Perspective

EXPERT INSIGHTS ON A TIMELY POLICY ISSUE

RAND EUROPE

PAOLA FUSARO, NICOLAS JOUAN, LUCIA RETTER, BENEDICT WILKINSON

Science and technology as a tool of power

An appraisal

November 2022

For more information on this publication, visit www.rand.org/t/PEA2391-1

In recognition of the rapid pace of innovation around the world, and an increasingly competitive geostrategic environment, the 2021 Integrated Review of Security, Defence, Development and Foreign Policy (IR) presented S&T as an integral part of the UK national security strategy, going as far as stating the ambition to make the UK an 'S&T superpower'.[1] Indeed, the COVID-19 pandemic illustrated how politically and economically important it is for a country to have an S&T ecosystem capable of breakthroughs such as delivering a new vaccine in a short period of time. Yet, a recent inquiry of the House of Lords Science and Technology Committee pointed out there is a perennial lack of overarching S&T strategy that would support the realisation of IR's bold ambition.[2]

This short commentary proposes an initial assessment of the UK government's stated goal to change the UK into an 'S&T superpower'. It does not derive from a single detailed RAND research; rather it seeks to offer a reflective perspective on the issue drawing on selected published research by RAND Europe and others. First, this commentary considers how, from a conceptual perspective, the objectives and boundaries surrounding the concept of 'S&T superpower' will need to be fleshed out to give the term a unified meaning that can bring together relevant stakeholders and guide implementation. Second, the authors reflect on the fact that, from a practical perspective, the UK government will need to marshal a cohesive S&T strategy and put in place effective policy levers to deliver it. Third, the authors argue that, from a financial perspective, and given its finite resources, the UK government will need to rely on an integrated approach to S&T investments that coheres public and private actors, and nurtures collaborative international partnerships in pursuit of scientific excellence and technological capability, despite barriers to cooperation.

S&T superpower: a conceptual conundrum

The concept of an 'S&T superpower' presents a fundamental challenge. Unlike traditional domains of international politics, such as trade, diplomacy or the military, S&T is largely an emanation of the academic and industrial sectors. As such, it does not translate naturally into a single instrument of power. There is no blueprint for how to establish the UK as an S&T 'superpower' nor, crucially, for how to exploit this status, should it be achieved. It is, therefore, important to consider, firstly, how to achieve advantage 'in' S&T, before pursuing advantage 'through' S&T.

There are many different ways a country can try to leverage its S&T base to gain an edge in the global competition of powers. In one such broad approach, the UK could proactively build up its S&T status through a strategy of engagement in cooperation with willing international actors. This would rely on the assumption that greater international S&T engagement would contribute to the UK's prosperity and soft power. Alternatively, the UK could opt for a strategy of entrenchment, primarily aimed at offsetting progress accomplished by its competitors. This, in turn, would assume a continuous drive for comparative advantage in reaction to other countries' technological advances.

The two approaches are not mutually exclusive. S&T has historically served as an impetus for economic performance and soft power (engagement) while also being leveraged for national security (entrenchment).[3] Long gone are the days when government and military research and development (R&D) labs dominated the funding and delivery of disruptive new breakthroughs, such as the computer, jet engine, or Internet. Instead, in the 21st century, the private sector has a key role to play, especially in translating and commercialising ideas emerging from basic research at universities. This includes both large multinational firms, some of whose R&D budgets far outstrip those of many governments or militaries, and innovative small and medium enterprises (SMEs).[4] Nonetheless, innovation is still often driven by governmental coordination of military, industrial and academic players, sometimes known as the 'triple-helix model'. This aims to combine the unique interests and strengths of the state (and its military), searching

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for a strategic advantage against competitors, with those of companies and academics looking for new market shares, social impact, or prestige – encouraging a mutually-beneficial alignment and collaboration among these three different sectors.[5]

