



Strategic advantage through science and technology: the engineering view

Summary

Given the increasingly critical and integral role of science and technology (S&T) in determining the nation's future it is necessary to consider if the UK's current approach to harnessing S&T is fit for the scale of need and national ambition. We believe it has not been to date and that there is much work to do to achieve this. The UK government has also recognised the need for change, as demonstrated by its recently published Science and Technology Framework¹.

Engineering harnesses the power of S&T to deliver tangible, real-world outcomes which benefit the UK. Capturing themes and reflections from the engineering community, here we set out: why we believe pursuing strategic advantage through S&T is essential and why now; our vision for achieving it; and where we believe that radical change is needed.

Strategic advantage through S&T:

Science and technology being harnessed purposefully to achieve defined outcomes for security, prosperity, resilience, international influence, and people and environment, with the aim of conferring comparative advantage for the UK.

Tensions and trade-offs will inevitably arise when choices are made on the outcomes we want to achieve for strategic advantage. Understanding and managing the tensions and trade-offs are integral to the strategic advantage approach and set it apart from 'business as usual'.

What does it take to achieve strategic advantage from S&T in the UK?

◆ **A comprehensive and strong research and innovation (R&I) system**, that spans research and development through to technology deployment and adoption, and acts as the foundation and fuel from which strategic advantage can be achieved.

◆ **Strategic direction** from informed choices about the outcomes and advantages the UK wishes to achieve by harnessing S&T, made by leaders who set out a plan for delivery and direct resources to achieve it, where impact may be far off, uncertain and require significant investment, and where multiple stakeholders and systems will need to be involved. Strategic direction elevates being good at doing S&T to reaping the benefits from harnessing S&T.

A systems approach where innovation policy is integral to all government departments.

A public sector that is confident and proactive in managing the risks associated with late-stage R&D and market creation when in pursuit of strategic advantage. Close-to-the-market interventions also mean creative and coordinated actions around demonstration, follow-on funding, infrastructure, manufacturing, procurement, standards and regulation, and technology adoption.

