Delivering a UK science and technology strategy

House of Lords Science and Technology Select Committee

Submission from the Royal Academy of Engineering – 25 March 2022

The Royal Academy of Engineering welcomes the opportunity to submit evidence to the House of Lords Science and Technology Committee's inquiry into delivering a UK science and technology strategy. 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.

What would it mean for the UK to be a "science superpower"?

1. The UK needs to be an engineering and technology superpower, not just a science superpower. As well as generating the ideas and research, we also need to deliver them to application, to create revenue from new products and services, and improve quality of life, and protect the security, health and wellbeing of the public. Support for the science base is necessary but not sufficient – engineering and technology that exploit excellent UK research will make the difference between a global leader in research and the substantial socio-economic and security benefits of exploiting R&D. This means testing and developing new technologies and innovations in the UK, leveraging private R&D investment, helping businesses grow and deploying innovations to get first mover advantage, including through public procurement.

2. The government's Integrated Review sets out the ambition to realise UK strategic advantage through science and technology. This strategic approach is presented as all-encompassing, with a long-term view on technology development, driving economic benefit from commercialisation of new technologies, delivering solutions to societal challenges, and guaranteeing national security. We welcome and encourage the consideration of the research, innovation and skills ecosystem in the round, as it is essential to achieve and sustain these ambitions.

3. A UK science and technology strategy should be outcome-led. We propose that by 2030:
    - R&D and innovation underpin the UK's long-term strategy for prosperity and an inclusive economy.
    - Government is taking a systems approach to deliver the strategy, working with effective join-up across departments and extensive engagement with the public, private, third sectors.
    - Government is making informed strategic choices and setting priorities on matters relating to technology and acts as an early adopter where appropriate, drawing on a deep understanding of the innovation system, researchers and businesses' experiences and expertise, and the capabilities needed to commercialise innovation.
    - The UK has a thriving innovation ecosystem, growing and scaling the leading innovative businesses of the future that drive a globally competitive high-skill low-carbon economy.

- The UK is a partner of choice for international collaboration.
- The UK is a driving force in international discussions setting out standards and regulations, safeguarding the security and prosperity of the UK.
- The UK government is applying a strategic long-term approach to skills, planning and working with industry to grow diverse UK talent, attract and retain international talent.

Progress towards desired outcomes should be monitored and evaluated against well-defined metrics.

Are the right structures in place in Government to implement a science and technology strategy?

4. The Academy welcomes the creation of the National Science and Technology Council (NSTC), the Office for Science and Technology Strategy (OSTS) and the new National Technology Adviser role. Set up to work across government with involvement of the Prime Minister and Ministers, there is an opportunity to deliver strong leadership and a long-term approach to science and technology across the government and the UK. Transparency on governance, roles and responsibilities will help build confidence and buy-in with the science and technology community, and hopefully endure beyond political cycles.

5. System approaches must be central to the way NSTC and OSTS operate and how they develop and implement a long-term science and technology strategy. Systems approaches bring an understanding of the context in which the system operates, stakeholders in the public and private sectors, and interdependencies. An understanding of the system and its complexity can better inform strategic choices and prioritisation to design and deliver the strategy, building on the UK's strengths, capabilities and address gaps.

6. A coordinated and whole government approach to implementation will be needed to successfully develop and deliver a strategic approach. A multitude of factors influence our ability to be a science, engineering and technology superpower, responsibility for these is spread across the whole of government, hence it's positive that Ministers and officials from multiple government departments are involved. A number of recent and new relevant developments are underway, including technology strategies such as the National AI Strategy, whole of government strategies such as the Levelling Up White Paper and Innovation Strategy and creation of new organisations such as ARIA. With strategic coordination, engagement and alignment across agencies and departments, these different components can be greater than the sum of their parts.

7. Engineering has a key role to play in delivering strategic advantage and should be an important voice in developing and implementing a strategic approach, both as external experts but also within the civil service. Attention should be given to recruitment to the civil service and the number of civil servants with an engineering or technical background, and the level of technical leadership departments have in place to define upcoming challenges and opportunities, to seek out, absorb and use appropriate advice. Continuing professional development also has a part to play for technical roles and technology literacy more broadly across the civil service. There is also a breadth of technical expertise available outside government, in academia, PSREs, industry, finance, that should be used as a valuable resource to draw upon to identify priorities for strategy design and implementation.

8. Engineering companies find strategic engagement across UK government organisations frustrating and fragmented; this makes the UK less attractive to invest in R&D.[1] The strategy should be user focused, considering the wider stakeholders in the private sector, including those beyond the usual suspects, that will be crucial for successful implementation.