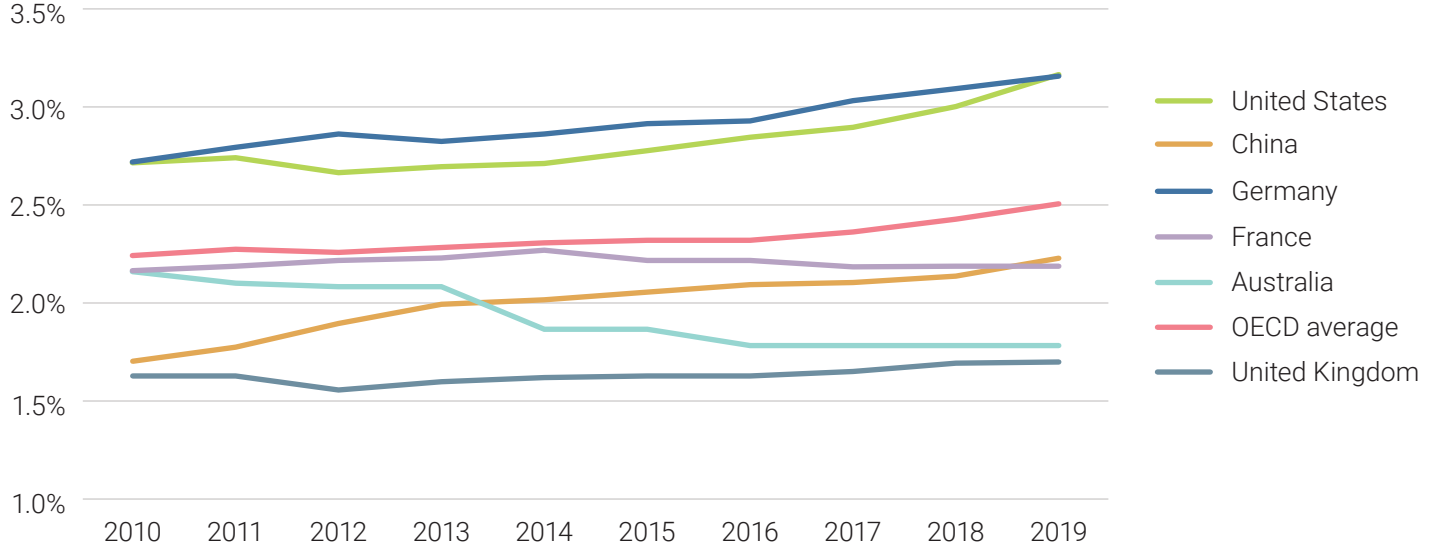
In this context, building the UK's S&T 'power' will require a combination of 'engagement' and 'entrenchment' across different areas of development. Such a strategy will rely on knowledge-intensive companies and universities, aligned as far as possible with overarching military, industrial and diplomatic objectives as shaped by the government. It will inevitably involve navigating complex trade-offs between protecting onshore, sovereign capability and enabling an open and competitive environment for pursuit of scientific excellence. These tensions already manifest themselves in a range of critical sectors, including energy, space and telecommunications.[6]

Bridging the investment gap

By stating the ambition to become an 'S&T superpower', the UK sets itself up for pursuit of a leading position in the global S&T rankings. In terms of public and private budget, the UK spent a combined total of £38.5 billion on R&D in 2020, similar in real terms to spending in 2019, and up from £30.5 billion in 2010.[7] While this increase was mostly driven by business investments, the UK government itself invested £15.3 billion in R&D in 2020, up from £13.6 billion in 2019 and £10.1 billion in 2010. These investments were mostly made through the seven research councils represented by UK Research and Innovation (UKRI).[8] The Ministry of Defence (MOD) also invested £1 billion in R&D in 2020 for its own military requirements, contributing to the overall government R&D figure.[9] Furthermore, the UK public and private sectors are projected to increase their R&D investments to £21 billion and £44 billion respectively in 2027, and to £32 billion and £63 billion in 2034.[10]

Nonetheless, compared with other wealthy post-industrial nations, the UK's public and private R&D spending as a percentage of Gross Domestic Product (GDP) is rather disappointing, as shown in Figure 1. According to the Organisation for Economic Cooperation and Development (OECD), the UK spent 1.7 per cent of its GDP on R&D

Figure 1: Overall public and private R&D spending as share of GDP in selected countries, 2010 to 2019



SOURCES: OECD (2022)

in 2019 (the most recent OECD figures available for the UK). This is noticeably less than economic giants such as the United States (3.5 per cent) and China (2.2 per cent), and even below the OECD average (2.5 per cent of GDP). It is also less than directly comparable countries such as Germany (3.2 per cent), France (2.2 per cent), or Australia (1.8 per cent). The UK's R&D investment projections (aiming for 2.7 per cent in 2027 and 3 per cent in the long term), while marking a significant increase, would still lag behind what the United States and Germany spent as a share of GDP in 2019.

