research and</u> technology funding agency, 2020.

<sup>&</sup>lt;sup>18</sup> Royal Academy of Engineering, <u>Radical innovation: a blueprint for a new UK research and</u> technology funding agency, 2020.

21). Industry has also responded with phenomenal speed and agility to mission and procurement driven challenges like the Ventilator Challenge, solving problems and delivering solutions at a fast pace. The Academy is collecting the lessons through its series 'Innovation in a Crisis', asking questions to those directly involved in rapid innovation, for example setting up the Nightingale hospitals, the UCL-Mercedes CPAP breathing aid collaboration and the VentilatorChallengeUK consortium<sup>19</sup>. There is a crucial and timely opportunity to take stock and learn from new approaches to rapid innovation, which will contribute to forming the new context for a new funding agency.

17. There is also clear appetite in the engineering community for more support of radical and high-risk research in the UK. However, the consensus is that this can be delivered by UKRI and should not be the focus of a new agency. A new funding agency should not take away from UKRI's funding capability, rather UKRI could benefit from more freedom and resource. Lessons from the rapid and agile response to the pandemic and the principles of autonomy and risk taking could be applied and benefit UKRI, to leverage the existing capabilities of the Research Councils to identify and fund more radical research.

## • What should be the focus be of the new research funding agency and how should it be structured?

18. The new funding agency should focus on radical innovation: setting large scale challenges with ambitious goals at the edge of possibility, where innovation is the only solution. These challenges would be underpinned by clearly defined technical problems, which gradually push the boundaries of possibility in order to progress towards delivering solutions to the customer. Fundamental research is not viewed as the primary focus, rather a rich base to draw from to integrate and drive development towards application.

19. Radical innovation is high risk high reward, delivering disruptive, beneficial outcomes and step changes in technology that reverberate far across society. There may be a high failure rate due to the difficulties of solving such ambitious challenges, but when these are solved, massive waves of technology can be unlocked and reverberate well beyond the original remit of the programme. DARPA programmes are credited with developing the precursors to the internet and GPS, for an example of the scale of radical innovation<sup>20</sup>.

20. The US ARPA model presents a number of key operating principles credited in the discussions held by the Academy for delivering successes in high risk high reward research and technology funding<sup>21</sup>:

- The customer provides a pull as an end-user for the technology solution being developed and is prepared to try new innovative solutions in the early stages of development. It cements the challenge into reality and provides real-world testing environments for translation into application. The scale and nature of the challenges mean that government and public procurement or industrial sectors

<sup>&</sup>lt;sup>19</sup> Royal Academy of Engineering, <u>Innovation in a crisis: webinar series</u>, ongoing.

<sup>&</sup>lt;sup>20</sup> About DARPA [Accessed June 2020]

<sup>&</sup>lt;sup>21</sup> Azoulay, P., Fuchs, E., Goldstein, A. P., & Kearney, M. (2019). <u>Funding breakthrough research:</u> promises and challenges of the "ARPA Model". Innovation Policy and the Economy, 19(1), 69–96.

are often the customer. The market is not always the primary target, there are however means to exploit commercial opportunities as they arise.

- High calibre programme managers with technical expertise and experience are given the opportunity to apply their knowledge and abilities to define and solve ambitious challenges<sup>22</sup>. 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 prioritise and reallocate funding to strategically drive the project forward at pace. They are deliberately strictly time-limited in their posts to introduce new ideas and respond to developments in research and technology. The US has a public sector research laboratory network from which these programme managers are often hired, and then return to, though many have also come from industry. The attractiveness of the role and ability to hire these experienced people is crucial to the success of the programmes.
- Independence and autonomy: programme managers have the freedom and flexibility to make rapid decisions, including on allocation and release of funds. The funding is responsive and covers the entire project costs: available to encourage progress, willingly and quickly withdrawn if projects are not advancing. With this model, consideration should also be given to the implications of the sudden withdrawal of project funding on staff and careers in universities.
- Freedom to fail: ambitious high risk-high reward projects require large amounts of funding with the freedom to fail. Project failure needs to be a recognised and accepted risk, especially as the outputs from 'unsuccessful' projects may still be exploited outside the project and produce value. If too many projects are successful, the ambition and risk-reward level of the challenge could be questioned. The beneficial outcomes of projects for wider consumers may often not be measurable for 10 to 50 years.

21. Consideration should be given to the ownership of intellectual property and recognition of ideas, including clear protocols for exploitation, such that they incentivise the ultimate aim of the agency – radical innovation.

22. To realise this vision of a new high-risk high-reward funding agency, significant culture change will be needed. The UK has tried before to implement these principles for ambitious, autonomous and fast-paced innovation funding. One such examples is the Industrial Strategy Challenge Fund (ISCF), which was set up in 2016 by the UK government to 'draw on the experience of the US Defense Advanced Research Projects Agency (DARPA) programme'<sup>23,24</sup>.

23. There is value in understanding and learning from the experience of the ISCF and what a new funding agency may have to grapple with. The ISCF is seen as a step in the direction of an ARPA-like model, and some have described it as a 'culture shock' to the parts of the UK research and innovation communities, including universities. However

<sup>&</sup>lt;sup>22</sup> About DARPA [Accessed June 2020]

<sup>&</sup>lt;sup>23</sup> HM Government, <u>Building our Industrial Strategy Green Paper</u>, 2017.

