Royal United Services Institute
for Defence and Security Studies

Occasional Paper

The Challenge of Change

Acquiring Technologies for Defence in the UK

Trevor Taylor and John Louth

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RUSI Occasional Paper, March 2020

Royal United Services Institute
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Published in 2020 by the Royal United Services Institute for Defence and Security Studies.

RUSI Occasional Paper, March 2020. ISSN 2397-0286 (Online); ISSN 2397-0278 (Print).

Printed in the UK by Kall Kwik.

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Preface

THIS PAPER IS based on the generic literature on innovation, the potential military capability improvements that are becoming available through today's rapid technological change, and the challenges facing UK defence capabilities arising from the assertive policy and defence acquisition activities of potential adversaries, including Russia and China. It builds on the authors' earlier work addressing the Third Offset Strategy of the US and its significance, or otherwise, for how the UK develops, sustains and affords its military capabilities.[1]

The paper was drafted before the commitment of the November 2019 Conservative government to the 'most profound review of Britain's defence and security since the Cold War' and the reports that Dominic Cummings, a prominent prime ministerial adviser, would be looking to reform defence acquisition practices and behaviours and, indeed, the UK civil service as a whole. This paper has relevance for all these activities.

As far as procurement is concerned, this paper underlines that the most pressing problem in this domain is not the traditional issue of the incidence of projects coming in late and over budget. Rather, the problems of today increasingly centre on the need for greater speed in defence acquisition, adoption and adaptation of commercial edge technology for defence purposes. These problems imply modifications to conventional wisdom about defence procurement: less emphasis on formal competitions among contractors, better mechanisms for hi-tech companies of all sizes that are focused on the civil world to get involved with defence and, overall, closer government working with the private sector.

Given the dynamic activities of potential adversaries and the emphasis on speed of acquisition currently visible in the US (where the use of Other Transactional Authorities is increasing), the risks of proceeding methodically but slowly appear greater than the risks associated with not setting comprehensive and precise user and system requirements at the outset of a programme or project. Contracts that deal with uncertainty and continual variance are needed in this regard, but this is the antithesis of many businesses' experiences with the UK's Ministry of Defence.

Significant reform to defence acquisition behaviours and practices are unlikely to be forthcoming if the 2020 Integrated Review takes a comparable form to the Strategic Defence Review of 1998 and similar exercises since, in which the UK's ambition to be a major player in both European and global security is reiterated, but without a real strategy of how this is to be achieved and sustained. Assertions that efficiency savings and reorganisation in defence will make such a policy stance affordable at similar levels of defence spending to those of today may also prove fanciful. Innovation requires a readiness to risk money, other resources and time on ideas that

1. John Louth, Trevor Taylor and Andrew Tyler, 'Defence Innovation and the UK: Responding to the Risks Identified by the US Third Offset Strategy', *RUSI Occasional Papers* (July 2017).

may well fail. If the outcome of the 2020 review is a clear focus on cost-cutting in defence, rather than the generation of innovative, battle-winning capabilities themselves, many of the messages in this paper are likely to fall on deaf ears.

Executive Summary

THE SUPPORT OF the Ministry of Defence (MoD) for enhanced innovation in military affairs is well-established. This paper explores the significant implications of this for the management of defence. Specifically, it uses the wider literature on innovation to articulate the environmental conditions, the features of an ecosystem, that encourage widespread innovation to take root and flourish.

It considers specifically:

- Demand and the perceived need for and urgency of significant improvement.
- Technology trajectories and the rate of technological change.
- Money and the availability of funding to enable scientific and technological advances to be transformed into usable military capability.
- Risk appetite, addressing the readiness of decision-makers to embrace the financial and technological risks usually associated with significant innovation.
- The scope of procurement and decision-making speeds.
- The availability of capable suppliers and the operation in networks.
- The presence of an intelligent customer that is ready to countenance the organisational and even cultural disruption that can be associated with major innovation.

One overall emerging theme is the need for government and the private sector to work together to optimise the overall impact of their respective areas of expertise and capability. Innovation seems unlikely to flourish in an adversarial context given the need for in-depth knowledge in four key areas:

- The condition and trajectory of core enabling technologies.
- How such technologies can be made to work in a system (and linked to other systems).
- The time and cost to manufacture a product with a known and acceptable degree of reliability.
- Insight as to what the market will bear.

The MoD has clear expertise in what the UK military market is seeking and has some understanding of core enabling technologies, whereas industry is clearly more expert in the middle two areas. The chances of successful innovation seem poor if the two parties see themselves as on opposite sides.

The paper offers a range of suggestions for change, not least regarding risk appetite, the urgency of timely decisions, the attraction of new suppliers, and the reinforcement of internal MoD expertise, while inevitably the availability of finance to support innovative opportunities is a major question mark.

Introduction

Acquisition Reform

THE STRUCTURES AND processes through which the Ministry of Defence (MoD) acquires its equipment and services would be easily recognisable to procurement civil servants from the 1980s. While they might be shocked at how much has been outsourced and at the number of state assets that have been sold to the private sector, they would easily recognise the modified processes of requirement specification; approvals; project prioritisation; financial planning; selection and execution of procurement strategy; contracting; and test and acceptance provisions. However, many aspects of in-service support arrangements – particularly those associated with private finance and contracting for availability – would appear new.

Acquisition reform, and not least the 1998 Smart Procurement Initiative, was about improving many of these aspects: writing requirements that were more precise and better documented from both user and system levels;[1] drawing up 10-year plans that were affordable and justified by policy; making better use of competitive tendering (and supposed 'partnering' after contract signature); writing taut contracts that could guide action in the event of problematic performance; being clear on test and acceptance arrangements; and thinking thoroughly about the in-service and disposal phases from early in a project. There has been some success with these matters and less is heard about time and cost overruns. Indeed, most of the projects in the MoD's 2018 Defence Equipment Plan are expected to come in under their expected cost.[2] The *Queen Elizabeth*-class carriers were a notable exception, but this largely reflects a premature Main Gate approval before the projects were fully comprehended.

On both sides of the Atlantic, defence acquisition reform of at least the past 30 years has been focused on the avoidance of 'waste'. It has involved a highly methodical and increasingly complex effort to carefully address all the elements involved. But there was little urgency about acquisition processes unless they involved Urgent Operational Requirements either on the eve of or during a major operation. In those cases, different processes and behaviours were introduced.

However, the world has and continues to change, and there are additional issues on the defence acquisition agenda. Prominent among them in the Western world is the need for innovation in light of the assertiveness and growing capabilities of potential adversaries, especially in the past

1. The Smart Procurement Initiative included the direction to generate specific, numbered user requirements in capability terms (namely, what the military needed to be able to do), which were then linked to system requirements with design implications.
2. Ministry of Defence (MoD), 'The Defence Equipment Plan 2018: Financial Summary', November 2018 (last updated March 2019), p. 37.

decade, with Russia and China chief among them.[3] Furthermore, the potential for innovation at the component, sub-system and system levels bolsters the need for modernisation, especially given the pace and direction of technological change. In short, both security challenges and technological opportunities are proliferating.

This paper considers the characteristics of an ecosystem that would enable defence innovation to flourish in the UK, given a projected rate of global innovation and technological change. It is concerned with defence acquisition processes as a core element of a larger capability-management system that requires both appropriate skills and an organisational culture that includes suitable risk appetites and delegation.

