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More Soldiers in the Laboratory

the militarisation of science and technology – an update

Chris Langley, Stuart Parkinson and Philip Webber

SGR

Promoting ethical science, design and technology

About the authors

Chris Langley holds degrees from University College London and the University of Cambridge. After post-doctoral research in neurobiology at Cambridge he has spent more than 20 years in science policy and the communication of science, technology and medicine. He currently runs ScienceSources, an independent consultancy, providing access to science, engineering and technology for the non-profit sector, together with training in communication skills. He has produced critiques of science and medicine for lay and professional audiences, and given presentations and invited lectures on science communication, ethical science and the military influence in science and engineering. Most recently he authored the Scientists for Global Responsibility (SGR) publications *Soldiers in the Laboratory* and *Scientists or Soldiers?*

Stuart Parkinson is Director of SGR. He started his career as an electronic engineer working for a military corporation, before ethical concerns led him to return to university to do a PhD in climate science. He has since carried out scientific research and education work across a range of areas including climate change policy, energy and the environment, science ethics and science policy. He has been an expert reviewer for the Intergovernmental Panel on Climate Change. He has also edited or co-edited numerous SGR publications including *Soldiers in the Laboratory* and 11 briefings/booklets as part of SGR's ethical careers programme.

Philip Webber has written widely on defence and ethical issues in relation to science and technology. His publications include the books *London After the Bomb, Crisis over Cruise* (both co-authored) and *New Defence Strategies for the 1990s*. He also co-edited SGR's *Soldiers in the Laboratory*. Dr Webber has been Chair of SGR for 13 of its 15 years and is head of a leading environment unit in West Yorkshire. His career also includes a spell as Deputy Director of Emergency Planning, South Yorkshire, and 12 years as a research scientist at Imperial College, London, where he gained his PhD.

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Summary

Military involvement in science and technology has expanded significantly in recent years, driven to a large extent by the so-called 'War on Terror' and related conflicts in Afghanistan and Iraq. In the USA, government spending on military research and development (R&D) is expected to reach a massive $78 billion in 2007, a 57% increase since 2001. In the UK – third in the world rankings in terms of government spending on military R&D – the changes have been more qualitative, with two new national programmes rolled out in the last two years: the Defence Industrial Strategy and the Defence Technology Strategy. The latter in particular marks an expanded effort to involve universities more deeply in military R&D.

This briefing charts the recent developments in this field, especially in the UK, updating the arguments provided in the 2005 report *Soldiers in the Laboratory*, produced by Scientists for Global Responsibility (SGR). By drawing on new information, including some gained through the use of the new Freedom of Information Act (FoIA), the briefing highlights how the military involvement in R&D continues to support a narrow weapons-based security agenda. We argue that this marginalises a broader approach to security, which would give much greater priority to supporting conflict prevention by helping to address the roots of conflict. As part of this case, we point out how R&D that aims to help tackle poverty, climate change and ill-health – and thus help to provide basic security for human populations – is under-funded compared with military R&D. As an example, in 2004, governments in industrialised countries spent a total of $85 billion on military R&D, but only $50 billion on R&D for health and environmental protection, and less than $1 billion on R&D for renewable energy. A similar imbalance can be seen in UK spending.

The briefing also highlights the fact that, despite the entry into force of the FoIA, the ability to obtain detailed information on military involvement in R&D, especially within universities, remains highly problematic and further reform is needed.

In conclusion, we argue that a major shift in scientific and engineering resources away from the military and towards areas that support social justice and environmental protection is long overdue.

Introduction

Spending on military objectives forms a large proportion of the budgets in both industrialised countries and the developing world. Global military expenditure now exceeds $1.2 trillion a year[1]. Spending on military science and technology has also reached very high levels. While the bulk of recent increases in spending are by the USA, the UK continues to spend significant amounts. Indeed, voices within the UK military sector and the House of Commons Defence Select Committee would like to see UK military spending increased to keep pace with the USA. Globally and nationally, spending on military objectives and the supporting R&D are rarely subjected to rigorous and non-partisan examination.

In January 2005, SGR published a report, *Soldiers in the Laboratory*[2] (SITL), which was a detailed examination of the military involvement in science and technology, especially in the UK, since the end of the Cold War. The report highlighted the extensive military involvement in research, teaching and technological development, and made the case that this strongly influenced the direction of work in many fields. In essence, we argued, such military influence leads to a focus on a narrow weapons-based security agenda, rather than a broader security approach that emphasises conflict prevention by aiming to address the variety of the roots of conflict.

This briefing provides an update on developments in the areas covered by the SITL report, and critically assesses the effect of such developments on the wider political landscape. We start by discussing the continuing growth in military budgets, together with the parallel increase in military dependence on computer systems, information and communication technology, and robotics as part of the so-called 'Revolution in Military Affairs'. We outline two new UK government strategies that demonstrate this trend – the Defence Industrial Strategy and the Defence Technology Strategy – and their role in pushing military involvement further into the university sector. We then present some pilot research, partly based on data obtained using the new Freedom of Information Act, which raises concerns both about the true extent of military involvement in the academic sector and the difficulty in obtaining such information. Finally, we reflect on the problems of the continuation of the high-technology security agenda and the growing evidence in support of a major redeployment of science and technology resources to meet other urgent needs.

