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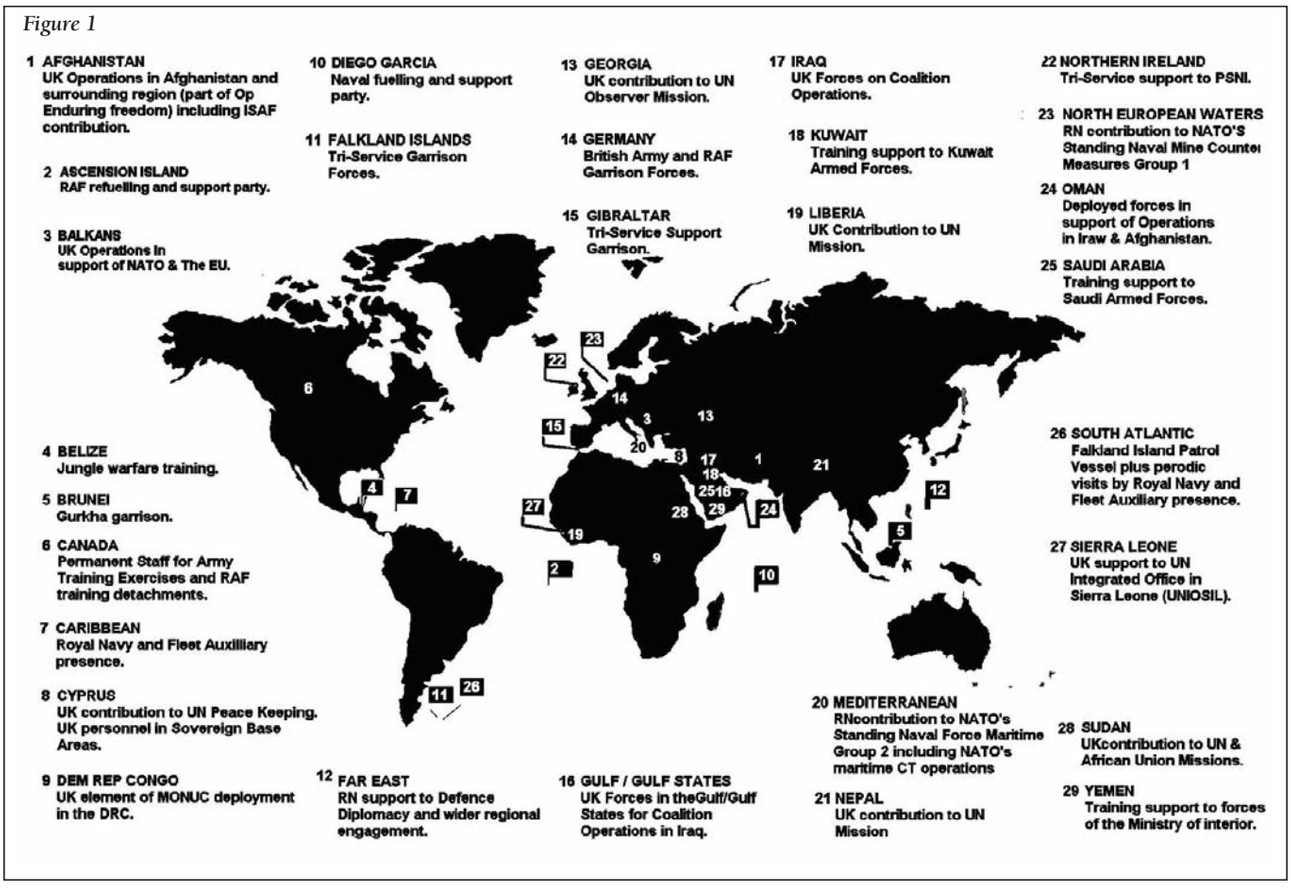
Defence Science – Maintaining a Cutting Edge

"Today the UK faces adversaries whose tactics change rapidly and employ ever more varied advanced and innovative technologies. This demands rapid evolution in our response, both tactically and in the technologies we deploy to combat the threats.[1]"