The Concept of Defence-Technological Innovation

'Innovation' can mean many things, and is also a contested term. This paper, therefore, begins by exploring its meaning in a Western defence context. A definition is provided in the Innovation Strategy for Defence Equipment & Support (DE&S) published by the MoD in 2017, which views 'innovation as the exploitation of ideas in order to implement a new or significantly improved product, service or process'.[4]

Analysts have long debated the relative importance of technology and people to military effectiveness. The British Army's longstanding model of the components of fighting power has the Physical (namely, the material) domain as just one of three key factors alongside the Conceptual and the Moral.[5] However, the air, naval and space domains are intrinsically equipment centric: humans cannot get off the ground without technological help, nor can one fight and swim at the same time. On balance, US philosophy is more associated with the idea that technology wins wars than its British counterpart – although it was the British developer of the jet engine, Frank Whittle, who allegedly observed that 'a nation's ability to fight a modern war is as good as its

3. John Louth, Trevor Taylor and Andrew Tyler, 'Defence Innovation and the UK: Responding to the Risks Identified by the US Third Offset Strategy', *RUSI Occasional Papers* (July 2017).
4. MoD, 'Defence Equipment & Support: Innovation Strategy', Policy Paper, March 2017, p. 2.
5. MoD, 'Army Doctrine Publication: Land Operations', November 2010 (last updated March 2017), Chap. 3.

technological ability'.[6] Whatever the importance of other components of fighting power, it is difficult to reject the specific assertion that technology will continue to change warfare.[7]

The nature of innovation in defence can be summarised in three points. First, military innovation is not just technological – in particular, new and better ways of operating can be devised without new equipment.[8] Second, technological innovation – including the modernisation of existing equipment – has implications for other elements of capability such as training. Technological innovation must be linked to a wider setting. The UK generated its TEPIDOIL (Training, Equipment, People, Infrastructure, Doctrine, Organisation, Information and Logistics) framework to support the effective provision of all the elements needed to generate usable capability from an equipment base, and 'disruptive technology' involves new equipment that requires major changes in elements of TEPIDOIL.[9] Third, innovation can apply to acquisition processes themselves, so that equipment can come into service more quickly. A central concern of this paper is the fact that technological innovation can become available for military capability only at the rate at which it can be procured.

There are at least four reasons why advanced technology remains particularly important to the UK this century. First, the UK cannot match the size of forces that its most serious potential adversaries, Russia and China, can put into the field. Second, military actors that rely on human commitment and ingenuity for success often have to take large personnel losses over a sustained period to avoid defeat – think of Russian losses in the Second World War and Viet Cong/North Vietnamese casualties in their struggle against the US. But what are historically considered as modest losses are highly unpalatable for today's Western publics, especially when wars are not fought for national survival but for more limited purposes. Third, there is political and military value in British forces having capabilities compatible with those of its main (and technologically focused) ally, the US. Fourth, despite its problems, the Western liberal-capitalist system has long had a comparative advantage in technological innovation and development. This is, however, being ambitiously challenged by China.

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6. Military History Matters, 'Conflict Scientists – Frank Whittle', 12 February 2015, <https://www.military-history.org/articles/conflict-scientists-frank-whittle.htm>, accessed 8 January 2020; James Long, 'Disruptive Innovation Wins Wars. Here's How the Army Can Get Better At It', Modern War Institute, 16 January 2019, <https://mwi.usma.edu/disruptive-innovation-wins-wars-heres-army-can-get-better/>, accessed 8 January 2020; Sean McFate, 'Technology Doesn't Win Wars. Why the US Pretends it Does', *Big Think*, 27 January 2019, <https://bigthink.com/top-video-splash/why-america-pretends-tech-wins-wars>, accessed 8 January 2020; Richard Williams, 'Technology Wins Wars, Not Men in Cap Badges', *The Times*, 6 July 2007.
7. Alex Roland, 'War and Technology', Foreign Policy Research Institute, 27 February 2009, <https://www.fpri.org/article/2009/02/war-and-technology/>, accessed 8 January 2020.
8. The US DOTMLPF (Doctrine, Organisation, Training, Materiel, Leadership and Education, People and Facilities) framework was developed to assess whether a capability gap could be filled by using extant resources differently. See AcqNotes, 'JCIDS Process: DOMTMLPF-P Analysis', <http://acqnotes.com/acqnote/acquisitions/dotmlpf-analysis>, accessed 8 January 2020.
9. For instance, see Terry Pierce, *Warfighting and Disruptive Technology* (London: Frank Cass, 2004).

British governments seem likely to continue to place considerable emphasis on technology as a prominent element of military power and should seek to take maximum advantage of what it could offer. However, technological changes must be considered in their wider context.

Technological innovation is not inevitable: indeed, most of human history is marked by its relative absence.[10] It is clearly not enough to simply command that innovation should occur. As much was recognised in the secretary of state's Foreword to the Defence Innovation Initiative Prospectus when he appealed to 'academia, industry, wider government, other partners and my own department to fire up their innovative instincts'.[11] The document referred to the need for a defence 'culture that is innovative by instinct'.[12] But, even so, some believe that innovation owes much to chance: the founder of Spotify, a music streaming service, observes that 'innovation is serendipity. It can happen when people get totally new influences or ideas that come totally from the side-lines'.[13] However, this paper rests on the argument that innovation is more likely to flourish in some settings rather than in others, and on the belief that if governments genuinely wish for defence innovation in the technological and wider capability development space, they must create a supportive context for such change that provides lubricants and incentives for both customers and suppliers.

Approach of the Paper

This paper draws on the extensive literature on innovation in general. Much has also been written specifically on defence acquisition by both scholars and practitioners, and there are many US and UK reports focused on improving defence acquisition.[14] In addition, this paper also draws on the experience and background knowledge of its authors, and further builds on two workshops, held under the Chatham House rule, that brought together practitioners from the state and private sectors. Participants contributed greatly to the thinking behind this paper, but bear no responsibility for any shortcomings.

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10. See James G Taylor, 'Consistent Scoring of Weapons and Aggregation of Forces: The Cornerstone of Dupuy's Quantitative Analysis of Historical Land Battles', Dupuy Institute, <http://www.dupuyinstitute.org/blog/2018/05/07/scoring-weapons-and-aggregation-in-trevor-dupuys-combat-models/>, accessed 8 January; see also Trevor Dupuy, *The Evolution of Weapons and Warfare* (Fairfax, VA: Hero Press, 1984).
11. MoD, 'Advantage Through Innovation: The Defence Innovation Initiative Prospectus', Policy Paper, September 2016.
12. *Ibid*.
13. David Rowan, *Non-Bullshit Innovation: Radical Ideas from the World's Smartest Minds* (London: Bantam Press, 2019), p. 11.
14. The Section 809 investigations mandated by the US Congress have been particularly concerned with speeding up acquisition processes. See Section 809 Panel, 'Report of the Advisory Panel on Streamlining and Codifying Acquisition Regulations', Vols 1–3, 2018/19, <https://section809panel.org/>, accessed 8 January 2020.

The paper explores the characteristics of an environment in which innovation should flourish, with attention paid to the relationships between the suppliers of innovation and its users. It identifies seven factors that would facilitate technological innovation within the defence environment, assesses how present these factors are in the UK and, where appropriate, offers recommendations for change where obstacles to rapid innovation can be discerned.

I. Factors For Successful Innovation

Demand

AS THE ADAGE 'necessity is the mother of invention' indicates, innovation often appears to be stimulated by the presence of a widely perceived need or set of needs.[15] Of course, there is not always a direct relationship between innovation efforts and related needs: Alexander Fleming's discovery that led to the development of antibiotics was accidental (although it required him to understand the significance of what he had observed).[16] However, Tim Harford's *Fifty Things That Made The Modern Economy* is replete with innovations that were prompted by recognised needs, including the development of air conditioning as a result of the heat problems of theatres in the American summer, and the invention of the 'S bend' in domestic plumbing to control the problem of smells in 19th-century cities. He observes that 'many of the inventions we've encountered have resulted from efforts to solve a particular problem'.[17] Clearly, business organisations must relate their major efforts to providing something which will fill a gap, sometimes one of great social significance.[18] Wars and even the prospect of such conflicts can expose needs and drive innovation: most recently, the widespread problem of improvised explosive devices in Iraq and Afghanistan prompted innovation to counter these weapons.