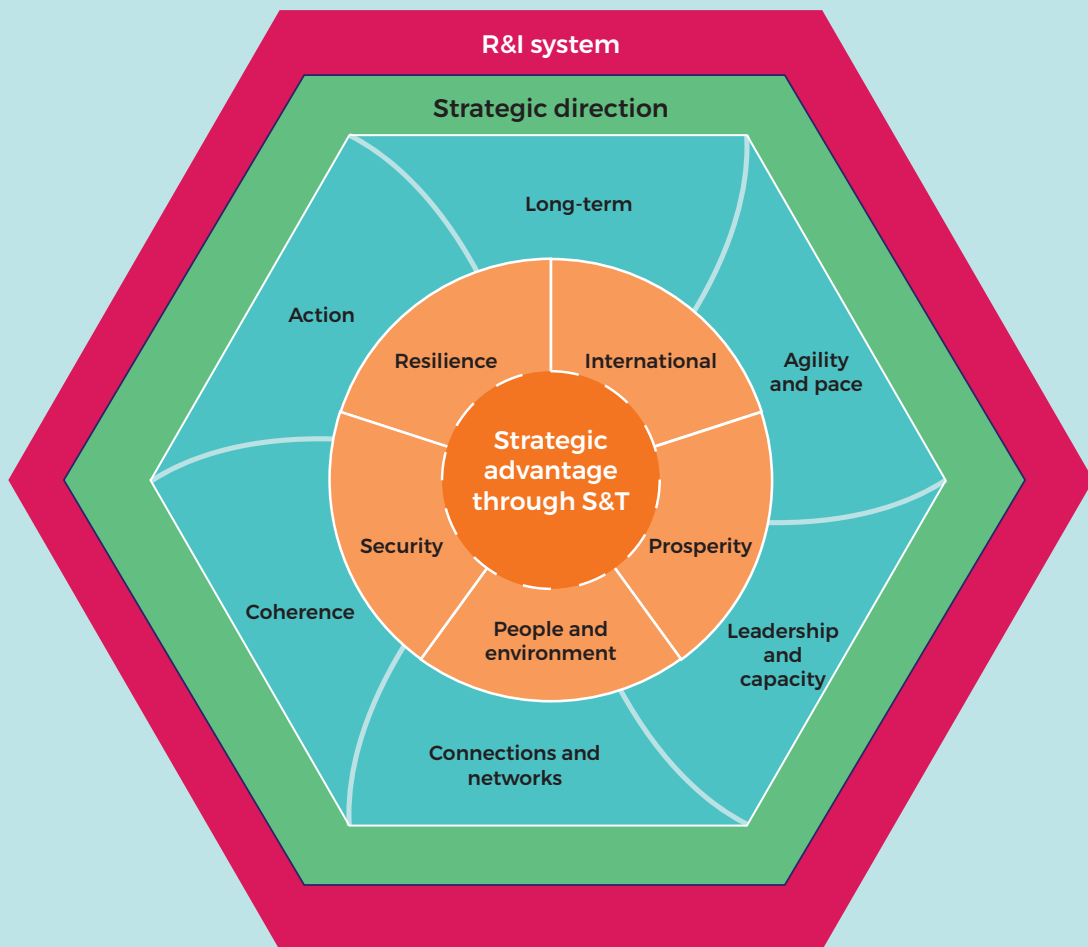


Figure 1: Strategic advantage through science and technology – types of strategic advantage and principles and pre-requisites underpinning it

Six principles for deeper consideration when implementing strategic direction in pursuit of advantage:



Long-term – long-term strategic direction, longer-term budgets, durable institutions and stability to enable the R&I system to deliver and provide confidence for businesses to thrive.



Agility and pace – act at pace and modify priorities when needed to make the most of newly emerging opportunities, address new threats, deploy resources well, operate at timescales that work for business, fail fast, and compete globally.



Leadership and capability – trusted and capable leadership, empowered to make decisions at pace, deploy resources and accept and learn from failure to deliver the broad and complex strategic advantage through S&T agenda.



Connections and networks – a ‘connect and convene approach’ that engenders a sense of ownership and commitment, with improved interfaces between government and business and optimised role for the networks and organisations that aid permeability such as public sector research establishments and catapult centres.



Coherence – coherent and sustained strategies and policies that align actions across regulation, funding, infrastructure and skills.



Action – interventions that accelerate progress towards outcomes and deliver results from strategies.

Our next phase of work will explore what it takes to bring these principles into operation successfully, looking in detail at the realities, tensions and trade-offs in achieving strategic advantage.

Strategic advantage through S&T: the engineering view

We believe it is imperative for the UK to harness S&T, so that it is a driving force for strategic advantage. This is an aspiration shared with the UK government, as outlined in the Integrated Review² and Science and Technology Framework¹. This position paper looks to the future and considers how to make this aspiration a reality.

Here we set out: why we believe pursuing strategic advantage through S&T is essential and why now; our vision for achieving it; and where we believe that radical change is needed.

We capture themes and reflections from the engineering community³. The very nature of the community means that it has extensive experience of harnessing S&T, working across disciplines and industries to integrate solutions and strategically shaping technology development for future needs.

Why change is needed

We are in a period of significant geopolitical instability with the consequent uncertainty and unpredictability of future events. As examples, the war in Ukraine, changing relations with China and the COVID-19 pandemic have all recently challenged the UK's resilience on a very broad front.

S&T also continues to advance rapidly with the speed of development and adoption of new technologies. This is enhanced by global efforts to solve emerging problems and exploit new opportunities, alongside the growing bodies of S&T knowledge that are increasingly open to all.

These complex and interconnected geopolitical, social and technological changes are challenging long-held norms, revealing vulnerabilities and presenting new potential threats. Such developments highlight the need for broader national resilience to threats that impact our security and ability to address societal, economic and environmental challenges. However, there is another side to the overall challenge and that is to be prepared and ready to grasp opportunities to increase well-being, quality of life and prosperity. Given the UK's productivity track record, increasing economic growth must also be a priority.

S&T are integral to addressing these challenges. From the rapid development and deployment of COVID-19 vaccines to the role of satellite communications in the war on Ukraine, to looking to the future and the potential role of quantum technologies in national security and opportunities to become market leaders in net zero solutions.

“Technology, statecraft, security and economics are entangled and mutually dependent”

Sir Jeremy Fleming KCMG CB, Director, GCHQ - RUSI Lecture, October 2022

Given the increasingly critical and integral role of S&T in determining the nation's future we must consider if the UK's current approach to harnessing S&T is fit for the scale of need and national ambition. We believe it is not. S&T can no longer be considered in isolation.

