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ECONOMIC
FORECASTING

THE ECONOMIC CONTRIBUTION OF BAE SYSTEMS TO THE UK AND IMPLICATIONS FOR DEFENCE PROCUREMENT STRATEGY

JANUARY 2004

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Executive Summary: Section I

What is BAE Systems?

- BAE Systems is a global prime defence and aerospace contractor, employing nearly 100,000 worldwide, with employment centres all over the world, and 63 within the UK.
- BAE Systems is involved in both manufacturing and services, in both the civil and military markets.
- Recent years have seen a pronounced shift towards the higher end of the value chain, as BAE Systems' typical product has become progressively more knowledge intensive, service-oriented, and involving systems integration rather than discrete pieces of hardware.
- BAE Systems is the principal prime defence contractor based in the UK. It represents a substantial base of intellectual capital in the UK, and continues to invest in maintaining and upgrading that capital.
- It should be noted that this paper does not seek to capture the full economic benefit the UK derives from Airbus UK, as this is not a wholly owned element of BAE Systems[1]. However, it should be noted that the significant contribution Airbus UK makes to UK economic activity (reflected in the Aerospace IGT report) can be attributed to the original corporate decision by the then British Aerospace to invest in the Airbus effort and to develop a centre of excellence in the UK for commercial aircraft wing design and manufacturing.

Direct Contribution

- BAE Systems employed 40,220 people in the UK in 2002 – equal to total employment in the office machinery and computers sector – with a particular concentration of employment in the North West of England.

[1] Except for the calculation of the spillover contribution to the UK deriving from the R&D spend channelled through BAE Systems, which includes Airbus and other Joint Ventures

- BAE Systems invested £500 million in 2002 in fixed capital – 160% higher than the UK average fixed investment per employee.
- BAE Systems exported a total of £3,000 million in 2002 from the UK, 1.6% of total UK goods exports. Net exports of BAE Systems' UK operation were worth £2,000 million, reducing the deficit on the current account of the UK balance of payments by 11%.
- BAE Systems created £2,294 million in value added in 2002, more than two-and-a-half times the total value added of the machine tools sector in the UK.
- BAE Systems contributed £1,150 million to the Exchequer in taxes in 2002.
- In 2002, £1,210 million was channelled into research and development via BAE Systems, 6% of total UK R&D expenditure. The evidence suggests that BAE Systems makes relatively efficient use of this R&D spend in terms of generating higher productivity.

Indirect Contribution – ie activity supported in the supply chain

- BAE Systems indirectly supports the employment of a further 49,060 people in the UK, with that indirect employment concentrated in the service sector.
- BAE Systems indirectly supports £211 million of fixed investment.
- BAE Systems indirectly supports a contribution of £1,403 million to the Exchequer via taxes.
- BAE Systems indirectly supports £2,044 million of value added further down the supply chain.

Induced Contribution – ie activity supported by the spending of BAE Systems dependent employees

- Direct and indirect employees of BAE Systems 'induce' (support with their expenditure) employment of a further 22,320 people in the UK.
- Induced value added is worth £1,086 million, 0.1% of UK GDP.

Catalytic or Spillover Contribution

- R&D spending channelled through BAE Systems adds around 0.1% points to UK GDP growth each year, by improving productivity across the whole economy. In the long run (after ten to

fifteen years), the total contribution could reach 1.5% points. In 2002, that would have been worth £15 billion.

- The catalytic contribution of the R&D spending channelled through BAE Systems is the main positive externality that would be lost if those funds were spent outside the UK.
- BAE Systems itself is a significant source of funds for R&D in the UK. This spending, together with the government funded R&D channelled through BAE Systems, means that the company is an important centre of technological innovation – contributing to the productive performance of the UK economy as a whole.

Other Contribution

- 21,800 staff at BAE Systems received some training during 2002.
- BAE Systems employs 1,100 full-time apprentices in the UK – 5% of all the engineering apprenticeships in the UK.

Total Contribution

- BAE Systems' total contribution to UK employment was 111,600 in 2002.
- BAE Systems' total contribution to UK fixed investment was £711 million in 2002.
- BAE Systems' total contribution to UK exports was £3 billion in 2002.
- BAE Systems' total contribution to UK tax revenues was £2.6 billion in 2002.
- BAE Systems' total contribution to UK value added was £5.4 billion in 2002.
- UK R&D spend channelled through BAE Systems was worth £1.2 billion in 2002.
- That R&D spending channelled through BAE Systems contributes around 0.1% points to UK productivity growth each year. In the long run, the total contribution could reach around 1.5% of UK GDP.