It is easy to explain the current emphasis placed by the US and the UK on defence innovation. Current military needs are defined by growing threats from Russia and China as these powers seek to modify the status quo in Europe and Asia respectively, and even beyond. For example, Russia is working to maintain its status by threatening the Baltic states, conducting a major offensive cyber campaign and, more generally, seeking to reassert Moscow's influence in the sphere of influence of the former Soviet Union. China has extensive claims over the South China Sea, and its naval and other military investments, the Belt and Road Initiative, and even its plans to colonise the moon make it hard to discern the actual limits of Chinese ambition. The two

15. Sean Atkins observes that 'a good vision provides much-needed focus to an organisation's innovative energy'; see Sean Atkins, 'Staff Sergeant Disruptor: Observations On Leading Innovation', *War on the Rocks*, 2 November 2016.
16. Katie Kalvaitis, 'Penicillin: An Accidental Discovery Changed the Course of Medicine', *Endocrine Today*, August 2008.
17. Tim Harford, *Fifty Things That Made the Modern Economy* (London: Little Brown, 2017), p. 282.
18. Rowan, *Non-Bullshit Innovation*.

countries are also significant arms exporters, including providing material to Western adversaries such as Iran – which in turn passes weapons on to other groups in Lebanon, Syria and Yemen.[19]

Affecting the supply side of innovation are the rising costs directly associated with the development, production and support of new and improved defence systems to replace established types of naval, air and land systems. Augustine's Law – which predicted that if trends continued, the entire US defence budget in 2054 would be devoted to the purchase of a single aircraft – has remained a credible problem. Even in 2010, *The Economist* noted that 'the chronic problem of exorbitantly expensive weapons is becoming acute'.[20] New types of systems and ways of tackling pressing problems (in other words, innovation) are thus needed.

On the demand side, from a UK perspective, the US may be about to generate a step-change in military capability. If the UK is to maintain its ambition of interoperability with the US on a major operation, it must make comparable changes.

Finally, in order to present any kind of credible narrative of UK strategic autonomy and for the MoD to meet its obligations to support the UK's prosperity agenda, the UK needs a significant defence-industrial sector that can succeed in competitive export markets where innovative, 'modern' capabilities are demanded.

Implication

The MoD cannot and does not assume that potential innovators have a good understanding of the needs and problems of defence, nor the specific areas of capability where innovation is particularly urgent. It also does not want myriad irrelevant offers, nor to indulge efforts that have no potential military utility.

Thus, the MoD is turning up and enhancing its messages to the rest of government, the industrial hi-tech sector and the public about the challenges of the UK's policy to remain an international military player and committed member of NATO. In September 2019, it published its list of key areas for technological advance: advanced materials; artificial intelligence (AI), machine learning and data science; autonomous systems and robotics; power, energy storage, conversion and transmission; sensors; advanced electronics and computing; and effector technologies.[21] At the same time, it presented a menu of the particular capability areas in which the MoD was looking for innovative ideas: the integration of information and activity

19. Jon Gambrell, 'AP Explains: How Yemen's Rebels Increasingly Deploy Drones', *AP News*, 21 May 2019; Julian Borger and Patrick Wintour, 'US Gives Evidence Iran Supplied Missiles That Yemen Rebels Fired at Saudi Arabia', *The Guardian*, 14 December 2017; Idrees Ali, 'US Touts New Evidence of Iranian Weaponry in Yemen, Afghanistan', *Reuters*, 29 November 2018.
20. *The Economist*, 'The Cost of Weapons: Defence Spending in a Time of Austerity', 26 August 2010; Steven Kosiak, 'Is the US Military Getting Smaller and Older? And How Much Should We Care?', Center for a New American Security, 14 March 2017.
21. MoD, 'Defence Technology Framework', September 2019.

across all domains; delivering agile command and control; operating and delivering effects in contested domains; generating defence people with the right skills, knowledge and experience; and simulating future battlespace complexity.[22] While these frameworks are broad and so can encompass a range of actions, the individual innovation cells within the Strategic Command and the individual services still need to take guidance from these documents and resist any urge to generate their own more parochial agendas.

Technological Development

A second variable is the state of technology itself. Compared with the pre-modern era, we live in a rich age of technological potential. Brian Arthur reasons that we have advances because technologies feed on themselves, combining in new ways through a process of 'combinatorial evolution':

> Early technologies form using existing primitive technologies as components. These new technologies in time become possible components – building blocks – for the creation of new technologies. Some of these in turn go on to become possible building blocks for the creation of yet newer technologies … The overall collection of technological bootstraps itself upward from the few to the many and from the simple to the complex. We can say that technology creates itself out of itself.[23]

Writing about evolutionary trends, Matt Ridley provides the simple illustration of how advances in both plastics and metallurgy were needed to make the wheeled suitcase practical (while larger airports and longer walks were enhancing the need for something to ease the relationship between gravity and luggage).[24]

In light of Arthur's and Ridley's considerations, the fast rate of advance in many areas of technology – coupled with an ever-better understanding of the natural world – means that the basic prospects for defence innovation appear positive. Electronics, software, synthetics, sensors, robotics, materials, battery technology, novel machine tools and genetic engineering are advancing rapidly.[25] Taking such developments into account, Yuval Noah Harari – among others – stresses the human potential to shape rather than be shaped by evolution.[26]

However, some words of caution are in order. Much technical innovation is at the component level, but many areas of defence rely on large, complex systems – often platforms where

22. MoD, 'Defence Innovation Priorities', September 2019.
23. W Brian Arthur, *The Nature of Technology: What It Is and How It Evolves* (New York, NY: Free Press, 2009). The other factor in his model is that technologies advance because, in one way or another, they capture and harness some natural phenomenon for a purpose.
24. Matt Ridley, *The Evolution of Everything: How Small Changes Transform Our World* (London: Fourth Estate, 2015).
25. Alec Ross, *Industries of the Future* (London: Simon & Schuster, 2016).
26. Yuval Noah Harari, *Sapiens: A Brief History of Humankind* (London: Vintage, 2011). See also Max Tegmark, *Life 3.0: Being Human in the Age of Artificial Intelligence* (London: Penguin, 2017).

space (and electrical power) is limited and where the integration of dozens of sub-systems and thousands of components can be a time-consuming, highly skilled and expensive challenge. The emergence of innovations at the component and sub-system level is balanced by the fact that their safe and effective introduction into the wider system may take time and money. Harford's discussion of the decades it took to adapt factories and production techniques to move from steam power to exploit the electric motor is a reminder of the demands raised by whole-system thinking.

Moreover, defence normally requires a high degree of performance and assurance because the price of error in a military operational context can be much higher than in comparable civilian applications. Many defence systems are also inherently hazardous. Obviously, some are designed to inflict destruction when used and must not go off by accident. Anything that flies is clearly a potential hazard to those on the ground if it fails. But even things such as tracked vehicles will, on occasion, travel on public roads;[27] here, track failure can cause major damage to other road users. The 'safety cases' (documents spelling out the reasoning and tests that demonstrate that a system is safe both to generate and to use) that have to be generated for new defence systems are often very extensive.[28] Obviously, civilian goods also need to be demonstrably safe to use, but civilian technology is rarely designed specifically to inflict damage. Identification, friend or foe (IFF) – which today should include facial recognition – and weapons accuracy are other areas where malfunction is hazardous to external parties. Thus, they require extensive safety cases, testing and extensive regulation. This can place a constraint on innovation, not least in the area of AI-based systems, which are discussed in more detail later in this paper.

In short, while the state of technology in the wider world suggests that much defence innovation is feasible, it is not certain that the opportunities will be properly seized and exploited to generate innovative capabilities.

Implications

The global rate of technological change and its possible future trajectories necessitate that the MoD, or perhaps the governmental defence sector as a whole, should devote significant human and financial resources to monitoring and understanding these issues. Within this, the role of scientific advice is particularly important, and such advice should come from the best scientific minds. Unlikely to be content with passively consuming the work of others, such people will want their own research programmes. The precise mix of what should be done within the UK government – most importantly, within the Defence Science and Technology Laboratory (Dstl) – and what should be outsourced is left open here, but it is important that those with scientific expertise should also possess a good understanding of the defence and security context.

27. In the UK, this is permitted at a speed of up to 40 mph.
28. See Acquisition Safety & Environmental Management System (ASEMS), 'SMP12. Safety Case and Safety Case Report', August 2019, <https://www.asems.mod.uk/guidance/posms/smp12>, accessed 8 January 2020.

