

MOD Area of Research Interest

This document sets out the collective high level areas of science and analysis interest for the Ministry of Defence. It reflects the extensive range of challenges faced by Defence and Security, although it is not comprehensive and it is not a list of projects, but rather themes around which Defence's challenges exist.

This MOD Area of Research Interest aligns to and supports the [MOD Science and Technology Strategy](#). The primary mechanism to implement the MOD Strategy is the MOD core research portfolio and this MOD Area of Research Interest.

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Defence Context

Science and technology (S&T) is critical to the UK's Defence and Security capability, whether this is horizon scanning to understand simple or sophisticated threats; or novel S&T to develop, design, and generate military capability; or having the skills and capabilities required to own and manage a sovereign nuclear deterrent.

The twenty-first century is one of increasing convergence, for example between defence and security (as seen with DAESH) and between military and civilian uses of S&T. Defence must prepare for this new world and S&T is essential to help MOD, and the United Kingdom as a whole, better position itself as a strong global player.

In supporting the delivery of military capability and operations on land, at sea, in the air and through cyberspace, we exploit science, research and technology from the full spectrum of scientific disciplines from mathematics, engineering, chemistry, physics, biology, software systems, medicine, through to social behavioural sciences.

In some areas, this may be finding technology solutions to counter emerging external threats or factors, such as the need for precision navigation and timing capability independent of GPS, to improve our resilience. In other areas we will need to understand the emerging development of potential game-changing technologies, such as those harnessing quantum phenomena, or energetic materials and novel weapons. This means not just understanding emerging technologies, but also the wider future political and societal context.

Our priorities focus on:

- **understanding** our changing physical and social operating environments and the effect of new technologies, through horizon scanning, a greater comprehension of social sciences and enhanced sensing capabilities;

- harnessing advances in information, **big data and autonomy**;
- enhancing **military capabilities** through technology, including power management, exploitation of the electromagnetic spectrum and advanced materials;
- reducing the long term **costs** of military capability, including platforms, space based capabilities and training;
- maximising the potential of our **people**; and having the right **technical skills** for the future.

Defence seeks to balance investment in S&T for longer term development alongside addressing shorter-term tactical needs and between technology-push from S&T providers, which creates new opportunities from S&T, and technology-pull from the end-users.

The rapidly evolving operating environment

Fifty years ago, major technological developments were primarily driven by the space race and the Cold War. Today, almost all technology development, derived from current global S&T investment, is driven by the consumer market. Advanced technology development, once the realm of government laboratories, is now carried out to a large extent in the civil and commercial sectors. As technology continues to be driven by market needs, exploitation of technology to meet defence and security needs will require an increasing focus and understanding of emerging technologies and their opportunities and impacts on the future of Defence and Security. As well as increased understanding of the evolving physical and social environments in which Defence operates.

Understanding implication of future technology - Our service personnel and systems will be threatened by the availability of a greater number of devices with diverse sensing modalities, weapon systems with longer range, enhanced lethality and an adversary who could deploy them in ways that exploit our vulnerabilities. Our ability to objectively assess threats from technological advances in areas such as cyber, unmanned systems and additive manufacturing, and quantify their consequences is key to our understanding of future risk.

Disruptive technologies – New technologies such as High Performance Computing, quantum information processing and synthetic biology have the potential to radically change the nature and environment of warfare in the future. The key challenge for Defence is understanding the risks and opportunities presented by the technologies and forecasting when and where the impact on defence will occur. How should Defence proactively shape our doctrine and policy to maximise the benefits whilst minimising the threat to defence?

Sensors – The basic human need to know and understand your environment is of particular imperative to the Armed Forces. Defence is interested in the development of small, low-power, light-weight, multi-modal sensing capabilities for example to detect explosive and chemical substances, and radio frequency emissions.

Determining intent – In complex environments involving a range of military and civilian actors, from a variety of cultural backgrounds, we need to be able to determine the intent of adversaries from posture, movement, emissions and stance prior to overt aggressive action.