Admittedly, comparative measures of R&D investment should also be put in the context of the quality of the UK's S&T contributions. Two metrics are often used to gauge this contribution: scientific publications and patent filings. As of 2020, the UK was ranked third in the world both in terms of the number of scientific publications and their citation share, a common proxy indicator for publications' perceived quality and impact within the global scientific community. Although the UK contribution has been in relative decline over the period 2016 to 2020, in absolute terms its publications output had a steady growth of 1.3 per cent per annum over the same period. This growth was superior to other leading countries such as the United States, France and Japan. The UK was also ranked first in terms of field-weighted citation impact, hence indicating that UK publications are cited more than comparable publications from other countries.[11] These figures suggest that UK scientific research compares well with other research-intensive countries, both in terms of quantity and quality of output.

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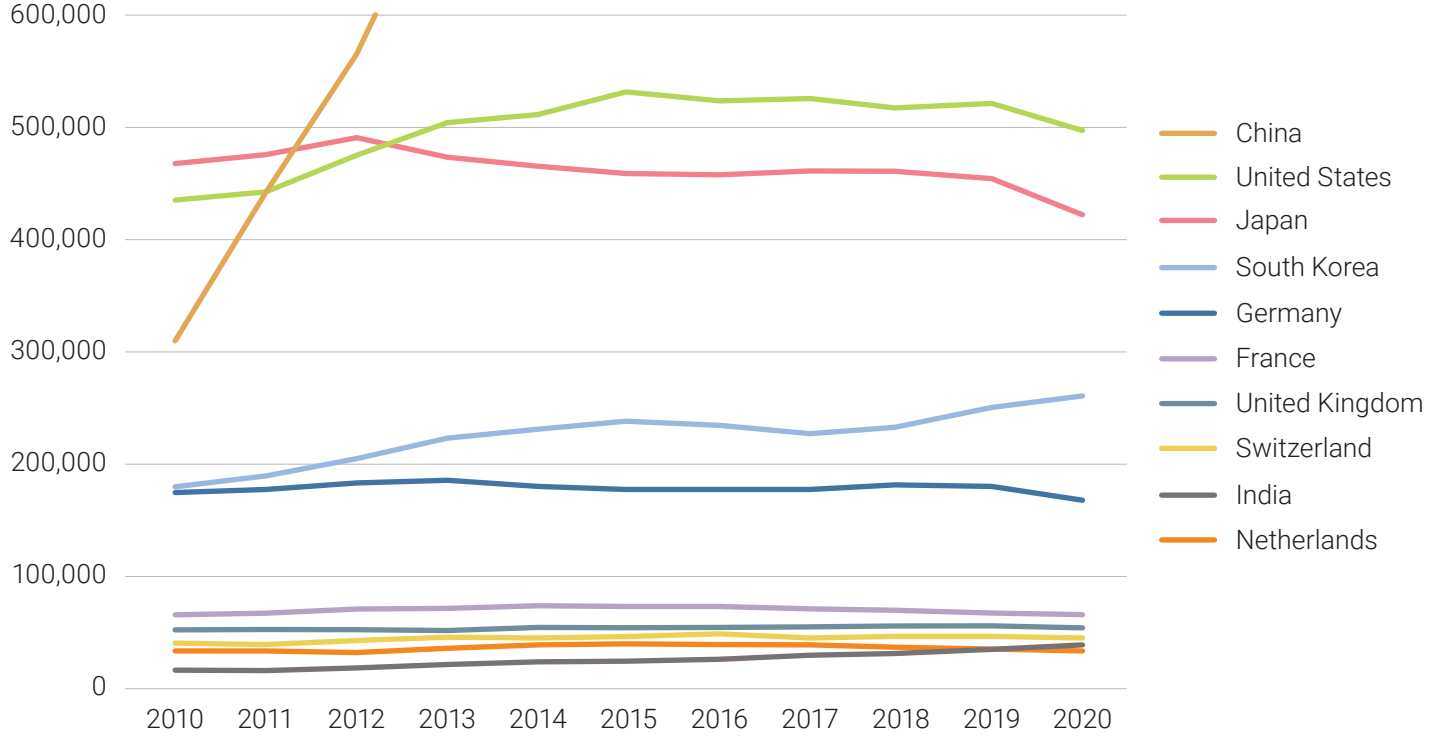
Nonetheless, the UK's high research performances may also come at a cost. Examples include the potential overcommitment of research staff, intense competition for available grants and academic research positions, or overutilisation of facilities, tools and infrastructure – introducing strain in the long run. Furthermore, the UK's strong focus on, and excellence in, basic research does not seem to translate as well into the commercialisation of 'blue sky' insights into new real-world technologies, products and services, which typically occurs within commercial firms. This is reflected in the enduring challenges that the UK faces in terms of investment and activity at higher Technology Readiness Levels (TRLs). It is also shown in the UK's less impressive performance in terms of patent filings, as suggested by Figure 2, where the UK ranks relatively low in the global