Platforms, major sub-systems such as sensors and propulsion systems, and even complex weapons should be designed from the outset to permit substantial modification during their lives, perhaps in unforeseen ways involving new suppliers. They may even need further technology insertion (most commonly, improved software) into initial production models before coming into full service. But designing and producing 'open systems' is easier to say than to execute. It can be a matter of specific things such as standards and interfaces, but also of more generic considerations such as providing space for additional kit, installing propulsion systems with power to spare and including a capacity to generate more electric power than that needed for the original requirement. Such features have initial procurement cost implications but, given that through-life costs exceed initial procurement costs by a considerable amount, spending on enhancing the adaptability of a system will normally be a sound investment.[29]

Money

A third variable is that innovation often requires significant funding for people's time and ideas, and for infrastructure, equipment and experiments, potentially over a long period. One of the striking features of many of the cases of innovation cited by David Rowan is the initial and continuing capital provided by the sponsors of innovation.[30] Innovation processes are often more disorderly and uncertain than the layperson might think, as Michael Brooks and Scott Berkun have explained.[31] Mariana Mazzucato underlines the need for basic, publicly funded research in areas where the pay-offs are distant and uncertain – though the private sector can be very effective in commercialising the groundwork generated by government money. Her lead case deals with the benefits taken by Apple from US Department of Defense (DoD) research.[32]

A relevant consideration in cases where private capital has pump-primed massive levels of investment and innovation, such as the IT sector, is the expectation of profit margins far above what would be acceptable to government spending authorities. In the UK, the Single Source Regulations Office has been reluctant to accept any margin above 9.9% on a sole-source contract.[33]

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29. Even in-service spending on a family car over a decade, with its relatively minimal maintenance needs, is likely to exceed the initial purchase cost. See AA, 'How Much Does It Cost to Run A Car?', <https://www.theaa.com/driving-advice/driving-costs/running-costs>, accessed 8 January 2020.
30. Rowan, *Non-Bullshit Innovation*.
31. Scott Berkun, *The Myths of Innovation* (Sebastopol, CA: O'Reilly Media, 2010); Michael Brooks, *13 Things That Don't Make Sense: The Most Intriguing Scientific Mysteries of Our Times* (London: Profile Books, 2010).
32. Mariana Mazzucato, *The Entrepreneurial State: Debunking Public vs. Private Sector Myths* (London: Anthem Press, 2013).
33. Single Source Regulations Office (SSRO), '2019 Contract Profit Rate: Recommendation Factsheet', March 2019, p. 1, <https://www.gov.uk/government/publications/2019-contract-profit-rate>, accessed 8 January 2020. The SSRO has developed a more complex system for determining allowable profit which will not be announced before March 2020. See SSRO, 'Single Source

Writing on the US context, Stephen Rodriguez advocates the Pentagon to both target its money at government laboratories for innovation – including in manufacturing technology, which could then be taken forward in the private world – and to engage more closely with venture capitalists and other sources of financing to generate defence-relevant innovation within the private sector.[34] That the MoD might itself serve as a source of venture capital – leaving it as, potentially, a shareholder of a small, innovative technology business – is not a possibility that has been taken seriously in the UK so far.

Indeed, just how much cash the British government is putting into defence innovation research and development is not absolutely clear. When Peter Luff was Minister of Defence Procurement, a commitment was made to spend at least 1.2% of the defence budget on research. Indeed, he was prepared to resign over the issue.[35] The government then continued to stress the increased resources being devoted to technology innovation, with a proliferation of initiatives and acronyms, funds and bodies:

- The 2015 Strategic Defence and Security Review launched the Defence Innovation Initiative and a Defence Innovation Fund (DIF) of £800 million to be spent over 10 years, directed by a Defence Innovation Unit (DIU) in the MoD's Head Office.
- Resources were directed to the Defence and Security Accelerator, which replaced the earlier Centre for Defence Enterprise, and to the Defence Solutions Centre – the previous Niteworks experiment of government-industry collaboration was abandoned.[36]
- In December 2018, the Modernising Defence Programme announced a Defence Transformation Fund (DTF) and 'Spearhead' programmes worth £500 million over an unspecified period to link innovation with faster acquisition processes.[37]

Baseline Profit Rate, Capital Servicing Rates and Funding Adjustment Methodology', October 2019, https://www.gov.uk/government/publications/2020-contract-profit-rate, accessed 8 January 2020.

34. Stephen Rodriguez, 'Good to Great: Innovation in the Industrial Base', *War on the Rocks*, 12 May 2017.
35. Remarks made to the authors, London, December 2018.
36. BAE Systems, 'Niteworks', <https://www.baesystems.com/en-uk/our-company/our-businesses-uk-/shared-services/advanced-technology-centre/niteworks>, accessed 8 January 2020.
37. Dan Patefield, 'SoS Announces Initial Transformation Fund Investments', TechUK, 12 February 2019, <https://www.techuk.org/insights/news/item/14766-sos-announces-initial-transformation-fund-investments>, accessed 8 January 2020; Desider, 'Geoff Set to Spearhead Innovative Delivery', March 2019, p. 23. On the Spearhead programmes, Gavin Williamson, then Secretary of State for Defence, explained to the House of Commons: 'We will launch new "Spearhead" innovation programmes that will apply cutting-edge technologies to areas including sub-surface threats to our submarines, our intelligence, surveillance and reconnaissance capability, and command and control in the Land Environment as well'. See Gavin Williamson, 'Modernising Defence Programme – Update', 18 December 2018, <https://www.gov.uk/government/speeches/modernising-defence-programme-update>, accessed 8 January 2020.

What is less clear from published documents is whether the £500 million DTF and the Spearhead programmes are supplements to or replacements for the £800 million DIF, and whether the DIU in the MoD has been supplanted by the Defence Technology and Innovation Board and the appointment in the MoD main building of a two-star Director Defence Innovation. It is also difficult to determine the share of these funds that is expected to be devoted to applied 'development' – getting an approved project into service – and how much will be devoted to general, pre-project commitment 'research'.

The government is beginning from a modest base compared with past efforts. Defence research was 27% down in 2014/15 in real terms compared with 2001 levels. Development spending was even more stark, down by 56% in the same period.[38] Today, it is not easy to see how development money can be easily increased, with the headroom of the Equipment Plan gone and potentially replaced by over-commitment.[39] While predictions about the long-term outcome of Brexit are fiercely contested, the uncertainty and the eventual terms of the UK withdrawal from the EU are likely to damage the British economy for up to the next decade. This will certainly make it more difficult for a government to raise defence spending much above 2% of GDP and would in any case make any such increase less impactful.

While increased collaboration with others – if it can be arranged – could generate some relief, there is questionable availability of government money to move potential innovations into developed products ready for military service.

Implications

At the top level, the authors share the widely held belief in Whitehall that the UK's current defence policy ambition for 'Tier One' forces – able to make a significant contribution to defence of the NATO area, act across the globe and operate a nuclear deterrent based on stealthy and reliable submarines – is simply unaffordable with 2% of any foreseeable UK GDP. Even the 2018 Equipment Plan was reported as being underfunded by about £15 billion.[40] Efficiency savings

38. For a detailed and referenced analysis of the funds relating to these figures, see Trevor Taylor, 'Written Evidence to House of Commons Defence Committee Inquiry on Defence Acquisition and Procurement', 17 January 2017, <https://www.parliament.uk/business/committees/committees-a-z/commons-select/defence-committee/inquiries/parliament-2015/defence-acquisition-procurement-16-17/publications/>, accessed 8 January 2020.
39. MoD and Defence Equipment and Support, 'The Defence Equipment Plan 2016', January 2017; National Audit Office, 'Ministry of Defence: The Equipment Plan, 2016 to 2026', HC 914, Session 2016–17, 27 January 2017. Over-commitment is a function of the actual costs of projects and the volume of resources devoted to defence. For an assessment of the latest defence spending plans, see Malcolm Chalmers, 'The End of Defence Austerity? The 2019 Spending Round and the UK Defence Budget', RUSI Commentary, 30 September 2019.
40. Peggy Hollinger, 'Ambitious Tempest Fighter Jet Programme to Accelerate', *Financial Times*, 31 December 2019.

are unlikely to make affordability possible,[41] as highlighted by the rapid return of the black hole in the MoD's finances that Philip Hammond claimed to have eliminated as secretary of state for defence in 2012.[42] This paper does not prescribe the shape of the UK's policy ambitions, but it does argue that the government should either downsize these or increase resources for defence.