The MOD Defence Technology Strategy captures the importance of defence science and innovation to maintaining a cutting edge, of providing the UK Armed Services with the capabilities they need to conduct a wide range of operations and deployments across the world. Figure 1 illustrates the extent of commitments by the UK Armed Services in 2007 across the globe and highlights their need for a breadth of capabilities to deploy in very physically and operationally different theatres[2]. Defence science is a key enabler in underpinning the versatility demanded of our troops and preparing them to meet the challenges of future conflicts. Alongside the unpredictable

Figure 1



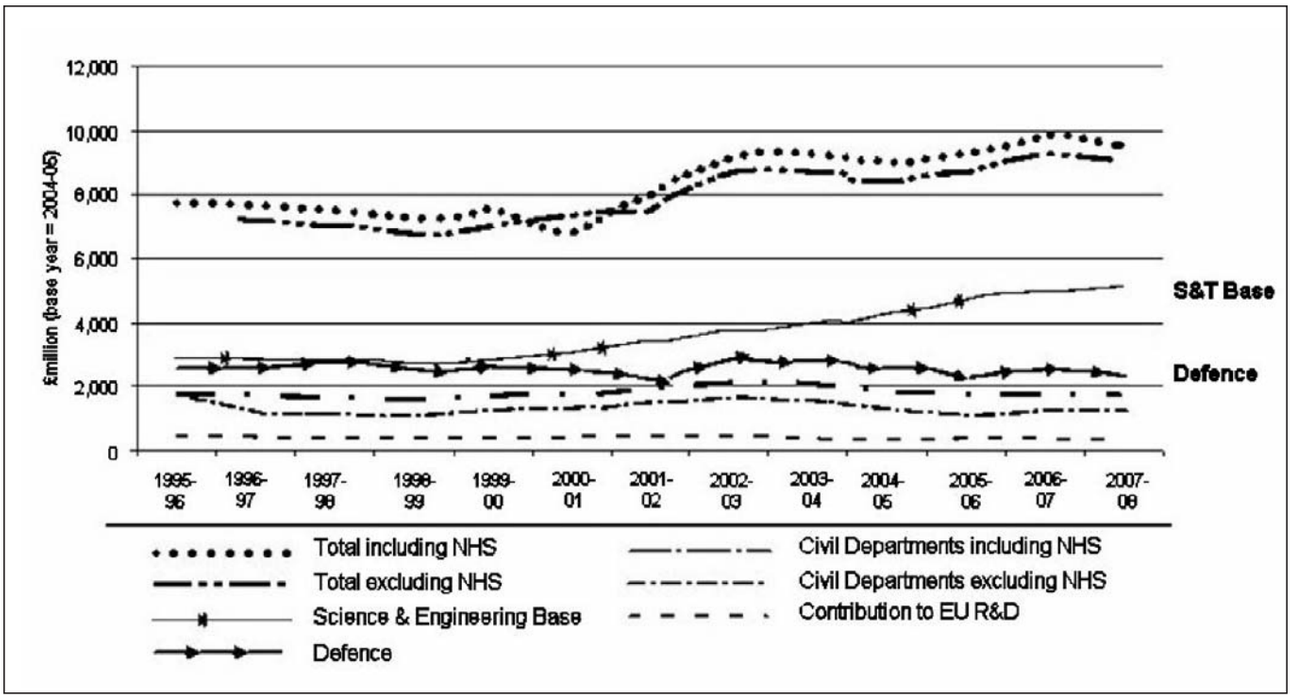


Figure 2: Government funded Science Engineering & Technology in real terms

nature of warfare, the demands on budgets and the declining career attraction to young people are some of the issues currently challenging UK defence science.

By the very nature of its business the MOD is an early adopter and user of cutting-edge technology. Ambitious early adopter customers encourage pull-through of science and innovation to meet the advanced needs of modern warfare. It is not surprising then that defence science and innovation in leading western nations has resulted in many advances in civilian life including satellite navigation, weather forecasting, mobile phones, flat-screen televisions, microwave ovens and ultrasound baby scans.

Recent work has demonstrated the strong correlation between the level of national defence investment in R&D and the quality of equipment or years of military advantage [3]. Due to historic investment the UK has a favourable position relative to the front runner, the USA. However, while the USA is preserving its leading position through a decade of increased spending on defence science, the UK and other European countries are eroding their positions of advantage. The expanding economies of China and India are increasing their R&D spend in line with GDP growth and will be on par with European quality of military equipment by 2020.