patent market. Low patent figures for the UK could suggest that the output of its scientific research has lower commercial potential than average, or that it is used more efficiently by other countries buying up and tapping into UK research for their own benefits. It is, however, important to note that not all patent filings necessarily lead to patent approval, and that not all patents are of equal value or perceived quality.

China, whose line had to be kept off-chart in Figure 2 for visibility, is especially known for generating larger number of low-value filings, tempering the apparently vast disparity between its patent activity and those of nations, such as the United States, who produce patent filings of a higher average value.

Figure 2: Top 10 countries by total patent applications, 2010 to 2020



*CHINA filled more than 1.4m patents in 2020 and was kept partly off chart to preserve the visibility of the other lines

SOURCE: World Intellectual Property Organisation (2022).

Implementing an integrated approach

Over the past year, the UK government has started to bring greater coherence to its S&T policies by working on a more integrated approach. A series of reforms have been laid out, feeding into realisation of the goals of the UK Innovation Strategy as published in July 2021.[12] On the infrastructure front, for example, the UK government has unveiled a new overarching Digital Strategy outlining measures to improve digital infrastructure, including achieving at least 85 and 99 per cent gigabit coverage by 2025 and 2030 respectively.[13] Regulations are also being redesigned to encourage growth and innovation, as set out in the 2019 White Paper on Regulation for the Fourth Industrial Revolution.[14] Example initiatives include the Financial Conduct Authority's regulatory sandbox, a tool enabling firms to work alongside the regulator to trial innovative products with consumers without the usual cumbersome compliance requirements.[15]

The government has also taken steps to improve access to finance from investors able to provide needed capital to promising companies, while simultaneously taking steps to protect academic institutions and UK firms from predatory behaviours by foreign actors. For example, UKRI offers protection of intellectual property (IP) and sensitive research through the Trusted Research and Innovation programme to facilitate the growth of small innovative companies and protect them from unfair competition.[16] The UK government has also made clear its desire to be more supportive of UK tech 'unicorns' by providing incentives for innovative companies to hold their Initial Public Offerings on the London Stock Exchange.[17] Immigration reforms can also contribute to that trend with the newly created Office for Talent, the introduction of the Global Talent Visa and a new graduate route to skilled jobs, bolstering the skill base for innovative companies, though these must be set against wider post-Brexit restrictions on freedom of movement.[18]

Against this backdrop, the IR outlined more governmental investment in S&T horizon scanning and foresight methods and tools to better anticipate and prioritise investments and policy interventions.[19] In particular, the document, and the Defence and Security Industrial Strategy (DSIS) that accompanied it, announced the creation of the 'Own-Collaborate-Access' framework to structure government decisions to prioritise, nurture and use sovereign S&T capabilities.[20] Guided by the strengths of the existing UK S&T base, government departments will now have three main strategic options to nurture S&T capabilities: to 'own' S&T developments from discovery to commercialisation; to 'collaborate' with strategic allies on S&T areas where the UK is not able to establish a dominant position but can provide a number of advantageous human and material capabilities; or to 'access' critical S&T developments through secure procurement supply chains and deals with friendly nations and industries.[21]

These decisions, whether 'owning', 'collaborating' or 'accessing', will require the coordinated efforts of multiple parts of government, ranging from the Department for Business, Energy & Industrial Strategy (BEIS), UKRI, the Home Office, the MOD, the Foreign, Commonwealth and Development Office (FCDO), the Department for Education (DfE), and others. The UK government under Boris Johnson created several mechanisms to try and drive a more integrated approach. In the wake of the IR, it established the National Science and Technology Council (NSTC) and the Office for Science and Technology

Strategy (OSTS). The former is a Cabinet Committee specifically designed to help achieve strategic advantage in S&T domains, and the latter was a small team in charge of the implementation and monitoring of the NSTC's recommendations within government.[22]