Human engagement - For future operations, are there alternatives to the use of hard/physical power? How can we best predict behaviour in response to our actions? How do we best engage with diverse communities, particularly where our adversaries may be hiding within the civilian populations? How do we work effectively with our Allies?

Information, big data and autonomy

In an increasingly connected and complex world, we need to optimise our use of rich and diverse data sets to inform decision makers in a timely manner. As the types and volumes of information available to the commander increase, this will place a greater importance on tools and techniques to collate, synthesise and visualise information in a timely and understandable way so that it can be readily acted upon. Different sources will have different degrees of assurance but combining multiple information sources greatly increases the robustness of the analysis – although we need to be able to show levels of certainty/uncertainty within the analysis.

Ubiquitous sensing and processing - in the future, sensors will become smaller and cheaper leading to their wide availability both in civilian applications and in defence. They will also be available to our adversaries. How they are deployed and how the information they generate is managed and used will be key. We need to understand how they will be networked and how automation could be exploited to task and manage them.

Reducing Cognitive Load - Greater access to data, information and services will challenge the cognitive loading on personnel. How can new technology help reduce this burden through, for example, autonomous software agents? Which functions could be carried out by machine and, conversely, what decisions will still need to be taken by human operators to ensure compliance with legal and ethical standards? How do we integrate these advances into our command and control systems?

Data Science and Decisions - How can MOD harness the benefits of data science? How do we build trust in automated systems? How do we integrate multiple sources of information with differing levels of uncertainty and represent this effectively and efficiently to busy decision makers?

Autonomous systems – What are the ways Defence could exploit autonomy and autonomous systems in military operations and potentially at lower cost than traditional high-end military platforms? What is the range of potential benefits of utilising autonomous systems in Defence; greater areas covered, persistent effects, or removing personnel from immediate danger? How can we reduce the need for human involvement in difficult, mundane and dangerous tasks such as bomb disposal, force protection or decontamination?

Integrating autonomous systems - Defence is interested in addressing the integration challenges of operating these new autonomous systems with legacy military capabilities. From a people perspective - what are the opportunities, costs and risks of introducing autonomous systems? How do we effectively integrate people with autonomous systems and define the boundaries and interfaces?

Maintaining advantage through enhanced technology

As commercial investment introduces widely available and low cost systems, the technological lead of the UK and its allies over adversaries is likely to be further eroded, with the democratisation of technologies such as additive manufacturing, cyber and unmanned systems enabling non-government actors to strike at the UK. To counter these advances we need to explore technologies which will improve the survivability of our people and platforms, extended their endurance, and ensure robust and resilient military capabilities.

Energy and power – Defence is interested in understanding how advances in energy generation and storage and smart materials may promote more efficient energy consumption, reduce logistic footprint, soldier burden and support high power future sensing and weapons systems.

Exploiting the electromagnetic spectrum - How do we develop approaches to maximise the use of the electronic spectrum in congested environments to ensure commanders are able to access the information they need? How can we improve secure transmission of information? How do we integrate new and emerging technological solutions with legacy equipment to achieve this communications edge?

Materials and structures – Understanding material selection and performance, ageing, shock and impact resistance, corrosion, design and lifeing aimed towards reducing the long term cost of military equipment across a range of platforms, weapons and application areas. How do we pull through promising materials quickly and at low enough cost to enable early adoption?

Self-sustaining forces - When the UK deploys forces overseas it has to ensure that they are supported by an appropriately robust and effective logistics infrastructure that ensures the timely delivery of consumables and other materiel. MOD is interested in all aspects of technology, or alternative ways of working, that minimise the logistic infrastructure particularly that exposed to risk. Interests span technology for reducing the logistic footprint itself for example through the use of renewable or alternative energy sources, through to the use of additive manufacturing that might reduce the need for a large holding of spares in-theatre.