Our vision

Strategic advantage through S&T:

S&T being harnessed purposefully to achieve defined outcomes for security, prosperity, resilience, international influence, and people and environment; with the aim of conferring comparative advantage for the UK.

This is strategic advantage through S&T. Action taken in pursuit of outcomes, beyond S&T for its own sake, where outcomes outline the kind of country we want to build with S&T.

Advantage can be considered within five broad categories:

- 🕒 **International:** the UK is a partner of choice for mutually beneficial collaborations and is influential in global technology development through international standards and regulations.
- 🕒 **Prosperity:** companies and industries are growing across the UK, creating skilled jobs and holding key positions in global value chains and markets, because of innovation strengths and technology adoption.
- 🕒 **People and environment:** the UK delivers sustainable and inclusive solutions for societal and environmental benefit.
- 🕒 **Security:** the UK stays aware of threats and ahead in technologies important to UK security, including through sovereign capabilities when necessary.
- 🕒 **Resilience:** S&T capabilities to anticipate, resist, absorb, recover, and adapt to shocks and stresses in the system with agility to enable continuity of delivery of critical needs such as safety, food, energy, and healthcare.

These different types of advantage have complex interdependencies and can't be considered in isolation. For example, becoming a market leader in quantum computing may deliver advantages in security, prosperity and international. More likely is that trade-offs will be required, for example if reshoring is needed in the pursuit of sovereign capabilities to achieve outcomes in security, there may be unfavourable international impacts.

Tensions and trade-offs will inevitably arise when choices are made on the outcomes we want to achieve for strategic advantage. Understanding and managing the tensions and trade-offs is integral to the strategic advantage approach and sets it apart from 'business as usual'.

There are two essential prerequisites to harness S&T to deliver strategic advantage:

🔷 Comprehensive and strong R&I system

The enabling environment for science, engineering, and technology. It is a complex system comprising multiple stakeholders and organisations who do, direct, enable and fund R&D and innovation across all disciplines and industries. A well-resourced and connected R&I system, which spans research and development through to technology deployment and adoption, and acts as the foundation and fuel for which strategic advantage can be achieved. While the UK needs to improve its enabling environment for S&T [[Box 1 sets out further thinking on the UK's R&I system](#)], a comprehensive and strong R&I system is necessary, but not sufficient to achieve strategic advantage through S&T.

🔷 Strategic direction

Informed choices about the outcomes and advantages the UK wishes to achieve by harnessing S&T, made by leaders who set out a plan for delivery and direct resources to achieve it. Multiple stakeholders and systems are needed to support strong leadership to make informed decisions to set goals that will determine our future and courses of action where impact may be far off, uncertain and require significant investment and long-term commitment. Strategic direction provides the foundation for harnessing strategic advantage through S&T by elevating being good at doing science and technology to reaping the benefits from harnessing S&T.

A comprehensive and strong R&I system is often presented as being in tension with pursuing strategic direction, as the latter requires prioritisation and choices, while the former can be seen as discipline and technology agnostic⁴. We think this tension is overplayed. Tensions and trade-offs are inevitable for strategic advantage as choices and priorities must be made, and not everything can be a priority. It is hard to do well, but that doesn't mean it isn't worth doing.

“Advances and research to such an extent that the UK leads and defines the future for itself as well as others”

Workshop participant

“Strategic advantage should bring agility and resilience to the whole ecosystem – joining dots between different stakeholders, instigating and nourishing corporate memory, lesson sharing and tolerating risks and failures”

Workshop participant

The current situation

Competitors, collaborators and adversaries are implementing ambitious plans to achieve strategic advantage for themselves.

The government's welcome ambition to achieve strategic advantage through S&T, as well as its science superpower and innovation nation objectives, have been accompanied by machinery of government changes to support delivery [[Box 2 sets out recent changes to the government's approach to strategic advantage through S&T](#)]. S&T policy approaches need to reflect the current R&I ecosystem, including its interconnectedness, the pace of technology development, and its strengths and weaknesses. These changes must guard against recent trends towards short-termism, inaction, and changing priorities⁵. Radical change to the way we approach and harness S&T is needed⁶.