In and beyond the medium term, the capacity to innovate is a key element of the ability to deter and, if necessary, defeat adversaries. Therefore, a reliable and persistent funding stream must be available. The commitment to spend at least 1.2% of the defence budget on research is thus a positive step, but the fall in resources for development work since the end of the Cold War and even the turn of the 21st century is a source of concern. Industrialists are well aware that the costs of integrating new technology into a larger system, which falls within the 'development' area, can exceed the initial costs of the enabling technology itself – something that the increased generation of open systems could potentially improve but not eliminate. Simply put, a technologically innovative government defence sector will need more money.

In a time when there is a growing concern about foreign – particularly Chinese – investment in small hi-tech business in the UK, an MoD venture capital fund to build stakes in promising firms is worth considering. Such a fund would have to operate with a risk appetite not traditionally associated with public money, and this is discussed below. The question is whether, beyond its innovation budgets, the MoD should invest and take equity in small, niche capability businesses and ventures. While losses would be borne by the MoD, significant gains could be shared with the Exchequer. This would be a radical practice for the UK, given the established aversion to state ownership of businesses and the financial risks of failure involved – but it is a model under serious consideration in the US, not least because it would encourage promising firms to look more seriously at the defence sector. It is also worth noting that UK competitors, including China and Russia, make extensive use of state-owned or state-controlled defence firms. The French government also maintains a major shareholding in many parts of its defence industrial sector. Both France and Germany see state ownership as the best model for much of their infrastructure, including rail systems.

Finally, financial pressures underline the need for the government to vigorously explore multinational collaboration. In cash terms, such projects provide access to the money and expertise of others. Historically, British defence collaboration has been focused on European allies – but new possibilities are now emerging, not least with Australia, Japan and perhaps Turkey. But Europe will remain a technologically and financially attractive source of partners, and UK defence must simply hope that the conditions under which the country leaves the EU do not significantly sour political relations with important European states.

41. Trevor Taylor, 'The Limited Capacity of Management to Rescue UK Defence Policy: A Review and a Word of Caution', *International Affairs* (Vol. 88, No. 2, 2012), pp. 223–42.
42. *BBC News*, 'Defence Budget "Balanced" – Philip Hammond', 14 May 2012.

Risk Management and Appetite

Innovation is a positive concept, but in practice it generally requires a readiness to tolerate failure and even see it as a learning opportunity.[43] As a successful mobile games developer has said, 'if there aren't many failures, we haven't been trying hard enough to do innovative things'.[44] There is a saying in some academic circles that it is difficult to be brilliant and original – this is understood by companies in which there is emphasis on small-scale experimentation and rapid learning so that failure is early.

However, in the MoD and its oversight bodies, including the Public Accounts Committee, it is not uncommon to treat any write-off of public funds as a waste of money. Furthermore, alongside the consideration of technological risks are the dangers of awarding contracts to firms that perhaps lack a strong balance sheet or have limited track records, especially in defence.[45]

If the MoD is to embrace and exploit technological innovation, there needs to be an education process both within and outside the organisation about the inherent risks of proceeding modestly and slowly. This may require a change in the organisational cultures of both spending and oversight bodies. One official with extensive experience in both the military and the DE&S told the authors that many in the DE&S's commercial branch are significantly averse to such risks as contracts not being perfectly worded and negotiated, a contractor not having a strong enough balance sheet to deal with problems, test and acceptance arrangements not being optimised from an MoD perspective, and so on.

The Defence Solutions Centre and the projects funded by the Defence and Security Accelerator programme should be able to help reduce risks of technology not advancing or working as well as expected, as should experiments such as the army's Autonomous Warrior Programme. Prototype programmes can be valuable, though they must be carefully designed to prioritise working through the difficult rather than the straightforward, and they should take account of the likely integration costs of bringing a system into service.[46]

However, there is a clear link between financial resources and appetite for risk: public sector organisations under great financial pressure are unlikely to embrace the increased technological

43. An estimated 90% of Silicon Valley start-ups fail. See Jacquelyn Schneider, 'Swiping Left on Silicon Valley: New Commercial Analogies for Defense Innovation', *War on the Rocks*, 16 May 2017.
44. Ilkka Paananen (CEO and co-founder of Supercell, a mobile games developer) quoted in Rowan, *Non-Bullshit Innovation*, p. 54.
45. For a similar situation in the US, see Schneider, 'Swiping Left on Silicon Valley'.
46. As the 2003 Public Broadcasting Service documentary 'Battle of the X-Planes' illustrates, the prototype competition between Lockheed Martin and Boeing for what became the F-35 did not focus on the software development and integration challenges involved in generating an aircraft with extensive sensing capabilities. See MDx Media, 'Battle of the X-Planes (JSF Documentary from 2003) – Lockheed X-35 / F-35 and Boeing X-32', 5 August 2016, <https://www.youtube.com/watch?v=Y_WPLeDmU6o>, accessed 8 January 2020.

and financial risks of innovation. Significantly, MoD leadership has never generated a statement of risk appetite to guide those working across the government defence sector.

A key question of risk management concerns the actual risk that is being managed. Are participants managing the risks and opportunities of the organisation, or of their own careers and reputation? Each can generate very different behaviours. Career-related risk management can mean projects being pushed through approval points prematurely, so that a team and its leader can be credited with a specific achievement before they move on to new appointments. But equally, and of particular concern to innovation, it can also mean excessive reliance on a specified set of potentially time-consuming processes to provide cover for decision-makers should something subsequently go wrong.

Implications

How should current MoD attitudes towards risk be modified, and how could this be brought about? Since current risk attitudes appear part of the organisational culture, change will be hard.

An initial step would be for the top of the MoD – at ministerial, Defence Board and Executive Committee levels – to follow Treasury guidance[47] and generate a statement of risk appetite with regard to commercial, financial, technological and political risk so as to promote cohesive decision-making in the acquisition space and to facilitate delegation and faster decision-making. Such a statement would make clear that the need to match potential adversaries' speed of advance will require the UK to take similar risks, that innovation ambition will inevitably produce some failures, and that protracted decision-making periods to assure all aspects of a project increase the risk of UK forces being left behind and make defence less attractive as a customer to potential suppliers and innovators.

Education on the implications of such a statement would be needed across the government acquisition community, but its messages would have to be backed by public rewards for those who followed its direction. Anecdotal evidence offered in the working groups conducted for this paper suggests that some commercial officers in DE&S – the only ones with the power to sign contracts – are among those most reluctant to accept financial or schedule risk, fearing that they may potentially be wasting public money.

A refreshed attitude to risk as a cultural enabler of innovation could come to the fore in the funding of future-technology demonstrators. These initiatives are, in essence, programme- and project-risk mitigation investments. This paper recommends a separate funding line for

47. HM Government, 'The Orange Book: Management of Risk – Principles and Concepts', May 2013 (last updated July 2019), p. 26. This guidance document asserts that it is the responsibility of the top of a department (namely, its board) to 'determine and continuously assess the nature and extent of the principal risks that the organisation is willing to take to achieve its objectives – its "risk appetite" – and ensure that planning and decision-making appropriately reflect this assessment'.

future technology demonstrators within the defence budget, to be used to address specific capability challenges as they arise. This could be matched by commercial funds for the life of the technology demonstrator, and where the intellectual property generated is co-owned by both public and commercial partners – potentially released to defence under licence rather than under the condition of sole MoD ownership.

The Scope of Procurement and Speed of Decision-Making

Affecting the ease and probability of innovation is whether an acquisition decision that has the optimum scope, is taken at the right moment and at speed is viewed as a virtuous commodity.

One of the issues for innovation around the scope of procurement is whether and to what extent the MoD should increase its autonomy in systems upgrades by buying not just the system, but also the information that would make the MoD a de facto design authority, able to modify the system without the original supplier's consent. Given that this would often involve a company handing over precious intellectual property, the costs could be high.[48]

Another question is whether bids for major systems should include explicit provision for design as open systems, in order to facilitate modification and technology insertion. This would be a big ask, given that the MoD often still fails to take through-life costs seriously at the early stage of a development project, despite years of commitment to their early and better treatment. It might also prove to be a tricky element to assess with evidenced fairness in a competitive tendering situation.