Reducing the long term costs of military capability

Defence spends around £8 billion annually on the provision of equipment and technological solutions for our Armed Forces. The cost of delivering and maintaining these platforms grows with technical complexity. For military platforms and weapons systems, there are significant technical challenges in driving down the cost of integration and ownership; integrating these systems into a networked environment; addressing a range of difficult targets; and providing the ability to defeat targets under highly constrained rules of engagement. This will drive the need for increased stand-off ranges of our platform and weapons systems which will require developments in our propulsion and airframe designs.

Cost - Traditional complex military capability is designed and built to counter technologically sophisticated military adversaries. What low cost, simple solutions exist to address the future spectrum of potential adversary capabilities? How can we ensure military units and capabilities are sufficiently agile to fulfil a range of potential roles and counter the spectrum of adversaries? How do we introduce asymmetric capability to our advantage? How do we integrate new technologies into complex systems at affordable cost?

Training – Preparing our people for operations with appropriate training can be costly. How do we harness advances in synthetics and simulation to reduce the need for real training? What technological advances will improve our ability to train and prepare for dangerous situations without exposing our people to unnecessary risks? How do we reduce our burden on the physical environment? What is the optimum blend of real/synthetic training? How do we measure the effectiveness of team and collective training?

Affordable space – How can Defence achieve affordable access to space? How can we harness advances in the commercial sector and maximise our use of space based services? How do we improve our situation awareness of space? Where are the opportunities to reduce the size, weight and power of space based capabilities?

Test and evaluation – What are the opportunities to reduce the cost and environmental impacts associated with the test and evaluation of large scale, integrated and complex military systems?

Supporting and protecting our people

Defence of the UK is critically reliant on access to an appropriately skilled and trained workforce. Demographic changes in the UK, combined with a range of technology advances are likely to change the role of the human in future military tasks – this will demand new skills and different ways of attracting people to join the Defence Enterprise.

Future skills - We assess that the world of tomorrow will be increasingly automated. How could we determine the different blend of skills needed by Defence in the future? With other sectors competing for the skilled labour, how could Defence ensure it can attract an agile workforce with the required skills?

Human performance - Are there opportunities to improve or augment human performance to reduce cognitive or physical burden? How do we cope with the impact of changes in climate impact on human performance? How do we design clothing and equipment to mitigate these constraints?

Managing careers - Where the need for people/human capital endures, how do we build fulfilling Defence careers, particularly in scarce skill disciplines where traditional military hierarchies, structures and approaches do not attract people with the skills we need for the future? How do we encourage a broader range of people to work in challenging roles and environments?

S&T Skills – The complex challenges faced by Defence requires a multidisciplinary approach. However of particular interest is access to those specialist skills relating to nuclear, energetics and explosives, autonomy, aerodynamics, big data and cyber. There will be a continuing demand for systems engineering skills to harness and integrate technology for military advantage. Within Defence there are opportunities for engineering and scientific apprenticeships, industrial placements and summer student placements which all provide the opportunity to work on challenging but exciting problems.

Improving how we conduct our business

In common with other areas of government, MOD is interested in developing tools and techniques to improve our understanding of the S&T landscape using a variety of approaches, such as scientometrics and data analytics¹ to inform S&T strategy, policy and commissioning. Such input will enable MOD to access a rich picture of where S&T capability resides, global investments and how we can better use this knowledge to supporting interventions, manage risk and signpost opportunities.

We are also interested to understand how developments in new engagement models and S&T funding tools and transactions, such as crowdfunding / crowdsourcing, hackathons, distributed ledgers, could impact on the way Defence and Security procures and delivers its outcomes and business in the future.

Contact us

For matters regarding this Area of Research Interest or the MOD S&T Strategy:

DST-StrategySecretariat@mod.uk

To submit research proposals please contact the [Defence and Security Accelerator](#):
accelerator@dstl.gov.uk

¹ Spanning capability in the UK, overseas, commercial and Defence/Security.