Summary of BAE Systems' economic impact on the UK economy (2002)

	Direct contribution	Indirect contribution	Induced contribution	Total contribution
Employment	40,220	49,060	22,320	111,600
Investment	£500 m	£211 m	-	£711 m
Exports	£3,000 m	-	-	£3,000 m
Taxes	£1,150 m	£1,403 m	-	£2,553 m
Value added	£2,300 m	£2,044 m	£1,086	£5,430 m

Catalytic contribution from R&D: 0.1% points on GDP growth, 1.5% in the long run.

How does BAE Systems benefit the UK economy?

- BAE Systems is the principal prime defence contractor based in the UK. It represents a substantial base of intellectual capital in the UK, and continues to invest in maintaining and upgrading that capital.
- Staff employed at BAE Systems benefit from that capital base since it enables them to have a higher than average level of productivity.
- Firms who currently supply BAE Systems also enjoy productivity benefits that they draw from that relationship, and rely on BAE Systems as a source of stability in their order book.
- The R&D funds channelled through BAE Systems – and those internally funded by BAE Systems itself - have a catalytic effect, improving productivity in other industries in the UK.

Executive Summary: Section II

Principles of UK defence procurement strategy

- Prior to the Levene reforms of the 1980s, competition in defence procurement at the prime contractor level was rare, and cost-plus contracts were the norm. Post those reforms, competition and fixed price contracts were the norm.
- The current principles of UK defence procurement strategy are most recently codified in the MoD publication 'Defence Industrial Policy' (DIP) of 2002. Competition is the bedrock of defence procurement.
- However, there remain important problems with the principles of defence procurement strategy:
    - The current strategy is based on assumptions about the structure of the global defence industry that may not be valid. The government is a monopsonist while BAE Systems is involved in a kind of oligopoly with a handful of foreign prime defence contractors competing on an unequal footing. That structure can result in unsustainably low profits for BAE Systems, and low quality in the delivery of defence capability to the MoD.
    - One reason for this is that foreign competitors often enjoy a competitive advantage over BAE Systems since they are not required to face international competition for their home market, and indeed can often be heavily subsidised by their domestic taxpayers.
    - UK defence procurement strategy does not provide the appropriate incentives to prime contractors to ensure that the desired defence capability is delivered. Because industry bears such a high proportion of the financial risks in a defence contract, its incentives to deliver quality are undermined.

The Practice of UK Defence Procurement Strategy

- In practice, the process of letting a prime defence contract in the UK rarely conforms closely to the strategic principles set out in the DIP:
    - The procurement decision tends to reflect a host of factors and the views of a host of interested parties, rather than a 'pure' decision based on the principles in the DIP. Industry often focuses on influencing the various interested parties rather than delivering the best possible product to the final customer.

  - The MoD is not organised in such a way as to maximise the chances of achieving the desired defence capability for the UK. In particular, there is often an absence of co-ordination between the different elements of a procurement project for a given defence capability, and sometimes a lack of communication between the MoD and industry that undermines the objectives of co-operation with and looking after the health of British industry, identified in the DIP.

- Although the DIP stresses the advantages of de-risking defence projects before they reach main gate, and the benefits of partnering and risk-sharing throughout the contract, this is rarely done in practice to the extent that would be consistent with the DIP.

Some Policy Options for Defence Procurement Strategy

- The MoD is likely to continue to spend around a quarter of its total defence procurement budget on products and services from BAE Systems into the indefinite future. Both the government and industry should recognise this fact, and try to devise a joint strategy for ensuring that BAE Systems is a healthy, profitable firm and that it delivers the required defence capability to the government. That may involve reviewing the question of whether prime defence contracts should always be open to foreign competition.

- As part of this, the government should focus on de-risking procurement contracts and putting in place joined-up structures in the MoD and elsewhere that have the best chance of delivering the desired defence capability when it is needed. That may imply undertaking or directly funding a large proportion of defence R&D itself, and re-organising the MoD to ensure that procurement projects are appropriately co-ordinated, and reviewing the question of whether fixed price contracts are appropriate for prime defence procurement decisions.

- BAE Systems should focus on putting in place the most efficient and cost-effective structures in its own organisation, with a view to maximising the value for money and spillover benefits that it delivers to the taxpayer. That may imply less focus on how many jobs are dependent on BAE Systems, and more focus on the quality that BAE Systems ultimately delivers to the UK government, and the advances in technology that its activities yield for the UK economy as a whole.