Closely coupled with an appropriate risk appetite is the need for speedy defence-procurement decision-making, if the armed forces are to keep up with the technology available in the civil commercial sector, as well as with potential adversaries. To quote Andrew Imbrie, 'it may not be the nation with the best technology that surges ahead, but the one with the most efficient and agile bureaucracy'.[49]

There is widespread recognition in both the UK and the US that the speed of government procurement is too slow. By spending much time and effort checking that all relevant information

48. The US Government Accountability Office examined this issue in 2011, and there are extensive US debates on this topic and tensions between customer demands and supplier willingness. See US Government Accountability Office, 'Defense Acquisition: DOD Should Clarify Requirements for Assessing and Documenting Technical-Data Needs', GAO-11-469, May 2011; W Jay DeVecchio and Locke Bell, 'Sikorsky: What the GAO Said and Did Not Say About Soliciting Data Rights', Government Contracts Insights, 30 May 2018, <https://govcon.mofo.com/compliance/sikorsky-what-the-gao-said-and-did-not-say-about-soliciting-data-rights/>, accessed 8 January 2020; Kelsey Reichmann, 'Fair and Open? Bulk of DoD Dollars Continue to Filter to a Few Market Giants', *Defense News*, 30 May 2019.
49. Andrew Imbrie, 'Artificial Intelligence Meets Bureaucratic Politics', *War on the Rocks*, 1 August 2019.

has been collected and analysed, and that all documents have been perfectly drafted, the MoD reduces the probability of many hazards – such as gaps and ambiguities in requirements – but significantly increases the risk that defence will not keep pace with technological change and potential adversaries. Potential suppliers can be driven away, including by the length of MoD contracts and the demanding terms they include. Business cases, multiple stages of approval and competitive tendering can generate auditable processes and confidence that some risks are being reduced and that value for money is being achieved – but they generally do not accelerate acquisition.

Can government and corporate decision-making move at the same speed as technology can advance? Some analysts see signs that a political emphasis on speed can have an effect, in particular on military space decisions.[50] But at least one major study finds this problematic in the US context, and argues that the 'DoD must put its acquisition system on a war footing and adopt a mission first approach … Rapidly and effectively acquiring warfighting capability and delivering it to Service Members takes precedence over other public policy objectives'.[51] Still, in the US, an endorsement of the increased use of Other Contractual Authority mechanisms where appropriate and the multiple recommendations of the Section 809 Panel on acquisition reform indicate a potential shift in favour of faster decision-making.[52]

The MoD's Spearhead programme includes a commitment to making faster choices, but these may require a culture change, both internally and in its overseers in the Treasury. Culture starts from the top of an organisation, and it can sometimes be a challenge to find the ministers, military leaders and senior officials who champion speed of technological decision-making over well-trodden managerial processes. However, even when found, such people need to be in power for a sustained period – since 2010, the average time in office of a UK secretary of state for defence has been well under two years.[53]

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50. Marcus Weisgerber, '"Space Force" Windfall Unclear for Eager Defense Companies', *Defense One*, 10 April 2019.
51. Section 809 Panel, 'Advisory Panel on Streamlining and Codifying Acquisition Regulations: A Roadmap to the Section 809 Panel Reports', February 2019, p. 1. Also see Jeffrey P Bialos, Christine E Fisher and Stuart L Koehl, *Against the Odds: Driving Defense Innovation in a Change-Resistant Ecosystem* (Washington, DC: Center for Transatlantic Relations, Johns Hopkins University, February 2017); Stan Soloway, 'Congress is Sending Mixed Messages on Defense Procurement', Government Executive, 26 May 2017, <https://www.govexec.com/management/2017/05/congress-sending-mixed-messages-defense-procurement/138203/>, accessed 8 January 2020. On the specifics of cyber warfare tools, see Z Fryer-Briggs, 'The Digital Front Line', *Jane's Defence Weekly* (Vol. 54, No. 18, May 2017), p. 24.
52. Jared Serbu, 'Section 809 Panel's Final Report Prescribes "Revolutionary" Changes to DoD Buying', Federal News Network, 15 January 2019.
53. Before Ben Wallace, the UK had five secretaries of state for defence between 2010 and 2019 with a mean tenure of 19 months. Even if the briefly serving Penny Mordaunt (less than three months) is excluded, the average of the remaining four was just 24 months. However, a long-serving

The central structure for UK acquisition is the CADMID cycle with its original two approval points at Initial and Main Gate.[54] Over time, many projects – of which the F-35 Lightning II is the most prominent – have been broken down into more numerous and limited approvals for chunks of the overall project. In 2019, the MoD also announced that it was adopting Treasury guidance and introducing a further, launch-approval stage.[55] This involves a Strategic Outline Case covering strategic, economic, commercial, financial and management factors, and a report on how scrutiny, assurance and approvals are to be addressed in a simplified and integrated way. The implication appears to be that the MoD will be even more careful about its decisions, not quicker.

Implications

Acquisition must be faster. Those involved in future-capability generation – specifically, commercial suppliers – must be confident that the process will be appropriately paced and devoid of unnecessary bureaucracy. These are long-term cultural and leadership issues. In terms of project scope, a clear and simple improvement would be for choices of contractor to be made within the time specified in the invitation-to-tender documents: any delays would then have to be publicly justified.

Capable Suppliers and Networks

Scholars of innovation emphasise the need for capable minds and organisations that are motivated by both material and ideational drivers: the Reformation and the Renaissance are widely recognised as liberating forces enabling European advances and what became the continent's scientific and industrial revolutions. Some of the literature also stresses the value and effect of having multiple entities linked in networks, particularly cities.[56]

Within the context of defence innovation in the UK, the supply side presents a series of issues. While the MoD pays for some internal research and technological work through the Dstl, most R&D activity is outsourced to the private sector, which also commits some of its own resources to these activities. There are thus questions of whether internal MoD findings should be shared

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defence minister is unusual in most NATO member states, meaning the UK is not an exceptional case.

54. CADMID refers to Concept, Assessment, Demonstration, Manufacture, In-Service and Disposal. Initial Gate approval takes place at the end of the Concept phase, and Main Gate approval at the end of the Assessment phase. See Smart Acquisition, 'The Acquisition Handbook', 4th edition, January 2002, <http://www.defence.org.cn/aspnet/vip-usa/uploadfiles/2004102932134509.pdf>, accessed 8 January 2020.
55. See HM Treasury, 'Business Case Guidance for Projects', March 2019, <https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent>, accessed 8 January 2020.
56. For example, see Steven Johnson, *Where Good Ideas Come From: The Natural History of Innovation* (New York, NY: Penguin, 2010), p. 10.

with potential private-sector suppliers to create a national innovation base, or whether MoD work should be held internally as a support for requirements specification and the assessment of industry offerings.

A further question is whether defence companies are likely to be wholeheartedly committed to innovation, given two considerations. First, the defence-industrial sector is dominated by a few large primes. Innovation requires organisations and their workforces to be committed to radical change – including potentially abandoning longstanding products and cherished practices that have long delivered revenue. Clayton M Christensen's influential studies show how difficult established companies find it to move away from a proven, successful product and line of activity to one with better long-term potential: Kodak's failure to embrace digital cameras is a well-known illustration.[57] Defence companies are likely to be similarly attached to established product lines, especially without customer pressure to behave otherwise. Second, Frederik Erixon and Björn Weigel argue that the control of many large Western businesses by pension funds, insurance companies and other large, risk-averse bodies make the companies which they own, trade and monitor very reluctant to embrace the risk of radical new products.[58] Large defence companies in the US and the UK, especially, are subject to the same focus on short-term performance.

Given that innovative products often involve the integration of several new technologies, they can require new combinations of companies to be formed and work effectively together. Extant defence platforms which are the basis of capability for navies and air forces have especially large and complex supply networks. Some literature on innovation emphasises the importance of formal and informal networks of organisations and people.[59] With this in mind, the question is whether existing supply networks have the expertise to deliver future innovation and whether existing prime contractors and their main sub-system suppliers are sufficiently open and accessible to new suppliers and partners.