While it is too early to judge the contribution of the NSTC and the OSTS, their removal will certainly prevent or slow down efforts to bring together a range of cross-departmental stakeholders with diverse incentives and interests. Achieving consensus on which S&T priority areas to invest in, and what approach would be best suited from 'own', 'collaborate' and 'access', is likely to be notoriously difficult. Conscious efforts will be needed to align the different perspectives, taxonomies and priorities of the various stakeholders (including engagement with industry and academic perspectives), supported by tools and methods for a more robust decision making.[23]

Wider enablers

Nurturing a healthy S&T base presupposes a mix of enablers.[24] Investing more and incentivising private investments would be an obvious start, but money is not the only factor in making a country more apt at developing an efficient and effective S&T ecosystem. In the long run, increasing the attractiveness of a country for talent, ideas and (trusted) foreign investments will also propel S&T growth. In this context, it can be argued that Brexit has made life much more difficult for the UK in its pursuit of a status of 'S&T superpower', at least in the short to medium term. Access to Horizon Europe funding for UK researchers is currently threatened by the dispute over the Northern Ireland arrangement, with further challenges

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experienced by UK higher education institutions in terms of attracting less talent from European Union (EU) countries.[25] Furthermore, the UK's exit from the European single market makes it inherently more difficult for British private companies to scale up commercial technologies in need of users, especially while trade deals with major alternative markets (such as the United States) are still yet to be negotiated and signed. New bilateral and multilateral agreements with emerging markets could theoretically compensate for the short-term challenges, but these agreements take time to establish, and the UK might be losing precious years at a pivotal time in the global competition for S&T advantage.

The UK will also face the harsh reality of increasing global competition. In the context of the so-called 'Indo-Pacific tilt', the IR highlights the UK's aspiration to cooperate selectively with China on trade, climate and investments, while also reaffirming China's status as a 'systemic competitor', a position now also recognised in

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the new NATO Strategic Concept.[26] This balancing act will not be easy to sustain in the long run, particularly in the S&T field, where many technology clusters are inherently dual-use, meaning that they may have both civil and military or intelligence applications. The UK's attempt at working with Chinese telecoms giant Huawei in the field of 5G, for example, proved too difficult on security grounds and faced significant political pressure from both the Trump administration and domestic critics.[27] The UK has since introduced the National Security and Investment Act, enhancing the government's ability to monitor foreign investments in innovative UK firms in key sectors and to intervene if it finds these threatening to UK sovereignty and security. Implementation of this new monitoring mechanism will require a 'learning by doing' approach that will carefully need to consider the trade-offs between national security and investment benefits on a case-by-case basis.

Finally, investments in S&T should be carefully paired with the establishment of robust regulatory frameworks facilitating the establishment of ethical, legal and regulatory norms.[28] As one example, the UK government has already published a set of regulatory and ethical frameworks with a particular focus on artificial intelligence (AI), including a set of AI Ethical Principles for Defence.[29] The FCDO is similarly leading on diplomatic efforts through the United Nations to promote responsible uses of novel space technologies.[30] However, clustering technology regulations will not be enough. The UK government will ultimately need a strategic and policy framework linking these technologies together. Ideally, this framework should also align with standards of other European countries, Five Eyes (United States, Australia, Canada and New Zealand), other partners' (e.g. Japan, South Korea, India) and to some extent Chinese standards, to stimulate business cooperation across continents, while also offering an open-market and democratic alternative to more authoritarian models. Regulating the activities of Big Tech companies will also be crucial to ensure they comply with antitrust and privacy rules and to mitigate the negative externalities of their products and services (e.g. managing the challenges that social media presents to democracy in terms of disinformation and online harms). Yet the UK has remained relatively passive on this issue compared with the EU.[31]

There is a real advantage in staying competitive in specific S&T technology clusters, both to become an attractive partner for international collaboration and to preserve certain national capabilities for reasons of national security, prosperity and resilience.

Forging a coherent set of S&T ambitions

To fulfil the ambitions set out in the IR, the UK government will need to articulate clearly what it means to be an 'S&T superpower' and which S&T areas it wants to prioritise with its finite resources. Considering the UK's economic weight, population size, and decision to exit the EU, competing with global S&T heavyweights like the United States or China is not a reasonable option. However, it does not mean that the UK government should give up pursuing an integrated S&T and innovation strategy. Nor does it mean that the UK cannot exert global leadership in key areas, especially given its outsized performance in basic research, its world-leading university sector, and its broader economic strengths in areas such as financial services or culture and media.