The latest developments

Military spending continues to increase

There is little sign that the large increases in military spending seen in recent years are slowing. Latest figures show that global military expenditure rose in 2006 to a massive $1.2 trillion[3] (in 2005 US dollars) – a figure likely to be an underestimate. Over the decade 1996 to 2005, the world total rose by $254 billion[4].

The United States' spending continues to be considerably higher than other countries. In 2006, it spent $529 billion, approximately 45% of the global total – costs in large part due to the so-called 'War on Terror' and related conflicts in Iraq and Afghanistan[5]. The Department of Defense (DoD) request for the military budget for Fiscal Year 2008 is $717 billion, which would make it the largest in real terms (taking into account inflation) since 1946[6]. The request for military spending in 2008 represents an increase of 100% over that agreed for Fiscal Year 2001[7] and there are no signs of a slowdown in the increases in military spending. Such increases come despite the USA having almost unchallenged military-technological and economic dominance in the world.

The country with the second largest military expenditure in the world is the UK[8]. In 2007/8, the planned budget is expected to be around £33.4 billion – an average rise of 1.4% each year in real terms since 2004/5[9]. Around £14.5 billion was allocated to procurement of military equipment in 2005/6[10].

However, it is extremely difficult to provide reliable estimates of total UK military spending, partly because it is complicated by 'unplanned' activities in Iraq and Afghanistan and other regions[11]. The conflict in Iraq alone cost £3.1 billion in the three years up to 31 March 2005[12]. The UK government also spent significant sums in the Balkans and Afghanistan in 2004/5. An additional factor in the increasing costs in the UK is a modernising and equipping programme which was set out in the 2004 Futures Capabilities programme – a supplement to the Defence White Paper a year earlier[13].

The strategic security rationale, especially within the USA and UK, continues to be a high-technology, weapons-based, networked approach – based on what some call the Revolution in Military Affairs (RMA). This 'revolution' is critically dependent on information and communications technology, aided by computer networks and robotic devices. It draws heavily upon the scientific and engineering expertise from the in-house R&D facilities of military corporations and government, but it also increasingly depends upon expertise in UK and US universities, as we discuss later. An important and controversial aspect of the RMA is its dependence upon robot vehicles (the human pilot often being remote) to deliver weapons and collect information[14,15]. Announcements from military sources in the UK and USA over the past twelve months envisage a significant expansion in the use of robotic devices in warfare with reduced reliance upon humans. This is a view echoed by the large military corporations like BAE Systems. We critically analyse RMA thinking later in this briefing.

Examples of the high-technology approach are amply demonstrated by the increase in big, complex, offensive weapon systems and their support infrastructure. For instance, in the 2007 budget, the US DoD wishes to pursue, among many high-intensity weapons systems, the Future Combat System, a suite of high-technology systems and their communications, currently costing a staggering $127 billion[16]. Similarly, although more modest in scale, the UK Ministry of Defence (MoD) plans a range of expensive airspace and 'deep target' attack systems, able to deliver powerful weapons at great distance[17]. Additionally, recently announced plans to replace the UK's Trident nuclear weapons system have been estimated to cost about £15-20 billion in 2006/07 prices, not including running costs[18]. Many other examples could be cited.

Obviously, these complex weapons systems depend critically on government and corporate military R&D. Globally this has also continued to rise, with the USA by far the largest funder. In 2007, the US government is expected to spend a huge $78 billion on military R&D[19] – a 57% real-term increase since 2001, and 30% higher than its Cold War maximum[20].

Although spending on military R&D in the UK is much smaller than that in the USA, it nevertheless remains one of the top countries in this area. For example, the most recent international estimates of government funding of military R&D indicate that the UK is the third highest in the world behind the USA and Russia[21]. The latest data shows that this level of spending has been relatively stable in recent years with £2.6 billion earmarked for 2006/07[22]. However, this spending continues to represent a large fraction of total government allocation to R&D – approximately 30%. In terms of socio-economic objectives, government R&D for 'defence' is second only to that for 'advancement of knowledge', and considerably greater than that for areas such as health, energy or environmental protection[23] – an issue which we discuss in more detail later on. It is important to realise that the majority of this government military expenditure goes on R&D within industry – arguably a major subsidy[24]. Further evidence for such a view has emerged from recent industrial figures. In 2005, aerospace industrial self-financed R&D in the civil sector was around 6% of its turnover, while in the 'defence' aerospace sector this figure was only 2%.

In contrast, the MoD total R&D investment was over 8% of the defence budget[25].

The European Union is also planning to implement a military R&D programme, which is to be overseen by the European Security Research Advisory Board (ESRAB) set up in April 2005. The members of ESRAB represent the 'interests' of member states, industry (including Finmeccanica, EADS and Thales), academia and the public[26].

However military R&D is notoriously difficult to link with specific weapon development and 'militarisation' in any simple way because of problems with interpretation of specific areas of R&D and dual use, where products of civilian R&D may be used within military settings and vice versa. The difficulties of making simple assumptions about the extent of a country's military R&D spend are described in more detail in the SITL report[27].

The global military industry has seen its income and sales rise considerably recently with the growth in government expenditure in this area. As an example, Table 1 shows the increase in the value of US government contracts awarded to the top military corporations, revealing just how lucrative the global 'defence' market is. In the UK, BAE Systems saw its operating profits for 2006 rise by 39% to £1.05 billion[28]. Such corporations continue to wield enormous influence within government[29], continuing the situation that we detailed in the SITL report. In addition, increasing trends towards consolidation, especially in areas perceived as expanding, tend to produce a monopoly of thinking towards strengthening a high-technology approach to security.