“Lack of specialist knowledge and advice, lack of unified approach and timings tied to political cycles (too short)”

Workshop participant

“S&T is a global endeavour, encompassing both collaboration and competition”

Integrated Review²

Radical change

If the UK is to effectively harness S&T, two long-held norms that underpin our current approach need to be challenged:

- **The positioning of innovation in UK policy priorities.** Innovation and S&T are integral to many UK priorities, from security to health and social care, from international partnerships to economic policy. Similarly, many of the policy levers that influence businesses' appetite and ability to innovate are spread across the whole of government, from immigration policy in the Home Office, to export in the Department for Business and Trade, and R&D tax reliefs in HM Treasury and HMRC. The creation of the Department for Science, Innovation and Technology demonstrates the importance to government of innovation policy, but a systems approach is needed, where innovation policy is integral to all government departments.
- **The timing of public sector intervention in R&D and innovation.** Governments often play a significant role in funding discovery research⁷. This is something the UK government does well. As S&T activities get 'close to the market' the private sector is expected to take on more of the funding and risk, as it is more likely to be the beneficiary. However, there is a compelling case for the public sector to provide more support to manage the risks associated with late-stage R&D and market creation – the socio-economic benefits from the new products, processes, services and technologies are shared, so the risk must be too. This case is arguably stronger when in pursuit of strategic advantage and in the face of interventionist global competition. Interventions closer to the market does not necessarily mean intervening in markets. It also means creative and coordinated actions around demonstration, follow-on funding, infrastructure, manufacturing, procurement, standards and regulation, and adoption.

“Businesses are good at optimising around a technology, but less good at quantum leaps”

Workshop participant

Therefore, achieving strategic advantage through S&T requires S&T policy to be integral to all government departments and creative interventions 'close to the market'.

We've identified six principles that must underpin the approach to strategic advantage. While they have a superficial simplicity there are inherent complexities, not least in implementation. They are also interlinked and, in some cases, conflict. Applying these principles to pursue a strategic direction requires discernment about when and how each principle should be implemented, and what the trade-offs might be. This overview of the principles is high-level and we have given some examples of where the principles have previously been applied well or otherwise. The next phase of this work will look closer at the reality of implementing these principles.

Six principles that must underpin the new approach:



Long term – setting the strategic direction to deliver a future the UK wants means planning for the long-term and sticking to that direction. S&T is a long-term endeavour. It takes time for new discoveries to be commercialised, for new industries to grow, and for existing industries to adopt new innovations. Harnessing S&T will mean taking action now where returns will not be seen in the immediate future. ‘Long term’ in this context also means ‘beyond five year political cycles,’ longer-term budgets, durable institutions, and stability to enable the R&I system to deliver and provide confidence for businesses to thrive.

Exemplar: Aerospace Growth Partnership and Aerospace Technology Institute – A long-term policy priority from government realised by long-term funding commitments.

“[The] UK needs to back the technologies the world will need in the future, not continue with what the world wants”

Workshop participant

“Investment in infrastructure and public procurement as a lever to leverage smartly to provide long-term incentives for industry to invest in the right way.”

Workshop participant



Agility and pace – to make the most of newly emerging opportunities, address new threats, deploy resources well, operate at timescales that work for business, fail fast, and compete globally, the UK needs to be able to act at pace and modify priorities when needed. This may seem paradoxical to the ‘long-term’ and ‘stability’ requirement, but it isn’t. Agility will be required within long-term strategic direction without compromising the long-term outcome being pursued. Long-term investment often underpins the ability to change course and respond rapidly, as the UK’s long-term research into vaccines proved when COVID-19 emerged. Expertise is required to assess whether and when changes are needed, so that any changes in direction are informed decisions.

Exemplar: Ventilator Challenge – in response to the COVID-19 pandemic the government called on companies to help manufacture, design and build ventilators for the NHS. The multi-stream approach that government had not attempted before, showed that government procurement could be agile and operate at pace.

“Support from government comes too slowly”

Dr Simon Thomas FEng, Paragraf



Leadership and capability – trusted and capable leadership is needed to deliver the broad and complex strategic advantage through the S&T agenda. Government must own this agenda, ideally with cross-party engagement. Governments are the custodians of the nation’s ambitions, resources, prosperity, security, and wellbeing. However, non-political and expert leadership will also be key when it comes to delivery. Leaders will need to be empowered to make decisions at pace, deploy resources, and accept and learn from failure. Leaders need to have a good understanding of their S&T domain and excellent access to expertise. A lack of S&T capabilities is an ongoing challenge within the UK’s civil service and parliament.