57. Clayton M Christensen, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail* (Cambridge, MA: Harvard Business Review Press, 2016); see also Pete Pachal, 'How Kodak Squandered Every Single Digital Opportunity It Had', *Mashable*, 20 January 2012, <https://mashable.com/2012/01/20/kodak-digital-missteps/?europe=true>; Nathan McAlone, 'This Man Invented the Digital Camera in 1975 — and His Bosses at Kodak Never Let It See the Light of Day', *Business Insider*, 17 August 2015; James Estrin, 'Kodak's First Digital Moment', *New York Times*, 12 August 2015.
58. Frederik Erixson and Björn Weigel, *The Innovation Illusion: How So Little is Produced by So Many Working So Hard* (New Haven, CT and London: Yale University Press, 2017).
59. Mark Zachary Taylor, *The Politics of Innovation: Why Some Countries are Better than Others at Science and Technology* (Oxford: Oxford University Press, 2016).

For innovative new suppliers in the civilian sector that could contribute to defence, there is a range of potential reasons for being reluctant to do business with defence:

- They may feel that the rate of return in the defence sector will be significantly lower than in larger civilian markets.
- They may not be content with the speed of government decision-making and the costly processes involved in bidding and contract management.
- They may fear export controls on their products if they have defence applications.
- Some have ethical objections to supporting the military, as the Google staff experience with Project Maven demonstrated.

Finally, innovations are typically generated by committed and able people. There was concern among those consulted for this study that if defence cannot show a capacity to move quickly, and if innovators cannot see their efforts resulting in significant change, they will leave for more rewarding sectors.

These considerations have been recognised by both the US and UK governments, which are consciously targeting civilian-origin technologies and small and medium-sized enterprises as potential defence suppliers.

In particular, developments in IT raise questions about the nature and identity of future prime contractors in defence. To date, responsibility for platforms has been allocated to those who are experts in their design and construction – namely aircraft, helicopter, ship and submarine builders. This has changed somewhat for some sensor-based systems, especially where the platform itself is not thought to require major protection systems.[60] Looking forward, it is conceivable that information- and AI-focused companies could become the leaders in platforms. This is what Tesla and Google are attempting in the automobile sector with their electric and self-driving vehicles. What sort of firms will be the best defence prime contractors given the direction of technological innovation?

In AI, the need for data, innovative practices in platform operations and maintenance will require the integration of government and private data. One working group for this study asked who owned the intellectual property associated with Project Tempest – an issue that will become more complicated in the event of it being an international collaborative project. Will the UK defence enterprise as a whole be able to take full advantage of AI's potential if issues of dispersed data ownership are not effectively addressed?

Established defence suppliers need to be ready to change the direction of their development expertise and to be ready to reduce the attention paid to established products. Companies in the civilian sector need reassurance about ethics and that the pains of moving into the sector

60. For example, Thales offers its maritime surveillance systems for use on satellites, aircraft and shore installations. See Thales, 'About Us', <https://www.thalesgroup.com/en/global/about-us>, accessed 8 January 2020.

will be worthwhile. Large, system-integrating companies will need to broaden their networks of collaborators and suppliers – both large and small – so that defence expertise and novel technology initiatives can be brought together to generate valued products. And the exploitation of AI will require dealing with the obstacles of diversified data ownership.

Implications

A discussion on suppliers, networks and the desire for innovation leads to one obvious insight: technological innovation is amorphous, and adaptive technologies are across a spectrum spanning large corporations dedicated to defence at one end through to small, niche partnerships not interested in the defence sector at all – but nevertheless possessing technological capabilities that could add significant value to defence – at the other. The MoD, therefore, needs to scan the horizon for the research activities of its current collaborators and historical partners – while also mining the insights and knowledge of parallel sectors, applicable technologies from the civilian sector and disruptive new entrants. As a result, the Dstl needs to be both an executor of MoD research unsuited for the private sector and a harvester of knowledge about defence-relevant technology across the globe. Given the rate and scope of technological transformation, this would be a role of strategic importance.[61]

This leads on to the final condition that, perhaps more than most, would enable and facilitate this paper's conception of innovation: the MoD as an intelligent customer – conditioned, lean and ready for disruption.

An Intelligent Customer Ready for Disruption

A final element in the innovation picture is the intelligence of customers and the readiness of customers and their related stakeholders to tolerate disruptive change.

When it succeeds, innovation produces gains, but also generates losers (for example, those who suffer reduced importance or even lose their job) – a trade-off which Harford describes as 'perhaps the biggest challenge for governments'.[62] Mark Zachary Taylor makes much of technological losers and points to the resistance to innovation that can take place through political activities.[63]

The UK TEPIDOIL and the US DOTMLPF frameworks help examine these considerations. As the original role of the American DOTMLPF framework points out, changing lines of development can be a significant source of innovation in itself. In the US Joint Capability Integration System, for

61. In an interview with Nick Watts, the Chief Executive of Dstl, Gary Aitkenhead recognised the relevance of much commercial-origin technology to defence. Aitkenhead did not explicitly address how his organisation was monitoring global developments. See Interview with Nick Watts, *Jane's Defence Weekly*, 10 December 2019.
62. Harford, *Fifty Things That Made the World Economy*, p. 284.
63. Taylor, *The Politics of Innovation*; see also Christensen, *The Innovator's Dilemma*.

example, the services are required to explore whether a 'non-materiel' solution to a capability gap is possible, involving a reordering of existing assets and practices.

A different consideration emerges when new technologies appear in the equipment domain that do require significant changes in other TEPIDOIL/DOTMLPF factors. Historically, there has often been resistance from the uniformed services when their established ways of working have been challenged – the machine gun was slow to win favour with the US and British military, and the Polish cavalry went to war in 1939 on horseback. In *Warfighting and Disruptive Technologies*, Terry Pierce spells out numerous cases of military conservatism and reluctance to embrace new possibilities.[64] Andrew Imbrie and Jacqueline Schneider of the US Naval War College and Sean Atkins of the US Air Force see such conservatism as a continuing concern.[65] A British warrant officer, with long experience in army headquarters, told the authors with a smile that the army was very keen on innovation in areas that did not matter to it – 'such as how to fight', which had long been a topic of change – but it was not at all interested in innovations that would change things that did matter. These areas include the regimental system, officer's messes and systems for the recruitment and advancement of individuals – in other words, organisational culture.

Some wariness about radical change is understandable: defence organisations are complex entities where change in one part can generate unintended consequences elsewhere, and new technologies may be insufficiently reliable in a context where many lives are at stake. The first steam-driven warships of the US, French and UK navies were also fitted with sails as a back-up measure. Moreover, the world of conflict often throws up surprises, such as when old transport technology (mules) proved useful in the mountains of Afghanistan.[66] However, failure to adapt can be extremely costly, as the Polish, British and French armed forces discovered in 1939 and 1940.

It is therefore important to examine an organisation's readiness for and resistance to disruptive change. Are the UK armed forces and their directing governmental authorities ready for the kind of change that might be around the corner? Examples of this change could include: a much higher proportion of naval forces operating underwater with small crews; aircraft and underwater vessels being piloted remotely, or even autonomously; physical human strength and fitness becoming less significant for military personnel; and the end of the tank as a specialist vehicle. Furthermore, what would be the British stance on genetically modified soldiers – a topic which is of considerable interest in China?[67]

64. Pierce, *Warfighting and Disruptive Technologies*.
65. Schneider, 'Swiping Left on Silicon Valley'; Imbrie, 'Artificial Intelligence Meets Bureaucratic Politics'; Atkins, 'Staff Sergeant Disruptor'.
66. Gordon Lubold, 'Fighting a High-Tech War with a Low-Tech Mule', *Christian Science Monitor*, 4 May 2009.
67. Elsa B Kania and Wilson VornDick, 'Weaponizing Biotech: How China's Military is Preparing for a "New Domain of Warfare"', *Defense One*, 14 August 2019.

The UK can point to a track record of taking on difficult change over the past 20 years, but the single services and their components were always concerned about the threat to their significance posed by the Equipment Capability Customer and its successor bodies, and their focus on capability-based requirements in the MoD centre. Their concerns were lessened by the Levene reforms, which gave them back more control over equipment requirements and choosing solutions. Rhetorically, one might ask if there was ever any possibility that the successor system to the cancelled Nimrod MRA4 maritime patrol aircraft would be anything other than another large piloted aircraft with either two or four engines. The UK eventually opted for the American P8A. The conservatism of the UK armed forces cannot be entirely ruled out.