9. It is crucial that a strategy builds on a deep understanding of the structures, processes, institutions that already work and have enabled success as well as those that created barriers. Lessons and good practice should be drawn from previous initiatives such as the Industrial Strategy, Industrial Strategy Challenge Fund and Global Grand Challenges.

10. A strategic approach to skills, ensuring appropriate skills development, diversity and numbers at the right stages of technology development, is key to delivering strategic advantage and successful innovation outcomes. We need a skills system that considers and can intervene in long-term skills supply aligned with government growth ambitions and infrastructure projects, alongside meeting immediate local employer needs. This strategic alignment of technology, skills and supply chain development will reduce innovation lead times, promote productivity and create a systems level response to current and future challenges. This system needs to be agile and responsive, consider skills in the round including graduates, apprenticeships and adult learning, and be based on a future understanding of workforce capabilities.

Does the introduction of a science and technology strategy challenge the Haldane principle and UKRI's commitment to fund outstanding research?

11. A government science and technology strategy must set direction and ambitions for the UK. Strategic advantage through science and technology goes far beyond research funding decisions and encompasses development and innovation towards particular policy goals. The Haldane principle, which applies to research funding decision, is not jeopardised by a strategic and systems-based approach.

12. The UK research base is a clear national asset and its strength should be maintained. High quality research, access to skilled people and the ability to collaborate with universities are key factors in attracting business R&D investment.[2,3] It will always be important for UKRI to continue to fund outstanding research as guided by the Haldane principle.

Is the UK realising the potential of its research investment?

13. UK research is excellent, globally leading in several areas. We should continue to support and strengthen UK research; maximising benefits generated will enable us to do so. More can be done to realise the potential of UK research, key areas for improvement are set out below (14-17), noting that this is not an exhaustive or comprehensive list.

14. The high quality of UK academic research and the ability to collaborate with universities are key factors in attracting R&D investment to the UK. More business-university interactions should be facilitated, as well as translation, diffusion and talent mobility between academia and industry. Recommendations from the Dowling Review of business-university

[1] Increasing R&D investment: business perspectives, National Engineering Policy Centre (2018).
[2] Increasing R&D investment: business perspectives, National Engineering Policy Centre (2018).
[3] Late-stage R&D: business perspectives, National Engineering Policy Centre (2021).

research collaborations should be implemented.[4] Successful recent and existing schemes should be restarted or expanded, including the Catalysts, CASE studentships and the KTPs.

15. Applied research plays an important role, linking research with innovation, and should be an important mechanism in the delivery of this strategy. The perception in the engineering community is that applied research is given lower priority than discovery research and innovation; an effective balance is needed. As novel technologies such as machine intelligence become deeply embedded across numerous fields of engineering, applied research is necessary to understand unintended risk or unappreciated opportunities, is vital to safe exploitation of technology, and can help identify new research challenges.

16. Spinouts form an important way of deriving impact from the research base and could be the scale-up companies and leading businesses of the future. Based on the experience of spinouts supported by the Academy's Enterprise Hub[5], changes that would increase likelihood of success include: division of equity that incentivise exceptional academic founders to drive their company forward, reflecting support provided by the university; relevelling information asymmetry on the spin out process to ensure academic founders aren't disadvantaged when entering negotiations; support for universities to resource their technology transfer offices for success in knowledge exchange.

17. Without a healthy ecosystem and support, deep tech companies risk moving elsewhere to grow. The UK is good at creating spinouts and start-ups, but much less at enabling them to grow here.[6,7] Challenges include lack of patient capital and finance for capital expenditure, skills shortages, and a culture accepting failure as part of the path to success.

How should state funding for research and development be allocated between different organisations, who should make that decision and by what criteria?

18. A diversity of funding mechanisms and approaches is required to support the research and innovation base. The choice of mechanism should be tailored to the desired outcome and stakeholders, with transparent and timely administrative processes proportionate to the level of award, with join-up across various mechanisms for a viable, supportive ecosystem. New approaches to funding should be trialled and evaluated for faster rates of innovation, with lessons shared widely for improvement across funders, including UKRI and ARIA.[8]

What more should be done to encourage private sector investment in research and development in the UK?

19. Increasing business investment in R&D is critical to reach the target of 2.4% GDP invested in R&D, much improvement is here if we are to succeed. Businesses are essential delivery partners for this strategy. All R&D carries multifaceted risk, arising from the scale of the technical challenge, cost, timing, market opportunity, competitive environment and other barriers to commercialisation. Business R&D delivers shared socio-economic benefits with new products, processes and technologies – there is a compelling case government should

[4] The Dowling Review of business-university research collaborations (2015).
[5] About us, Royal Academy of Engineering Enterprise Hub. [Accessed online on 02/03/2022]]
[6] Spotlight on Spinouts 2021, Royal Academy of Engineering & Beauhurst (2021).
[7] Evidence for the UK Innovation Strategy, BEIS (2021).
[8] Radical innovation, Royal Academy of Engineering (2019).

share the risk of R&D with businesses too. To fulfil its ambitions, the UK government must make the UK a more attractive environment for businesses to invest and conduct R&D in.