Exemplar: Vaccine taskforce – the taskforce was headed up and populated by individuals drawn from the private sector with expertise in pharma investing. They were empowered to make decisions, take risks and allocate funding.

“To engender a sense of ownership and commitment among those all involved”

Workshop participant

“Bold and courageous leadership to look beyond everyday concerns”

Alison Atkinson FREng, AWE plc



Connections and networks – well-connected communities around a technology or goal can help identify the needs of different stakeholders, opportunities and practical considerations for action, and they can be rapidly mobilised. They provide consistent access to expertise and experience to support informed decision-making. While it is a somewhat simplistic model, the three key interfaces are between industry, academia and government. It is clear that there is more to do to improve these interfaces, especially between government and business. These interfaces need to be relatively permeable, and the networks and organisations that provide a bridging capability, such as public sector research establishments and catapult centres, must be optimised. Improvements to the interfaces between businesses, spanning from micro-SMEs through to large corporates, to facilitate innovation and adoption would also be beneficial. A ‘connect-and-convene’ approach that engenders a sense of ownership and commitment among those all involved is preferable to a ‘command and control’ approach.

Exemplar: VentilatorChallengeUK – consortium of UK industrial, technology and engineering businesses from across the aerospace, automotive and medical sectors that came together to produce medical ventilators for the UK, established through existing connections and networks.



Coherence – coherent and sustained strategies that align actions across regulation, funding, infrastructure, skills and government’s convening power will be needed. Countries around the world are pursuing joined-up approaches to promote growth in priority sectors, like renewable energy generation, semiconductors and green transport, to help them become world leaders in these key industries⁸. Coherence requires extensive engagement and alignment across government departments and agencies, and extensive industry input. Lack of coherence is a weakness of the UK’s system – engineers and engineering companies find strategic engagement across UK government organisations frustrating, fragmented, and not joined-up.

“Policy, network and coordination – to join up the system and work towards well-set goals and strategic direction ‘relay race where you don’t drop the baton’”

Workshop participant



Action – strategic advantage through S&T will not be achieved without action. Action means intervention. Developing strategies or new lists of priority technologies will not effect change if there is no action. Ensuring the enabling environment is excellent, such that we have a comprehensive and strong R&I system, while it will increase the likelihood of harnessing S&T for strategic advantage, it is not sufficient. Choices will need to be made about where to pursue strategic advantage and resources will need to follow.

“It means nothing if you don’t do something”