Table 1 – Top Ten US Department of Defense contractors: percentage increases in the total values of contracts awarded between 2001 and 2006 and value of contracts

Rank & company	% change from 2001 to 2006	Value of contracts (Fiscal Year 2006, in US$ billions)
1. Lockheed Martin	+81.2%	26.6
2. Boeing	+52.1%	20.3
3. Northrop Grumman	+222.6%	16.6
4. General Dynamics	+53.3%	10.5
5. Raytheon	+80.6%	10.1
6. Halliburton	+1325.2%	6.1
7. L-3 Communications	+950.5%	5.2
8. BAE Systems	+442.3%	4.7
9. United Technologies	+36.4%	4.5
10. Science Applications Int Corporation	+83.6%	3.2

Source: World Policy Institute[30]

Box 1 – Defence Industrial Strategy (DIS)[31]

The UK government's Defence Industrial Strategy was published on 15 December 2005. It sets out a strategy for the MoD to work 'effectively' with the UK military industrial sector to improve the procurement of equipment. The DIS strengthens the dependence of the UK's security upon increasingly sophisticated technologies and points out that the "UK's battle-winning military capability remains heavily dependent on the development, exploitation and insertion of world-class technology"[32]. Key themes of the DIS include working with the National Defence Industries Council to frame the Defence Technology Strategy and identifying alternatives to competitive procurement – good news for the military corporations like BAE Systems, Rolls Royce and QinetiQ.

New UK military technology programmes

Since the SITL report was published in early 2005 a number of changes have occurred in the complex network of military support for science and engineering in the UK. A major factor in this change has been the launch of the Defence Industrial Strategy (DIS) in December 2005, followed by the Defence Technology Strategy (DTS) released in October 2006 with much fanfare by Lord Drayson, the Minister for Defence Procurement. The main elements of the DIS and DTS are summarised in Boxes 1 and 2.

Both the DIS and DTS illustrate the large and increasing emphasis on a high-technology, weapons-based approach to security – driven by RMA thinking – and the key role of the UK's scientific and engineering community. It is clear that powerful lobby groups such as the Defence Industries Council, the National Defence Industrial Council and the Society of British Aerospace Companies played an important role in shaping both the DIS and DTS, with the resultant heavy emphasis on the projection of force.

One of the key strands in the DTS is to seek, through the government's Defence Science and Technology Laboratory (DSTL) and the recently privatised QinetiQ, closer relationships (in the UK and abroad) with university expertise in science and technology in order to support military objectives. We discuss this further below.

The DIS and DTS also underscore continuing dependence on collaboration with the USA – for example, in the Joint Strike

Box 2 – Defence Technology Strategy (DTS)[33]

The UK government's Defence Technology Strategy was published on 17 October 2006. It contains many of the recommendations of the DIS and stresses the pivotal role of advanced weapons and their support systems in the country's 'defence posture'. The DTS provides a detailed picture of where the military R&D will be focussed, and how promising areas of technological development must be pushed forward. The DTS identifies areas in need of further investment or R&D effort – these include:

- general munitions and explosives;
- cross-cutting technologies – including sensors, platforms and radar;
- command systems relying on telecommunications and information gathering that use networks (a cornerstone of RMA);
- close combat support – including protective clothing and vehicles able to withstand explosives more robustly;
- counter terrorism;
- robotic and fixed wing aircraft;
- helicopters;
- maritime weapons and vessels – including submarines;
- complex weapons;
- emerging technologies – which include nanotechnologies and devices that interface people and machines;
- methods of detecting and disabling chemical, biological, radiological and nuclear weapons.

The DTS also contains a number of discrete programmes to enhance R&D training in military areas. These include doctoral studentships and postdoctoral research fellowships, the latter in conjunction with the Royal Society[34].

Fighter programme. The many UK-US collaborative activities develop 'interoperability' – that is, the ability of systems, units or forces of the two nations to work closely together in order to meet military objectives of mutual importance. Such interoperability further strengthens the UK government's commitment to the RMA and its technological infrastructure, whilst stimulating associated spending on R&D including within universities. And, of course, it further ties the UK more tightly into US foreign policy.

Further collaboration is demonstrated by a joint US Defense Science Board and UK Defence Scientific Advisory Council Task Force meeting on Defense Critical Technologies, whose details were published in March 2006[35]. It suggested the major areas in which technology should play a pivotal role in security, many of which coincide with the DTS categories in Box 2. The Task Force also felt that much effort should be expended in attracting talented researchers into 'defence' research. The recommendations of the task force will draw increasingly on UK and US university expertise.

In addition to developments in UK government strategies in this area, a number of important changes have also been observed recently in the UK-based military corporations. In general, acquisition activities in the world arms industry have become increasingly significant since 2004[36]. They enhance military corporations' power and further spread their strategic importance across national boundaries. One UK example is the case of BAE Systems acquiring United Defense (USA) which makes this company a key contractor to the US DoD. Another example is QinetiQ, a major UK military technology specialist, comprising staff previously working within the government's own military research laboratories[37]. QinetiQ was launched on the stock market in 2006 despite considerable opposition from parliament. Even before this launch, the company maintained an aggressive and expansionist corporate focus – acquiring four US aerospace and military companies by 2005. Its role in framing the security agenda on both sides of the Atlantic is thus growing, and contributes to the further implementation of RMA.