SECTION I: THE ECONOMIC CONTRIBUTION OF BAE SYSTEMS TO THE UK

1. Introduction: what is BAE Systems?

- BAE Systems is a global prime defence and aerospace contractor, employing nearly 100,000 worldwide, with employment centres all over the world, and 63 within the UK.
- BAE Systems is involved in both manufacturing and services, in both the civil and military markets.
- Recent years have seen a pronounced shift towards the higher end of the value chain, as BAE Systems' typical product has become progressively more 'weightless'[2]: knowledge intensive, service-oriented, and involving systems integration rather than discrete pieces of hardware.
- BAE Systems is the principal prime defence contractor based in the UK. It represents a substantial base of intellectual capital in the UK, and continues to invest in maintaining and upgrading that capital.

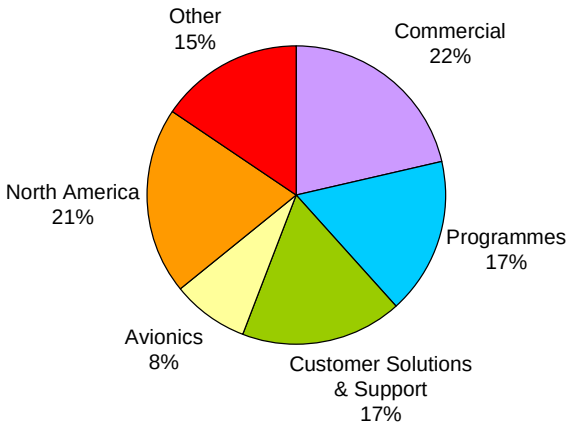
BAE Systems is a complex organisation that straddles a number of different industrial sectors and regions. It is involved in both manufacturing and support services, in sectors as diverse as aerospace and information technology, and has both military and civilian customers in the UK and abroad. It employs nearly 100,000 staff globally, and has 63 employment centres within the UK, and others in Europe, Saudi Arabia and the USA. It is the 364th largest company in the world, and the 25th largest in the UK, by sales[3]. The objective of this section of the paper is to describe in detail the various activities of BAE Systems, and to put those activities in the context of the wider economy.

1.1 The current structure of BAE Systems

In 2002, BAE Systems' total global sales revenues amounted to £12.1 billion. The Annual Report and Accounts provide details of how these total revenues were distributed across the different business groups, summarised in the pie chart below.

[2] See 'The weightless economy in economic development', Danny Quah, in *Information Technology, Productivity and Economic Growth*, OUP 2001.

Chart I.1.1 Distribution of BAE Systems revenues by business group, 2002



Commercial Aerospace, accounting for 22% of total revenues, includes projects such as the A400M Airbus (in fact a military transport aircraft), along with other members of the Airbus family. This part of the business is essentially involved in (largely civilian) aerospace manufacturing.

The Programmes business group, accounting for 17% of total revenues, consists of both air systems, including the F-35 Joint Strike Fighter, Nimrod, the Eurofighter Typhoon, and the Hawk trainer jet; and sea systems including Astute, the Type 45 destroyer, the Landing Platform Dock, the Offshore Patrol Vessel, the Auxiliary Oiler, and underwater systems such as the Spearfish Torpedo. This part of the business is also largely manufacturing, but it is military rather than civilian, and encompasses both aerospace and sea vessels.

Customer Solutions and Support (a further 17% of total revenues) provides through-life support across the whole range of BAE Systems products. This part of the business can be thought of as largely in the service sector – analogous to after-sales service in the auto industry.

Avionics, accounting for 8% of total revenues, is the electronic equipment necessary for aviation, encompassing controls for the Joint Strike Fighter, Defensive Aids Sub-Systems for the Apache helicopter and other platforms, Radar for the Typhoon and other aircraft, Head Up and Helmet

[3] Forbes Global 2000

Displays for the Typhoon, the F16 and other aircraft, as well as Primary Flight Controls for Airbus and the Boeing 777. This part of the business operates in the aerospace sub-sector of the electronics industry.

The North America business group, with 21% of total revenues, encompasses all the activities of the North American part of BAE Systems' operation. It encompasses projects such as the Joint Tactical Radio System; the integration of the electronic warfare system into the JSF; the Future Combat System; the Joint Chemical Agent Detector; as well as avionics for the C-17 transport and for the F-22 fighter.

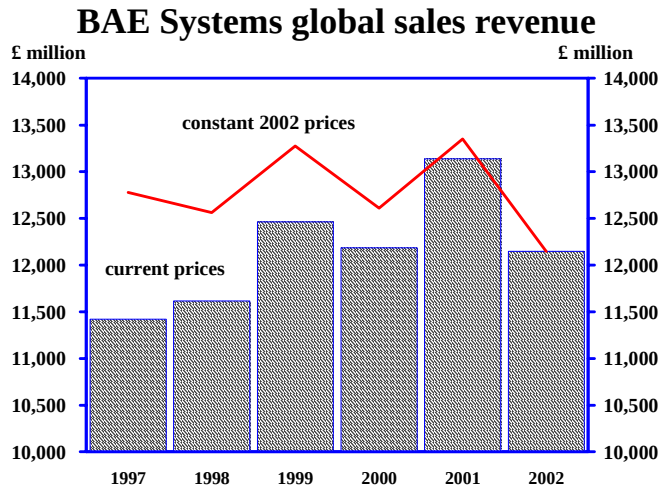
The remaining 15% of total revenues are accounted for by international partnerships, HQ and other operations.