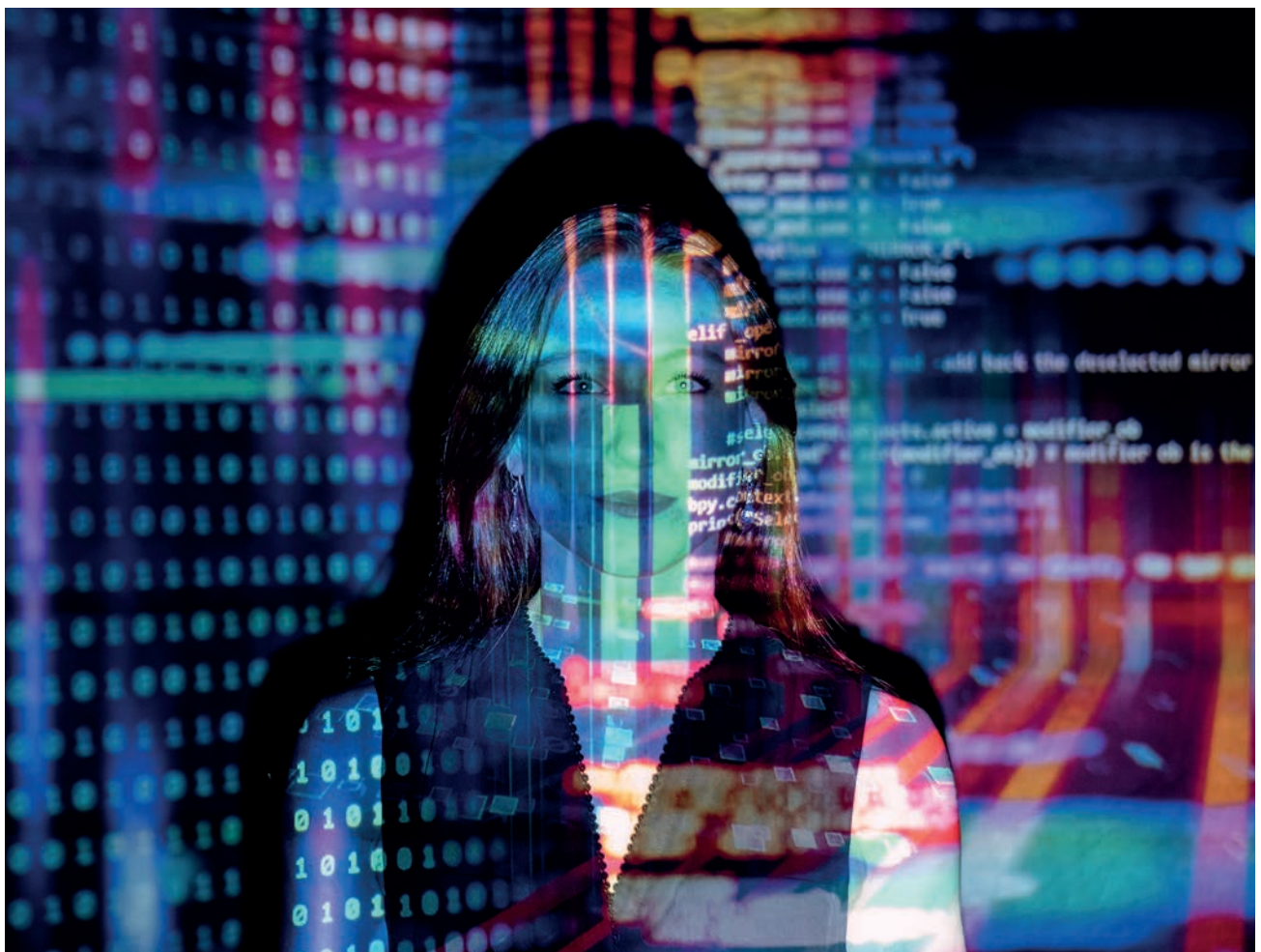
Workshop participant

What next?

Our next phase of work will explore what it takes to successfully operationalise these principles, looking in detail at the realities, tensions and trade-offs in achieving strategic advantage.

In parallel, we will build on our work tackling some of the challenges arising as the UK pursues its strategic advantage through the S&T agenda:

- [Strategic advantage through science and technology: exploring the UK semiconductor innovation system](#) ↗
- [Strategic advantage through science and technology: how can public procurement drive innovation in pursuit of national goals?](#) ↗



Box 1. Comprehensive and strong R&I system

A comprehensive and strong R&I system is necessary but not sufficient to achieve strategic advantage through S&T. The current R&I system in the UK is complex, and at times disconnected, hindering its capacity to reach its full potential. A significant body of work already exists on the strengths and weaknesses of the UK's R&I system and where change is needed. Here we highlight the Academy's key work on this topic.

Late-stage R&D: business perspectives [↗](#), National Engineering Policy Centre (2021)

Nurturing the UK's late-stage R&D will reap considerable rewards. It would enable us to measure up with competitor countries, retain talent and capture the spill-over benefits of our world-class early-stage businesses. It would send a signal to the rest of the world that the UK is a place where bold risks can be taken and nurtured.

- Government and industry should co-design new industry-led programmes, to accelerate R&D in internationally competitive sectors and technologies that are vital to the delivery of national priorities.
- Existing initiatives, institutions and infrastructures that support late-stage R&D should be strengthened and scaled to help businesses strengthen and scale their innovation activities and, in turn, their growth.

Radical innovation [↗](#), Royal Academy of Engineering (2019)

Reflections from the engineering community on what a new UK research and technology funding agency should do.

- 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.

Increasing R&D investment: business perspectives [↗](#), Royal Academy of Engineering (2018)

We identified areas that attract companies to invest in R&D in the UK and areas where improvement is needed:

Building on strengths	Action needed
Engineering workforce	Late-stage development and demonstrators
Innovation funding	Public procurement
Non-financial innovation support	Joined-up government approach
Collaboration with universities	Ownership and financial structures
Collaboration between businesses	Innovation in engineering services
Tax incentives	Innovation across sectors

The Dowling Review of business-university research collaborations [↗](#) (2015)

Strategic business university research collaborations provide a myriad of benefits to their participants. The Academy's then President was commissioned by government to see how such collaborations could be increased and improved.