Military partnerships with UK universities – recent developments

The SITL report described the various processes underpinning military R&D effort in the UK and the resultant complex collaborations, involving government departments, military corporations (and their lobbies) and university research groups. In particular, the report highlighted that since 2002 a host of new military-university consortia had been set up, most notably the Defence Technology Centres, the Towers of Excellence, and the Defence and Aerospace Research Partnerships (DARPs)[38]. These collaborative activities are strengthened by the DTS as detailed below.

We used the new Freedom of Information Act – which came fully into force in January 2005 (see Box 3) – to assist our investigations in this area, examining certain elements of military involvement in UK universities in more detail through a pilot study. However, we initially experienced slow, evasive and obfuscating responses from both government ministries and some universities. In one case, for example, a contact at the MoD claimed that the funds provided to universities through the Towers of Excellence were not directly from the Ministry and the universities "may receive funding via subcontractors although we have no visibility on this and as such can provide no further details"[39]. We experienced a number of difficulties in receiving responses to questions asked of the MoD and so we filed a

Box 3 – The Freedom of Information Act (FoIA)

The FoIA was passed by the UK parliament in 2000 and fully came into force in January 2005. Its intention was to provide for the public an open access point to government and a range of public sector organisations. The Act applies to 'public authorities', which includes central and local government and also colleges, schools and universities from whom information on a host of issues can be obtained – in principle. Most information that does not breach copyright, commercial 'sensitivity' or the UK's security is essentially available to citizens. The key stumbling block is that if the public authority thinks that it will cost them more than £450 (in the case of universities) or £600 (for central government) to find and prepare the information they can turn down even the most reasonable request. In addition, it is up to the Freedom of Information official approached as to what is excluded by the Act or what 'delaying tactics' are used. Plans are afoot to further curb the Act to limit media access and other major users of the legislation.

complaint to the Ministry. This highlighted several errors in the handling of our requests for unclassified information, and an internal review was undertaken in the summer of 2006, which ruled in our favour. Our experiences indicate that some government departments seem to have scant regard for open government.

We have now assembled data on the levels of military sector funding, including some information on university departments in our pilot study. At the time of writing, further research in this area is being pursued.

Our research indicates that funds from military sources are provided to many more within the university sector than those high-profile universities involved in various consortia mentioned above. For the most part, these funds for military objectives escape notice by many in science and technology. In a democratic society, the extent and nature of such funding should be clearly in the public domain.

In the Fiscal Year 2005/6, the MoD provided an estimated £22 million through its Science and Technology Programme to UK universities[40]. This funding figure does not take account of support for university R&D for military objectives from the Department of Trade and Industry (DTI – now reorganised into the Department for Business, Enterprise and Regulatory Reform and the Department for Innovation, Universities and Skills). The DTI was unable to provide detailed figures relating to their university funding in 'defence areas' when asked by SGR under the terms of FoIA – itself a worrying situation. In addition to the UK government budgets, the military corporations (both UK and overseas) and foreign governments also provide funding for R&D effort in British universities. The US government provides military funding for UK research through, for instance, the Departments of Defense and Energy and the Office of Naval Research, and the European Union is set to provide funding for EU-wide 'security research'. Hence the total amount of funding from military sources will undoubtedly be considerably higher than the above figure suggests.

Currently there are four main ways in which MoD funding can reach universities to support R&D activities with a broadly 'defence' objective[41]. The first is to subcontract through the two main military research organisations discussed earlier, the government-run DSTL and the recently privatised QinetiQ. The DSTL provides funds of about £5 million per year to 60 universities in the UK. The Universities of Cranfield, Cambridge, Birmingham and Oxford, as well as the London School of Hygiene and Tropical Medicine, have been involved in such funding through DSTL over the past 3 years[42]. The second path for MoD funding is through the Joint Grant Scheme, which also involves the research councils and the DTI (although the scheme is undergoing changes following the launch of the DTS and reorganisation of the DTI). The third pathway is through the Defence Technology Centres and the Interdisciplinary Research Centres (two in nanotechnology and one in advanced computation). The fourth main route is as direct funds from the MoD – this accounts for around £220,000[43].

Defence and Aerospace Research Partnerships are allied to the Joint Grant Scheme and are part-funded by the MoD, the Engineering and Physical Sciences Research Council (EPSRC) and what was the DTI. In 2006 seven DARPs involved 16 universities. The Towers of Excellence are still featured as joint partnerships with industry and government but detailed up-to-date information is lacking, although they are discussed in the DTS[44]. The universities currently involved in the main military-university consortia are given in Box 4.

These programmes and consortia, in the main, address various operational aspects of the RMA, especially the development of various sensors, autonomous vehicles, and the psychology of humans involved with war waging, communication technology and computational data handling. For instance, the Defence Technology Centre in electromagnetic remote sensing, which received £1.65 million from the MoD alone in 2005, supports research into sensors in the electromagnetic spectrum that can improve the detection of vehicles and people at longer range and in a variety of adverse weather conditions[45]. Such sensors cannot however discriminate between targets that may or may not have military importance. Similarly, the Defence Technology Centre in data and information fusion, which had MoD funding of £1.3 million in 2005, provides expertise in data handling, arising from a host of sources including robotic vehicles[46]. In all the MoD has earmarked around £90 million over a five year period to support the Defence Technology Centre programme[47].