There is a real advantage in staying competitive in specific S&T technology clusters, both to become an attractive partner for international collaboration and to preserve certain national capabilities for reasons of national security, prosperity and resilience. The recent COVID-19 pandemic showed the decisive advantage of investing and cooperating in the field of biomedicine with RNA therapeutics. Scientific breakthroughs and new technologies will similarly be needed to help address challenges such as climate change, poverty, terrorism or state threats. A robust approach to identifying future such national priorities will be needed to avoid picking winners at a cost of fostering a genuinely innovative S&T ecosystem. The UK government should, therefore, systematically channel its S&T ambitions in specific fields in which it has identified: 1) existing national assets (including skills, patents and institutions); 2) the ability to benefit from extant or maturing regulation and funding; and 3) the capacity to deliver significant security, influence, prosperity and social value benefits.

Notes

[1] Cabinet Office (2021).

[2] House of Lords (2022).

[3] Freeman et al. (2015); Guthrie et al. (2018).

[4] Freeman et al. (2015).

[5] Parks et al. (2019).

[6] Dortmans et al. (2022).

[7] Hutton (2021).

[8] Research councils directly overlap with the traditional definition of S&T, which encompasses several disciplines including Engineering and Physical Sciences (EPSRC), Medical (MRC), Science and Technology Facilities (STFC), Natural Environment (NERC), and Biotechnology and Biological Sciences (BBSRC). The remaining two research councils (the Economic and Social Research Council, ESRC and the Arts and Humanities Research Council, AHRC) do not generally fund technical R&D activities.

[9] MOD (2020).

[10] Campaign for Science and Engineering (CaSE) (2019).

[11] Department for Business, Energy & Industrial Strategy (2022).

[12] Department for Business, Energy & Industrial Strategy (2021).

[13] Department for Digital, Culture, Media & Sport (2022).

[14] Department for Business, Energy & Industrial Strategy (2019).

[15] Cabinet Office (2021).

[16] UK Research and Innovation (2022).

[17] Swabey (2022).

[18] Cabinet Office (2021).

[19] Cabinet Office (2021).

[20] Ministry of Defence (2021).

[21] Council for Science and Technology (2021).

[22] House of Lords (2022).

[23] For examples on a decision-support framework for 'own-collaborate-access' decision making in relation to space capability see Retter et al. (2022). For an international comparison of similar policy approaches across Australia, Europe and the United States, see Dortmans et al. (2022).

[24] Freeman et al. (2015); d'Angelo et al. (2018).

[25] Adams (2022).

[26] NATO (2022).

[27] Fildes (2021).

[28] Gunashekar et al. (2019); Weinbaum et al. (2019).

[29] UK Ministry of Defence (2022a) and UK Ministry of Defence (2022b).

[30] Black (2022).

[31] Beioley (2022).

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About the Authors

Paola Fusaro is an analyst working in defence and security at RAND Europe. Her research focuses on defence industrial policy and military acquisition, horizon scanning, new and emerging technology (e.g. AI/ML, autonomy, nanosensing, quantum), space, and a range of security topics, from sub-state warfare to climate change.

Nicolas Jouan is a defence and security analyst at RAND Europe. His research interests relate to arms production, acquisition policy, supply-chain analysis, European defence and regional geopolitics. He has contributed to policy research projects for high-profile clients including the UK Ministry of Defence, the UK Defence Science and Technology Laboratory and the UK Office for Security and Counter-Terrorism.

Lucia Retter is a research leader at RAND Europe and co-directs RAND Europe's Centre for Defence Economics and Acquisition. Her research focuses on understanding the factors driving government strategy, policy and decision-making at the nexus between security, influence and prosperity, including the benefits, trade-offs and risks associated with different capability development programmes.

Benedict Wilkinson is deputy director (defence) and co-director of the Centre for Defence Economics and Acquisition at RAND Europe. His areas of research interest are wide-ranging but include UK defence and security policy; defence acquisition and industry (with a particular interest in defence economics); wider geopolitics and national strategy; counter-terrorism and counter-extremism.

About this Perspective

This Perspective examines the UK Government's ambition to use science and technology (S&T) as a tool of power and an integral part of the national security strategy, as stated in the 2021 Integrated Review of Security, Defence, Development and Foreign Policy. The commentary highlights the authors' reflections on critical enablers for a successful realisation of this ambition, including conceptual, practical and financial levers. This perspective does not derive from a single detailed RAND research; rather it seeks to offer a perspective on the issues drawing on selected research by RAND and others.

About the Centre for Defence Economics and Acquisition

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PE-A2391-1