- Recommendations included measures to increase mobility of staff between universities and businesses, increase recognition and reward of use-inspired research in universities, and to reduce complexity and 'hide the wiring' of the R&I support system so it is easier for businesses and academics seeking support to navigate.

Box 2. Government approach to strategic advantage through S&T

The government first announced its ambition to pursue strategic advantage through S&T in March 2021 as part of the *Integrated Review of Security, Defence, Development and Foreign Policy*¹. Strategic advantage through S&T is defined as taking a more active approach to building and sustaining a durable competitive edge in S&T, to ensure the UK has the tools and influence to shape a future on our own terms. Such an approach is required in a world where S&T is increasingly an arena of systemic global competition. (The Integrated Review Refresh was published on 13 March 2023.)

To enable the UK to achieve strategic advantage through S&T the National Science and Technology Council (NSTC), chaired by the Prime Minister, was established in June 2021 along with the Office for Science and Technology Strategy (OSTS), located in the Cabinet Office, and the creation of the National Technology Advisor (NTA) role. The first NTA was Sir Patrick Vallance HonFREng FRS FMedSci, who was simultaneously the Government Chief Scientific Adviser. The NSTC was demoted from a Cabinet Committee during Liz Truss' premiership but was reinstated and is being chaired by the current Prime Minister Rishi Sunak.

Over summer 2022 the OSTs ran a number of engagement activities with the S&T community and technology prioritisation work is underway.

On 7 February 2023, the Department for Science, Innovation and Technology (DSIT) was established, with the Secretary of State confirmed to attend Cabinet. NSTC will remain a Cabinet Committee, and the majority of the OSTs functions move to DSIT.

On 6 March 2023, DSIT launched a new Science and Technology Framework¹. The Framework outlines a strategic vision for positioning the UK at the forefront of global science and technology by 2023 and sets out ten actions. The first is 'Identifying Critical Technologies', with the vision that "the UK has a track record of defining, pursuing and achieving strategic advantage in prioritised areas of S&T application to deliver prosperity and security for the UK on our own terms and deliver benefits to global society". The five critical technologies in focus are: AI, engineering biology, future telecommunications, semiconductors and quantum technologies. The other levers set out in the Framework will be used to "create the environment for these technologies to flourish in the UK". The OSTs team is dedicated to driving progress on the Framework across government.

Members of the working group:

Dr Dame Frances Saunders DBE CB FREng – Chair
Professor Dame Helen Atkinson DBE FREng
Professor Charles Baden-Fuller FBA
Elspeth Finch MBE FREng
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Dr Nick Starkey – Director, Policy & International

References

- 1 *Science & Technology Framework – taking a systems approach to UK science & technology*, DSIT, March 2023.
- 2 *Global Britain in a Competitive Age: the Integrated Review of Security, Defence, Development and Foreign Policy*, HMG, 2021. *Integrated Review Refresh 2023: Responding to a more contested and volatile world*, HMG, 2023.
- 3 A series of workshops and events with the engineering community and key stakeholders were held in June 2022. 56 stakeholders participated, including eight innovative SMEs, 15 large businesses, academics, and others from public sector research establishments, the finance community, professional engineering institutes and think tanks.
- 4 *Creating, not picking winners: How to develop an industrial strategy which works for everyone*, Chris White and Benedict Wilkinson, Kings College London, November 2017.
- 5 For example, the House of Lords, Science and Technology Committee's report "*Science and technology superpower: more than a slogan?*", published in August 2022 stated 'Evidence of sustained focus, implementation and delivery is lacking' and the House of Commons, Business, Energy and Industrial Strategy Committee's report *The semiconductor industry in the UK*, published in November 2022, highlighted that the UK is falling behind other governments in mitigating risks and noted that the UK's semiconductor strategy was already nearly two years in the making. As of 12 February 2023 the UK's semiconductor strategy has still not been published.
- 6 *Radical Innovation, A blueprint for a new UK research and technology funding agency*, Royal Academy of Engineering, 2019.
- 7 *Ensuring a successful UK research endeavour*, A Review of the Research Councils by Paul Nurse, 2015.
- 8 *Green Deal Industrial Plan*, European Union, 2023 and the USA's *CHIPS and Science Act*.



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Together we're working to tackle the greatest challenges of our age.

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We're developing skills for the future by identifying the challenges of an ever-changing world and developing the skills and approaches we need to build a resilient and diverse engineering profession.

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