Box 4 – Military-university consortia – participating universities and level of funding (where available)

Towers of Excellence

Guided weapons

- Cranfield
- Imperial College London

Radar

- Birmingham
- Cranfield
- Imperial College London
- Sheffield
- Surrey
- University College London

Underwater sensors

- Bath
- Heriot-Watt
- Imperial College London
- Loughborough
- Southampton
- University College London

Synthetic environments

- RMCS Cranfield

Electronic warfare

- Cranfield
- Loughborough
- Strathclyde

Data obtained October 2006 – no funding details available

Defence and Aerospace Research Partnerships

Currently comprise 14 projects at seven universities and are jointly funded by the EPSRC and DTI. The seven universities are Bristol, Cambridge, Cranfield, Glasgow, Oxford, Imperial College London, and Southampton. The total value of current funding from EPSRC (DTI and other funding sources not included) of these projects is £3.18 million. Since their inception and including the current projects, the DARPs have comprised 55 projects to the value of £11.2million (EPSRC figure – again, funding from other sources is not included).

Defence Technology Centres

Data and Information Fusion

- Bristol
- Cambridge
- De Montfort
- Imperial College London
- Southampton
- Surrey

This Centre allocated £1.3 million to the participating universities in 2005/6

Human Factors Integration

- Birmingham
- Brunel
- Cranfield

This Centre allocated £1.3 million to the participating universities in 2005/6

Electromagnetic Remote Sensing

- Birmingham
- Cranfield
- Edinburgh
- Glasgow
- Heriot-Watt
- Imperial College London
- Leeds
- St Andrews
- Sheffield
- Southampton
- Strathclyde
- University College London

This Centre allocated £1.6 million to the participating universities in 2005/6

Systems Engineering for Autonomous Systems – robotics

- Bath
- Heriot-Watt
- Imperial College London
- Leicester
- Liverpool
- Loughborough

This Centre allocated £2.2 million to the participating universities in 2005/6

QinetiQ plays a significant role in placing approximately £2.5 million of MoD subcontracts with universities, particularly with Imperial College London, Cranfield, Sheffield, York and Southampton[48]. Oxford and Cambridge similarly attract such funds in smaller amounts from QinetiQ[49]. QinetiQ provided almost £0.5 million to Cambridge for 20 projects in 2004[50]. The company also leads the Haldane-Spearman Consortium, which is involved in the 'Preparing People for Operations' programme, which uses the human sciences to prepare military personnel for the armed services[51]. The Consortium comprises 19 members, some of which are universities, including Birmingham, Cardiff, Glasgow, Cranfield School of Management, Loughborough, Nottingham and York together with small businesses and consultancies.

In addition, QinetiQ facilitates staff moving from the company to become visiting professors and visiting lecturers at various universities. QinetiQ staff are also on industrial advisory boards, and the committees of the EPSRC, and participate in Industrial Awards in Science and Engineering PhDs (part funded by QinetiQ and EPSRC)[52]. QinetiQ has also set up its own university partnerships outside the programmes mentioned above – the universities participating are currently Bath, Cardiff, Oxford, Imperial College, Southampton, Lancaster, Surrey and York[53]. It is understood that this collaboration is set to increase[54].

Other military corporations also, of course, continue to fund R&D in universities separately from those that involve government. BAE Systems, for example, has a variety of 'relationships' with universities (around 60 worldwide) for R&D purposes, four of them 'strategic'[55]. Rolls Royce continues to run its University Technology Centres, many of which involve military work. These were discussed in the SITL report[56].

Another military-university collaboration is the Counter Terrorism Science and Technology Centre, which was opened in April 2006. This links academic expertise with the in-house specialist knowledge of the MoD and other government departments and, of course, from the intelligence community. Military corporations will also have an input as the suppliers of surveillance systems and associated software. The Centre is mandated with "ensuring coherence across MoD's science and technology activities in support of counter terrorism"[57]. Whether the Centre plans to co-ordinate or initiate research into the causes of and support for terrorist activity remains an open question. Currently it gives priority to areas such as secure information systems, threats from special weapons, sensors and diagnostics plus computational support of counter terrorism operations. The UK government's stance on dealing with terrorism concentrates on the symptoms rather than a deeper understanding of what causes and legitimises terrorism for a very small number of individuals. Hence, it is likely that it will be these symptoms, and not the causes, which will be the Centre's major focus.

One further funding stream for military R&D is worth noting. In July 2006 the Research Acquisition Organisation (set up in late 2003 by the MoD) launched the 'Competition of Ideas' with new funding, initially to the tune of around £10 million, in order to seek from academia "ideas and innovative research proposals" for military objectives[58].

It may be argued that the levels of funding discussed above only represent a small proportion of the MoD's R&D budget and are indeed small compared with total funding for the universities. However, there are several reasons why the situation we have outlined is more critical than these figures apparently indicate. Firstly, as mentioned earlier, a total figure for military funding of R&D in UK universities is simply not available and, given the variety of other funding paths, it is likely to be significantly higher than the figures above. Secondly, research in civilian areas as well as military can be dual use, i.e. have military or civil applications. Again compiling accurate figures is problematic. Thirdly, with falling and amalgamated numbers of university departments in physical sciences and engineering (see later) – areas of especial value to the military – it becomes much harder for any such departments to operate without military involvement, which reduces the opportunity for independent thinking on questions of security and surveillance for example. Finally, of course, there is the general problem of the narrowness of the R&D agenda that is stimulated by the UK's reliance on RMA thinking. We will revisit these issues later.