Defence science in the USA is seen to deliver both security and economic benefit and the USA makes extensive use of defence science to pump prime industry into a position of global competitiveness. Comparison of US and UK Government funding of science and innovation indicates that a far higher proportion of US Government expenditure is mission driven and therefore conducted in industry, in contrast with the UK. Mission driven research delivers outputs with a higher level of technology readiness and closer to market. Over the last decade UK Government-funded science and technology has increased in real terms, Figure 2, while that for defence has been declining [4]. The UK is investing more strongly in investigator-led science which is characterised as 'blue skies' and further from market than mission-driven science.

Cutting edge science relies heavily on a skilled workforce, particularly in the fields of physical sciences and engineering. Yet these are the very subjects which have become increasingly unpopular with young people. As the Sainsbury Review highlighted there has been a 20-year decline in the number of students taking A-level physics which has not yet been reversed [5]. These statistics are of concern for a country that has set itself a goal of creating an 'Innovation Nation'. Like many UK organisations engaged in high technology business, QinetiQ has a very active STEM (Science Technology Engineering Mathematics) Outreach programme. The company engages with young people in a variety of STEM activities to give them an insight to the exciting and rewarding careers in science and engineering and to encourage them to consider careers in these fields.

References

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4. DIUS SET statistics 2007
5. HM Treasury Sainsbury Review of Science & Innovation 2007

Defence Science in the UK has had a world changing impact on military capability, and on wealth creation in the wider economy. Looking back into the 20th Century, UK defence science developed RADAR, the jet engine, liquid crystal displays, advanced electronic materials and devices that underpin much of modern technology including mobile phones, thermal imaging, vertical take-off flight and carbon fibres. These examples, and there are many more, have had a profound impact on defence and many have opened huge new markets in civil technology.

This should not be a surprise. In defence, second-rate technology is never good enough, and the need to maintain combat edge makes defence an early adopter. So as well as stimulating innovation, defence often provides the early exploitation route for new technology as a 'sling-shot' to volume commercial application.

Defence science has also had substantial impact on recent military operations. For example, the Tornado fast jet combat aircraft is a classic case of how defence science has provided advanced and responsive capabilities through technology insertion. Tornado was conceived in the 1960s and introduced into service in the 1980s as a low level, all weather bomber in response to cold war operations. But as a result of the changes in the security landscape, a series of technology upgrades have been applied which have transformed this platform into one of the world's most effective close air support fighters. This has been possible through BAE Systems, QinetiQ and MOD working closely together to draw on advances in technology to meet operational needs responsively as they emerged.

Another example is the rapid development of the SWIMS (Shallow Water Influence Mine-Sweeping System) robotic boats to support the clearing of the Khor Abd Allah waterway in Operation TELIC to enable safe landings by the Royal Navy. This innovative capability drew directly on the outcomes from defence research into robotics and mine countermeasures. In its review of Rapid Procurement of Capability to Support Operations[1], the NAO said *"[MOD] has shown impressive ingenuity to deliver customised solutions to the warfighter, such as SWIMS. QinetiQ had been undertaking research on the use of remote controls and this technology was fitted to the boats to create remote controlled shallow water influence mine sweepers, reducing the risk of loss of life."*

Other examples include Electronic Warfare, where UK defence science has produced truly world beating products, a technology which is saving lives in current operations every day, battlefield robotics which are proving to be a vital capability to deal with roadside bombs, and hybrid electric drive for armour vehicles which will provide advances in range, greater flexibility in vehicle layout, improved options for protection and reduced logistics for supply of fuel.

Defence science will continue to have profound impact into the future. Long endurance (of many months) for unmanned air vehicles is becoming possible through solar power, exemplified by QinetiQ's Zephyr UAV which holds the world record for endurance of unmanned flight. Quantum technology will impact on searching large amounts of data, on development of more effective sensors, and on enhancing computer security. We will see novel technology applied to the soldier to improve protection, support co-operative engagement, reduce fratricide, and help build relationships with local peoples. More powerful architectures will make evolution of future equipment more agile and less costly. Smart materials will create new concepts in design and reduce operating costs.