It must be recognised that disruption from innovation can be unexpected and unwelcome. The former Chief of Staff of the US Army (later Chairman of the Joint Chiefs) General Mark Milley has complained that the rise of information and communications technology has helped to move the US Army away from mission command and towards the micromanagement of operations by senior commanders.[68] Despite the speed of communications, micromanagement can slow decision-making (with consequences such as those presented in the 2015 fictional film, *Eye in the Sky*). Thus, any innovation programme, such as the UK's Army Warfighting Experiment that significantly challenges key ways of doing things and the future of existing organisations and people, must overcome almost inevitable resistance.

Intelligent customers are an important aspect of reacting to technological advance and the disruption it may entail. In order to manage risk effectively and prioritise investment, the defence customer must understand technology, and be aware of what is possible today and what may well be possible tomorrow. Technological expertise includes understanding of safety considerations and, of course, how technologies can be adopted and adapted to generate military advantage. One of the participants in this study argued that the outsourcing of the last 30 years has deprived the MoD of much scientific expertise, with the result that the MoD itself cannot assess what sensible regulation would look like for emerging and future technologies. As a consequence, there is a tendency to rely on established – that is, outdated – and extensive processes, and to pass work to a first round of consultants who undertake safety case and regulatory tasks, and then to the employment of a second round of consultants who review the work of the first.

The intelligent customer also needs a clear sense of how best to acquire a given technology, which involves a sophisticated acquisition workforce that understands the pressures and risks of the commercial world. There is a real possibility in the UK that, through commitments to reduce the number of civil servants and to outsource many defence functions, the MoD has become excessively reliant on outside 'customer friend' organisations to help it understand what should be done. It must rely extensively on consultants to articulate requirements, specify safety standards, evaluate bids and manage commercial relationships with its suppliers.

68. Sydney J Freedberg Jr, 'Let Leaders off the Electronic Leash: CSA Milley', *Breaking Defense*, 5 May 2017; Crispin Burke, 'The Army Wants to Let Troops off the "Digital Leash". That's Easier Said Than Done', *Defense One*, 15 May 2017.

Implication

Optimising the defence ecosystem for innovation will be difficult, challenging the organisational cultures of both the users and producers of technology. Yet this optimisation is vital for UK defence if it is to meet the security challenges and threats facing the country. Emphasising innovation in a sector where there is only one customer – the government – limits the scope for a confrontational, transactional and overly linear approach to the generation of defence capabilities. This is, of course, the very criticism that could be levied at CADMID and myriad in-service commercial agreements. The role for the government is to sponsor the private sector in a manner that releases rather than constrains innovation, generating enduring technological advantage over the UK's adversaries.

Conclusions

THIS PAPER IS premised on the UK's critical need for continual innovation and the insertion of advanced technologies into defence systems – a requirement that is more strategically significant than the good husbandry of resources or diligent commercial monitoring, important though these things might be procedurally. To explore this idea, the paper used a model of seven dimensions enabling innovation to be inserted and, culturally, ever present across the sector:

- Demand.
- Technological development.
- Money.
- Risk appetite and management.
- Scope of procurement and speed of decision-making.
- Capable suppliers and networks.
- An intelligent customer ready for disruption.

This paper builds on expansive literature covering defence and innovation to explore the characteristics of an ecosystem that would have evolved, and been deliberately reformed, to embrace technological and behavioural innovation and continual change.

If businesses are to be incentivised to devote their best staff and ideas to defence work, they require open and early dialogue with the government – and its existing commercial partners – about what the military would value. Hi-tech firms that are new to defence will not want their good ideas prematurely exposed to the wider world through competitive tender processes and documentation, and they will look for the quick decisions and results of the commercial world.

The UK government has little option but to take on the risks of treating industry as a partner from an early stage of innovation work. The chances of successful, radical and innovative defence solutions will be reduced if the government and its suppliers see each other as operating in a zero-sum, adversarial situation, given their respective knowledge and expertise on the four key aspects of successful innovation:[69]

- The condition and trajectory of core enabling technologies.

69. This framework reflects the work of Marco Iansiti, *Technology Integration: Making Critical Choices in a Dynamic World* (Cambridge, MA: Harvard Business School, 1997); and the GAO in its knowledge- based approach to defence acquisition. See GAO, 'Best Practices: Using a Knowledge Based Approach to Improve Defense Acquisition', Washington DC, January 2004, and then used in its subsequent annual reports on Defense Acquisitions: Assessments of Selected Weapon Programs.

- How these technologies work together in a system.
- The time and cost to manufacture and market reliable capability.
- Insight as to what the sector and its market can bear.

As a starting point for change, the implications highlighted in this paper suggest the following activity in each category:

Demand

- The government should overtly articulate the strategic security challenges faced by the UK.
- Innovation and hi-tech capabilities should be placed at the centre of the narrative in addressing these challenges.

Technological Development

- The government should acknowledge the importance of scientific advice, and review the level of funding necessary to understand the speed and significance of technological change and what it means for defence.
- Major systems should be conceptualised and designed as open systems that can be continually modified and updated, with new technologies inserted throughout the life cycle. Standards on open systems should be developed and applied to the acquisition of new defence capabilities.

Money

- The government should consider changing the CADMID cycle so that continual, through-life modifications are the norm, associated with the regular insertion of new technologies:
    - Specific technology demonstrators should be planned and financed relating to upgraded capability identified in earlier phases of CADMID.
    - The financing of these capability-specific technology demonstrators could be shared between MoD, the prime contractor and the owners of the disruptive technology which is sought for the upgrade.
    - Moreover, these technology demonstrators could be commercially established as joint ventures between the MoD and private sector, sharing the intellectual property and downstream commercial benefits.
    - For business cases and approvals, consideration should be given to establishing an identified funding line for capability system innovation.

Risk Management and Appetite

- The MoD should consider its attitude to risk, so that new suppliers with an evolving track record and organisational structure, and weak balance sheet, can still offer niche technologies to defence.

- In developing risk-based three-point estimates for programme approval, schedule risk (time) should often be considered for a higher decision-weighting than cost risk.

The Scope of Procurement and Speed of Decision-Making

- Culturally, speed should be valued as much as cost when it comes to decision-making for the acquisition of capabilities:
    - The MoD should consider the costs and advantages of purchasing time-sensitive data packages relating to a system to diminish reliance on a prime contractor for innovative upgrades.
    - When considering purchases from suppliers outside the UK, the British capacity to introduce innovations into those systems should be considered alongside the UK's capacity to reject innovations from an external supplier that are not needed by its military.
    - The MoD should consider the incentives in place for the speedy insertion of new capabilities.
    - The MoD should assess its current stances and consider introducing new policies and practical measures for actively encouraging new entrants into the defence sector.
    - As part of DE&S reform, the MoD should build increased awareness among its staff of the cost and consequences of its own processes and how these should be continually tested, appraised and developed.

Capable Suppliers and Networks

- The MoD should consider using the Dstl as a strategic asset to generate a repository of technological knowledge, rather than undertake or commission research itself (though there might be exceptional necessity for this):
    - Much of this knowledge repository, at summary level, could be public. This would encourage new suppliers and niche technologists to engage with defence.
    - The new networks that result could be exploited within refreshed technology demonstrators.

The recommendations offered above, if enacted, would greatly help the MoD to act as an intelligent customer, culturally and behaviourally comfortable with disruption and technological transformation. The MoD's cultural condition is, perhaps, the principal strategic issue facing UK defence today. But we should not be shocked by such an assertion. Transformational technologies – airpower at the beginning of the 20th century, the tank as a unit of battlefield mobility rather than the horse, the jet engine – all brought profound change to the way defence capability was viewed, generated and used. Today is no different except that, perhaps, the speed and range of technological change is significantly faster and broader. The lesson from history for defence decision-makers is to reform or fall behind and, eventually, face defeat. The UK now confronts the same test, with the same consequences.

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