Military involvement in schools

Additional to university research partnerships are a range of schemes in which military corporations provide educational materials and support to UK schools and colleges. Many of the larger corporations provide extensive science and technology materials attuned to the National Curriculum. In addition, they run a range of activities for schools. Current examples include BAE Systems' School Challenge competition and a theatre-based roadshow[59]. Rolls Royce runs a science prize for teachers[60], while DSTL has a science and engineering ambassadors scheme[61], and the Atomic Weapons Establishment runs the 'AWEsome' science campaign[62]. The major US military corporations are also involved in a very wide range of 'educational activities'.

Military employers are also very active at the college level. The large-scale involvement of BAE Systems, for example, was discussed in the SITL report[63].

It is especially common for military corporations to build good relations with schools and colleges local to their main industrial facilities, which helps ensure their future workforce and where there is least opposition. For example, BAE Systems has sponsored schools in cities like Portsmouth, Bristol and Plymouth not far from their local divisions or factories[64].

Military industry clearly wants to encourage uptake of science and technology subjects at school in order to ensure a supply of qualified staff for the future. A little-discussed secondary aim of this strategy is their wish to encourage schoolchildren to associate the subjects with the particular company so that they are more likely to come and work for them rather than for anyone else. However, this strategy can undermine critical questioning of the role of the military from an early age – something that is becoming more urgent, as we examine further in the next section.

The problems with new developments in military science and technology

Current military strategy – and its failings

As we highlighted earlier, the UK and USA currently base their military planning on the so-called Revolution in Military Affairs, a high-technology, weapons-based, networked approach to waging war. Box 5 explains more of the rationale behind the RMA. In general, it encourages a mindset that emphasises a military technological approach to dealing with international disputes rather than relying on more human-centred means to avert war, reduce conflict or plan for peace. Technology is arguably supplanting a more nuanced approach to foreign policy[65]. With this high technology deployed as part of a package comprising overwhelming force of arms, the assumption is that quick military victories can be achieved while at the same time keeping civilian casualties low[66].

However, the shortcomings of the RMA approach to conflict (and post-conflict reconstruction) have become all too clear recently, especially in Iraq. Despite the conventional forces of Saddam Hussein being quickly defeated, the US-led coalition has found itself facing opposition forces that have responded by simply mutating into insurgencies where 'enemy combatants' hide among the civilian populations. So, even though the coalition forces outnumber the insurgent forces by between five and ten times[68, 69] and they have considerably more sophisticated and powerful military technology at their disposal (following the rationale of the RMA), they are obviously failing to defeat the determined insurgency. Indeed, this situation illustrates very clearly the lack of a military solution to the problem of 'asymmetric warfare'.

In addition, the RMA strategy of using 'high precision' weapons, argued to minimise casualties, is also being shown to have serious flaws. While it may be possible to accurately hit a pre-determined target with, for example, laser-guided missiles, the fact that 'enemy combatants' respond to this threat by simply hiding among civilians leads to serious problems in determining exactly who the target should be. Furthermore, the coalition's regular use of air strikes, even using smart weapons, often causes high rates of civilian casualties simply because of the size of explosives. The respected organisation Iraq Body Count, which documents and analyses the civilian casualties in this conflict, recently highlighted the indiscriminate nature of air power pointing out that: "'Precision' and high-power, high-technology weaponry cause a higher ratio of child-to-adult deaths than relatively primitive devices such as handheld firearms and manually-triggered roadside bombs"[70]. Indeed, the large and increasing numbers of civilian casualties due to this conflict – at least 70,000[71] and possibly numbering in the hundreds of thousands[72] – highlight starkly the shortcomings of RMA thinking.

To compound these problems, the so-called 'War on Terror' is simply failing to stop international terrorism. Indeed Al-Qaeda and other related organisations are actively using the conflicts in Iraq and Afghanistan to recruit new fighters.

Despite these serious problems, high-technology weapons systems remain the central focus of national security despite even senior military commentators accepting that terrorists are neither effectively deterred by overwhelming military force, nor

Box 5 – Revolution in Military Affairs (RMA)[67]

The Revolution in Military Affairs came to international notice during the 1990/91 Gulf War. It grew from the observation in 1982 of Soviet general staff member Marshall N V Ogarkov that long-range precision strike weapons such as cruise missiles, when connected to a military telecommunications web, were able to gather a host of intelligence in three dimensions from the battlefield and potentially bring about a rapid and resounding defeat of enemy forces. He realised that this could effectively revolutionise the waging of war. Resultant discussions in the military in the USA and Soviet bloc gave rise to what was to become the RMA. The UK military, with its close working relationship with the USA, has also adopted RMA thinking. Two key elements are cited in support of the rationale for RMA and its 'transformation' of war. The first is the intention to keep casualties to a minimum, especially amongst the RMA-enabled forces. The second is the dominant idea within military thinking that conflict is a problem that can be dealt with mainly through the application of superior technology. Such thinking has played a fundamental role in war since at least the Second World War. These imperatives have given rise to the creation of a seemingly limitless 'battlespace' (with no clear demarcations between conflict and non-conflict zones), because of its very marked reliance upon advanced communications systems technology, especially computer networks able to converse and collect data over a military internet linked via satellites.