20. R&D is global, and businesses' investment decisions, both large multinationals and small mobile high-tech companies, are not limited by borders, including businesses already in the UK. The UK has a much higher proportion of business R&D financed by the rest of the world than peers, nearly double the proportion in France or Germany, and a lower proportion of R&D funding going into late-stage development, compared to the US, Israel or Japan.[9] While success in attracting FDI should be recognised, the globally competitive environment should not be overlooked. There is a choice to be made: enable companies to take bold risks here, or they will go elsewhere. Innovation will happen irrespective of the UK's policies, what is at risk is the UK's ability to drive and benefit from it.

21. In a series of interviews, those responsible for R&D decisions in engineering businesses across the UK[10] identified strengths to build on, including collaboration with universities and between businesses, innovation funding, tax incentives and non-financial support. Areas where the UK performs poorly relative to other countries, with potential to transform business R&D investment, are late-stage development, public procurement, joined-up government, ownership and financial structures, innovation in engineering services and across sectors.

22. Late-stage R&D is a key part of the innovation process, taking a proof of concept or prototype through to commercial application, and is the majority of R&D that businesses do. We identified five key common resources essential for conducting and managing the risks associated with late-stage R&D: R&D infrastructure, investment, people, partnerships and market environment.[11] Government can influence these resources to encourage business R&D investment, bringing returns and socio-economic benefits to people in all parts of the UK, beyond the individual business contributing to growth in the local area, with tradeable solutions, new markets and jobs, increased productivity.[12] Government should:

- Target support for late-stage R&D, including through co-designed industry-led programmes building on the success of the Aerospace Technology Institute.
- Strengthen and scale existing initiatives and infrastructures that support late-stage R&D, including with the uplift in Innovate UK's budget and by promoting and supporting strategic innovation infrastructures such as the NPL and Catapult Centres.
- Signal to the world the UK is the place for businesses to undertake late-stage R&D and unleash innovation with clear signposting of the UK offer.

23. Public procurement is an under-leveraged tool in the UK's innovation ecosystem, a long-identified challenge with known solutions that require real commitment from government to address.[13,14] It has the potential to transform companies' investment in R&D in the UK, stimulate innovation, business growth and adoption across supply chains. Government can provide the pull-through to stimulate greater market uptake and deliver best value to the

[9] Main Science and Technology Indicators, OECD (2021).
[10] Increasing R&D investment: business perspectives, National Engineering Policy Centre (2018).
[11] Late-stage R&D: business perspectives, National Engineering Policy Centre (2021).
[12] Late-stage R&D: business perspectives, National Engineering Policy Centre (2021).
[13] Public projects and procurement in the UK, Royal Academy of Engineering (2014).
[14] Consultation response: transforming public procurement, Royal Academy of Engineering (2021).

public purse. Leadership and action are critical to change culture across government, embed openness to procure innovation and act as early adopter.

How well does the UK collaborate on research with international partners and what can it learn from other countries?

24. R&D and innovation underpin the ambitious, global vision for the UK as an outward-looking leading trading nation and choice destination for inward investment and talent, drawing on the UK's credentials as a leader in engineering, research and innovation. Succeeding as a science superpower won't happen in isolation; collaboration is essential. Support is needed to help researchers and businesses navigate legislation such as the National Security Investment Act or ITAR in the US.

25. EU research and innovation programmes are unique in the scale and scope of the support they provide for multinational cooperation and large-scale international collaborations. The UK should seek the closest achievable association to Horizon Europe.

26. The UK has typically not delivered many strategically focused large-scale research and innovation collaborations. A recent exception to this is the Newton and Global Grand Challenges Fund programmes, now cut, that strategically drove significant expansion in research partnerships with the world's fastest developing economies. Policy and priority changes, and oscillating budgets damage trust and aren't conducive to being a partner of choice.

27. International collaboration brings significant advantages to research and innovation activities and may be more appropriate than competition, including for: economies and practicalities of scale (e.g. large scale research infrastructure such as CERN and demonstration facilities); collaborations for areas with UK strengths across other parts of the innovation landscape and supply chain to deliver socio-economic benefits of innovation; blue skies research to rapidly build on key breakthroughs in international research.