In summary, defence science has always been a driver of military capability, and will remain vital to the Nation's defence and security needs. The platform of knowhow and demonstration systems that defence science funding creates has played a rather unsung role in ensuring our forces have the equipment they need; many of the responsive procurements draw directly from research, and could not otherwise have been achieved in time. One can argue that investing in defence science is an *antidote to uncertainty.* The UK can take considerable pride in the quality of its defence science, which is seen around the world as one of our most impressive assets. And because defence science invariably stretches the envelope of what is possible, it continues to drive innovative opportunities that create wealth across the economy.

Andrew Sleigh

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During discussion the following points were raised

How much of the research is self generated and how much from other sources? The majority of the work is funded by customer funds such as the Ministry of Defence. Unlike many other companies in this field we are not a manufacturer. QinetiQ has no involvement with biological warfare as that area is retained within government. We are partners with DSTL and there is opportunity for us to understand what they are doing and for us to contribute to work they undertake in the chemical and biological fields. This area is managed jointly by DSTL and the Ministry of Defence.

In the UK although Research Council funds have doubled, overall R&D expenditure including the Research Councils is still 0.7% of GDP. The conclusion therefore must be that defence R&D has dropped faster than the projection indicated. The

overall impression is that compared with US, we are not doing enough in this country and it is not clear what we should be doing. The US places more emphasis on mission-driven research and the term R&D is a very broad category. In the UK we draw more heavily on basic science in conjunction with universities, and this raises the question of how much defence science can the nation afford?

The expenditure on R&D takes several different forms from applied science with rapid returns to basic science which takes longer to generate an impact. Hence measures of expenditure do not provide a clear view of the overall benefit likely to be obtained. The presentation exhibited our strengths essentially in physics and engineering. However the whole point here is to get an advantage in conflict and to respond to the adversary doing different things. If Iraq teaches us anything it is that we have done very badly in anticipating the outcome. Who should be having the responsibility for a more sophisticated heart of research in defence and asking what is the nature of tomorrow's conflict? Have we got to relearn the lessons of Malaysia that we have forgotten? Whose responsibility is that? How is the world changing? Do you accomplish your goals by retooling a bomber? Or might you be better off by not dropping bombs?

The return of increased capability for expenditure in the UK is value for money when compared with the US, which shows lower rate of return overall for a much greater expenditure. It is not easy to understand the future, it may be possible to understand the risks. You do need to have somebody responsible for a no-holds-barred approach. However the approach should assume that you will not necessarily be able to foresee the outcomes and therefore need to build flexible architecture into the platforms that can adapt to the circumstances as they evolve. People in MoD are speaking that sort of language. Another strategy would be to invest in people skilled in social sciences.

China in 2020 and the UK appear well positioned on the capability chart with an optimum return for the investment made compared with all other entries. Fundamental research investment in the UK Research Councils also bypasses the MoD. The model adopted in the UK depends on the relationship between the science base academics and the take up and build supply chain that makes things happen, as exemplified by QinetiQ. That is what matters and work at the University of Warwick is a good example of this arrangement.

The US spends approximately $600 billion on defence and a further $100 billion on homeland security and intelligence, much greater than anyone else, which puts them in a different league. There is no sign of any slowdown in this expenditure. In the UK we use our skills to take technology such as Global System for Mobile technology (GSM) for example back to the UK. Our defence science base also facilitates our interaction with the US in an effective way. This enables the UK to sit at the top table and access US development technology directly, especially because they know we have the knowledge to do it ourselves should we need to do so.

TOWARDS 2020 SCIENCE AND THE EUROPEAN SCIENCE INITIATIVE

MEETING OF THE PARLIAMENTARY AND SCIENTIFIC COMMITTEE ON TUESDAY 15TH JULY

Towards 2020 Science

Professor Stephen Emmott
Head of Science, Microsoft

Science will be absolutely central – indeed critical – to understanding and addressing the most important challenges we face this century; indeed perhaps any century, not least because the scale of the challenges is so great this may be the last century we have to address them. Chief amongst them are:

1. possible rapid and highly non-linear climate change and loss of Earth's life support system,
2. pressures on the planet with a population of over 9 Billion people,
3. intractability of the prevention and eradication of a range diseases that prematurely kill millions of people every year,