can they be destroyed by force deployment[73, 74, 75]. As Robert McNamara, the chief architect of US Vietnam policy, admitted in 1995:

"We failed then – as we have since – to recognize the limitations of modern, high-technology military equipment, forces and doctrine in confronting unconventional, highly motivated people's movement."[76]

Science, technology and the broader security agenda

In the SITL report, we put the case for a much greater emphasis on the role of science and technology in helping to tackle a wide range of social and environmental issues, from global poverty to climate change. These factors, we argued, are often key contributors to insecurity and conflict. Since then, the case for approaching security problems from a broader perspective has been bolstered by a growing number of studies. One compelling assessment has come from the respected think-tank, the Oxford Research Group, which published its report, *Global Responses to Global Threats*[77], in 2006 (updated in 2007[78]). In this, the authors argued, there are four key security threats that face the world over the coming century:

- Climate change
- Competition over resources
- Growing inequality and marginalisation
- Global militarism

They pointed out that only a reshaping of global political priorities would prevent these very serious problems from leading to conflict.

A key aspect of these problems is spiralling military budgets set against shortfalls in spending elsewhere. As we pointed out earlier, the global military budget is now above $1,200 billion a year. In comparison, annual global spending on international development aid is less than a tenth of this figure (official development assistance in 2005 was $107 billion[79]) and continues to fall well short of that needed to tackle global poverty. The imbalance can also be seen in a comparison between military budgets and spending on measures to tackle climate change. In the UK, for example, the MoD budget in 2005 was approximately £30 billion[80] – over 50 times the estimated spend on measures to mitigate climate change (£545 million[81]).

In R&D spending, the imbalance is arguably even greater. For instance, in 2004, the governments of the OECD countries (most industrialised countries) collectively spent approximately $85 billion on military R&D compared with only $50 billion on R&D for health and environmental protection[82]. Equivalent spending on R&D in the field of renewable energy – key for tackling climate change – was less than $1 billion that year[83]. Figure 1 illustrates the imbalance.

The situation in the UK is similarly disturbing. In 2004/05, government spending on R&D for 'defence' purposes was approximately £2.6 billion compared with only £1.4 billion for health and environmental protection[84]. Government spending on renewable energy R&D climbed to only £37 million in 2005[85] – equivalent to less than 2% of the government's military R&D budget. Meanwhile, figures from the UK's Department for International Development show that its research budget was less than £100 million in 2005[86] – equivalent to less than 4% of the military spend.

Some steps that are being taken are reducing the imbalance. In the UK, for example, the government announced a new Energy Technologies Initiative in 2006 to support R&D in technologies that can help tackle climate change. It pledged an average of £50 million a year for 10 years to help support this[87]. While this is certainly very welcome, much greater increases in R&D budgets for tackling climate change, global poverty, etc. are obviously justified while the case for retaining military R&D spending at current levels looks increasingly shaky. Nevertheless, there is significant political pressure for the MoD actually to increase its R&D budget. One notable recent example was a report from the House of Commons Defence Committee, which expressed concern that the gap between US and UK R&D spending was widening and urged the MoD to try to catch up[88]. Clearly this Committee needs to take a broader perspective.

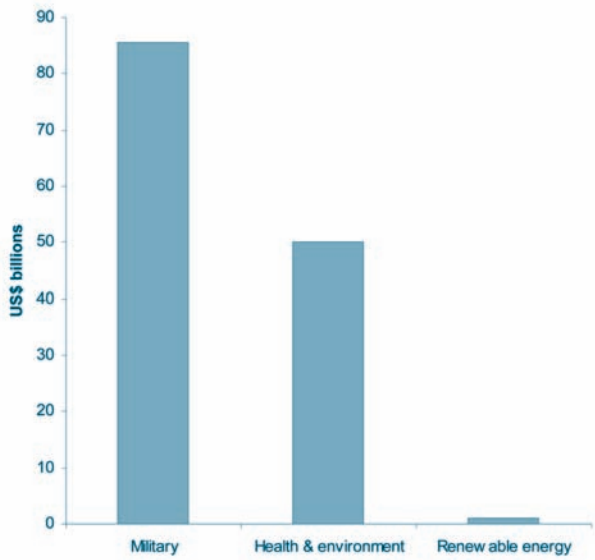

Figure 1 – Comparison of government R&D spending in industrialised countries, 2004.

Figures are in US$ (purchasing power parity). Those for military and health/environment R&D are for OECD countries. Figures for renewable energy are for IEA countries (OECD minus four minor countries). References are given in the main text.

Jeopardising the science and technology skills base

A further key factor when considering the available science, engineering and technology resources, and how best to utilise them, is the supply pathway of suitably trained scientists and engineers.

In the UK, there is widespread concern about skills shortage in many areas of science and technology. This is illustrated by the low number of graduates in physical sciences and engineering. Between 1994 and 2001, the number of graduates in these subjects fell dramatically – by an average of 26% – despite a major expansion of higher education[89]. The numbers have yet to recover significantly. Indeed, in subjects such as chemistry, the fall has continued[90]. This has been compounded by the closure, since 1997, of 18 physics departments and 28 chemistry departments[91].