<sup>&</sup>lt;sup>24</sup> HM Government, <u>Industrial Strategy: building a Britain fit for the future</u>, 2017.

more autonomy, risk-taking, speed and independence from HM Treasury and ministerial control than is currently seen in research and innovation funding is critical. It was perceived that in order to get HM Treasury funding approval, it was necessary to remove as much risk as possible. The Challenge Directors lack the level of autonomy and flexibility given to ARPA programme managers. ISCF moved fast for the UK funding environment, but did not reach the same speed and agility as ARPA, particularly because of the perception or desire to manage these through conventional routes of competitions.

24. ARPA-type challenges are set by the programme managers, taking full advantage of their skills and experience. They typically spend 12-18 months researching and defining their programme<sup>25</sup>. This is an element that is missing from ISCF where the Grand Challenges were set ahead of the recruitment of Challenge Directors. In some cases, ARPA does provide an overarching direction to the challenge directors by focusing on specific sectors for example defence or electronics. In this case, a suggested focus for a UK ARPA would be the construction sector and net zero.

25. Industry sector-led bodies, such as the Advanced Propulsion Centre and the Aerospace Technology Institute, are other examples to learn from. These organisations bring together programmes and partners to address the strategic R&D challenges of the sector, responding to a 'customer' pull akin to the ARPA model.

26. Diversity and inclusion should be embedded within the agency and its ways of working to ensure wider benefits<sup>26</sup> for the organisation.

### • What funding should ARPA receive, and how should it distribute this funding to maximise effectiveness?

27. With the economic impact of the pandemic still to be fully seen, the launch of a new funding agency would demonstrate the ambition and the strength of the government's support to increasing R&D investment in the UK. However, a new funding agency should not happen at the detriment of existing bodies and funding initiatives which provide wider economic benefits to the country.

28. Substantial resources is a key characteristic of DARPA programmes. A pilot programme should be strategically scaled and focused on well-selected challenges. The costs of R&D vary significantly across sectors, and the ability of a new funding agency to deliver radical innovation will depend on being appropriately funded.

29. The UK government has proposed a budget of £800 million over five years, or an average £160 million per year, to support this new funding agency<sup>27</sup>. This budget is relatively small compared to other funding agencies and the potential high cost of an ambitious innovation programme. It would be more effectively spent on a small number of projects receiving ample funding. For comparison, DARPA has grown to maintain an annual budget of \$3.5 billion for about 250 research and development programmes or

<sup>&</sup>lt;sup>25</sup> Azoulay, P., Fuchs, E., Goldstein, A. P., & Kearney, M. (2019). <u>Funding breakthrough research:</u> <u>promises and challenges of the "ARPA Model"</u>. Innovation Policy and the Economy, 19(1), 69–96.

<sup>&</sup>lt;sup>26</sup> Royal Academy of Engineering, <u>Why is D&I important?</u> [Accessed 23/06/2020]

<sup>&</sup>lt;sup>27</sup> Budget 2020, 11/03/2020.

approximately \$14 million per programme per year<sup>28,29</sup>. UKRI had an annual budget of  $\pounds$ 7.4 billion in 2019/2020<sup>30</sup>. The first two waves of ISCF funding amount to 84% more than proposed for the new funding agency, over a shorter period of time, with a budget of £986 million for 497 projects and £488 million in private match-funding<sup>31</sup>.

30. ARPA-type funding models provide full programme costs. Many UK funding programmes involving businesses require match funding and research grants generally cover 80% of costs. A departure from match funding requirements in the UK would be a significant change. Private match funding presupposes the existence of a commercial customer. Many of the challenges which an ARPA model could be used to solve may not always have a clear existing commercial customer. Alternatively, a process including government contracts may be a means to encourage private match funding.

31. Significant change from the value for money concept deeply embedded in UK research and innovation funding structures would be needed for radical innovation. The value for money assessments for disruptive innovation may not be assessed until 10 to 50 years later. A longer-term outlook will be needed or alternative approaches to assessing value, for example as a means to build capability, both in technology and skills and include projects deemed unsuccessful in achieving their goal but which will have most certainly produced outputs of value.

32. The capability of the people and the facilities contributing to innovation activities is a key and valuable output. In the process of progressing a project, whether the outcome is successful or not, the people involved will have developed skills, knowledge and expertise on the topic. There may also be spill-over effects, whether in new ideas or technological developments from the project. Much is learnt in failure and could be both captured and valued.

#### • What benefits might be gained from basing UK ARPA outside of the 'Golden Triangle' (London, Oxford and Cambridge)?

33. An ARPA-type funding model is driven by the skills and capabilities of participants, rather than a place-driven initiative. Different skills and expertise exist across different parts of the UK; the geographical distribution of funding by a UK ARPA and associated benefits will depend on the nature of the projects and must be driven by maximising the chances for the projects to be successful. Furthermore, a pilot scheme does not necessarily call for new infrastructure and may not require a centralised structure

34. However, it is well established that public R&D funding is heavily imbalanced across the UK, with London and the South East disproportionately benefiting compared to the other regions.<sup>32</sup> The geographical distribution of funding and benefits, as well as the role devolved and local governments could play in governance structure, could be included as part of the assessment and lessons learnt from the pilot.

<sup>&</sup>lt;sup>28</sup> Budget [Accessed June 2020]

<sup>&</sup>lt;sup>29</sup> About DARPA [Accessed June 2020]

<sup>&</sup>lt;sup>30</sup> BEIS, <u>The allocation of funding for research and innovation</u>, 2018.

<sup>&</sup>lt;sup>31</sup> <u>Industrial Strategy Challenge Fund</u> [Accessed June 2020]

<sup>&</sup>lt;sup>32</sup> NESTA, <u>The missing £4 billion</u>, 2020.