Government and industry are putting significant resources into trying to increase the uptake of science and technology by students, from school through to university. Indeed military industry, as we discussed earlier, can be heavily involved in such initiatives. This raises some important issues. Firstly, it can discourage debate, from an early age, about the ethical dimensions of military involvement in science and technology and the broader related issues. If a school, college or university department is particularly dependent on resources from a military source, then this seems especially likely. With the shrinking numbers of university science departments mentioned above, the numbers able to remain independent of military involvement will also fall – again, threatening the potential for debate. A second important concern is that a close association between the military and science or technology education can give the impression to students that this is their main or best career option. This would not only narrow their career prospects, it could also put off those students who do have ethical concerns about the military sector from studying science or engineering altogether. There has been little research into these concerns. However, there are signs that they may be significant factors[92].

Given the limited supply of physical scientists and engineers, a further key concern is the competition for these professionals between the powerful military sector and other sectors such as cleaner technology. Military industry has long enjoyed strong political support – indicated not least by the DIS and DTS, as well as its role on advisory committees as discussed in the SITL report. So, given the raft of major projects either underway or planned – including the Astute Submarines series, upgrade of the Atomic Weapons Establishment, the Future Aircraft Carrier programme, the Joint Strike Fighter, Trident nuclear weapons system replacement, and Type-45 Destroyers – it seems unlikely that the government would allow skills shortages to become problematic for the sector. Against this, sectors like renewable energy are trying to expand to meet the urgent threat of climate change. There is a lot of potential for expansion as shown by a recent DTI report. It estimated that, under the right conditions, the sector could expand from 8,000 in 2004 to as many as 35,000 jobs by 2020[93]. However, it will be difficult to achieve this figure if skills availability does not increase and the military sector is able to use its political and financial strength to ensure it is not the one that faces a skills shortfall.

Conclusions

This briefing highlights some of the key developments related to military involvement in science and technology that have occurred in the UK and overseas over the past three years.

It demonstrates the following:

1. The emphasis on a high-technology, weapons-based approach to complex security issues remains prominent in government and industry in the UK, USA and elsewhere. This is despite considerable evidence of the shortcomings of this strategy in current major conflicts and as a long-term approach to security. As a result of this trend, non-offensive security stances tend to be marginalised, especially where the presence of military corporations are to be found, not only within government decision-making bodies but also within teaching, research and the governance of the universities.
2. Efforts to further embed military R&D in the universities are proceeding rapidly, despite the lack of discussion within the scientific and technological communities. This process has the potential to impact negatively on the R&D mechanism within non-offensive security programmes and key areas of civilian work such as cleaner technologies. Additionally academic freedom is likely to be compromised.
3. The availability of science and technology skills in civilian areas such as cleaner technologies is likely to be compromised by the continuing large-scale presence of the military in education, research and industry.
4. There is an urgent need for a full and open debate about both military policy and the role played within it by science and technology. Neither is being pursued to any significant measure by politicians of the main political parties or any of the professional institutions, despite considerable public concern.
5. It is often from our universities that perspectives critical of those of the powerful, such as the military, emerge. However, when government policy, through a range of initiatives, pushes the universities into developing closer ties with the military and acting more like commercial entities with more resources devoted to projects with financial aims, then dissenting voices can be marginalised. This problem is compounded by the large number of closures and amalgamation of departments in physical sciences and engineering, leaving academic staff feeling vulnerable and limiting sources of independent critiques of security.

It is clear that since we published the SITL report, the military has put in place plans to expand and strengthen its involvement with and influence over the UK science and technology sector with significant emphasis on building and further consolidating links with universities. Yet it is also increasingly clear that the narrow, high-technology, weapons-based approach to tackling international tensions and conflicts is failing in many situations. Furthermore, the imbalance between resources – scientific, technological and beyond – devoted to the military and those allocated to broader approaches to security problems continues to be massive. The recommendations made in the SITL report – not least, the need for a major shift in scientific and engineering resources away from the military and towards areas which support social justice and environmental protection – continue to hold true. Indeed, a recent report from the think-tank, BASIC, argues that there is also potential for real economic and employment benefits if the UK industrial sector is switched away from its large-scale dependence on military projects to areas like renewable energy[94].

It is high time that science and technology, both in the UK and globally, were redirected, giving far greater prominence to ethical and practical concerns, which impact on both humans and the environment[95].

Acronyms

AAAS	American Association for the Advancement of Science
BASIC	British American Security Information Council
DARPs	Defence and Aerospace Research Partnerships
DIS	Defence Industrial Strategy
DSTL	Defence Science and Technology Laboratory
DTI	Department of Trade and Industry
DTS	Defence Technology Strategy
DoD	Department of Defense (US)
EPSRC	Engineering and Physical Sciences Research Council
ESRAB	European Security Research Advisory Board
FoIA	Freedom of Information Act
IEA	International Energy Agency
MoD	Ministry of Defence (UK)
OECD	Organisation for Economic Co-operation and Development
OSI	Office of Science and Innovation
R&D	Research and Development
RMA	Revolution in Military Affairs
SGR	Scientists for Global Responsibility
SITL	Soldiers in the Laboratory

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(All web links correct as of 05/07/07)

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About this briefing

This briefing follows on from the 2005 report *Soldiers in the Laboratory: military involvement in science and technology – and some alternatives*, hailed as "the most comprehensive document in this field in the last 35 years" by Professor Steven Rose, Open University.

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