The current structure of BAE Systems reflects in part the merger of British Aerospace with GEC Marconi, in November 1999. That merger boosted the revenues of BAE Systems relative to those of the former British Aerospace – the consolidated series are shown in the charts in the next section.

1.2 How has BAE Systems evolved in recent years?

BAE Systems has grown in terms of total global revenues in recent years. The chart below shows how global revenues have changed since 1995, both in current prices and in real (inflation-adjusted) terms – including proforma Marconi numbers prior to the merger of British Aerospace and Marconi.

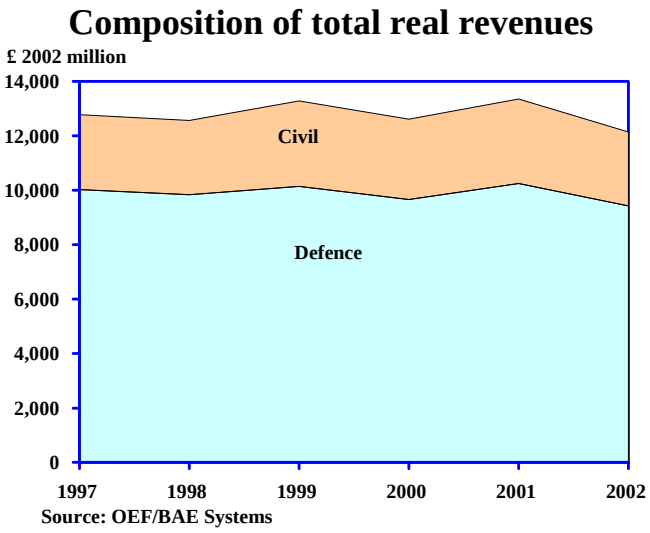
Chart I.1.2



BAE Systems total consolidated global revenues (ie including the appropriate share of revenues accruing to GEC-Marconi before the merger) have grown in current prices since 1997, but have been rather flat overall in constant prices, with 2002 in particular a relatively weak year.

Within that total, the majority (78% in 2002) of BAE Systems' revenues are from military rather than civilian sales. Both sources of revenue have exhibited a similar profile in recent years, with most of the fluctuations year on year down to defence rather than civil revenues.

Chart I.1.3

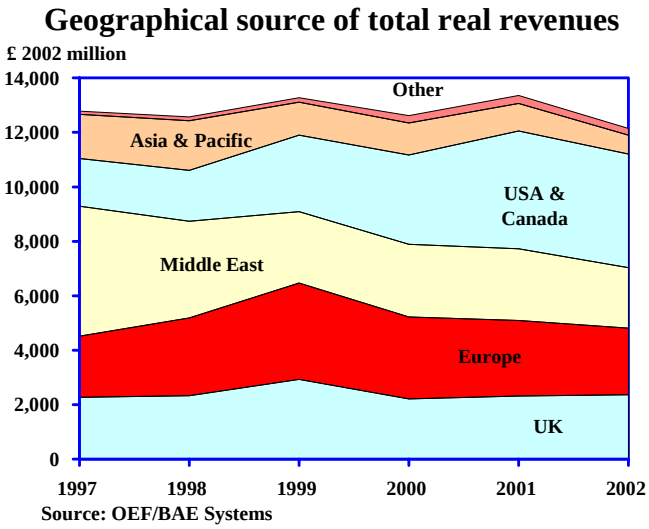


Another way of looking at these revenues is in terms of their geographical source. The USA and Canada together now make up the largest regional source of revenues to BAE Systems (accounting for 34% of the total), with sales into that region having shown by far the strongest growth over the last seven years. Sales into the UK and the rest of Europe have also increased, while sales to the Middle East and Asia and Pacific have declined – although the Al Yamamah project in Saudi Arabia remains a key source of revenue.

Table I.1.1: Geographical source of revenue

	Sales in 2002 £mn	% of total sales
UK	2,372	19.5%
Rest of Europe	2,435	20.0%
Middle East	2,223	18.3%
USA and Canada	4,171	34.3%
Asia & Pacific	698	5.7%
Other	246	2.0%

Chart I.1.4



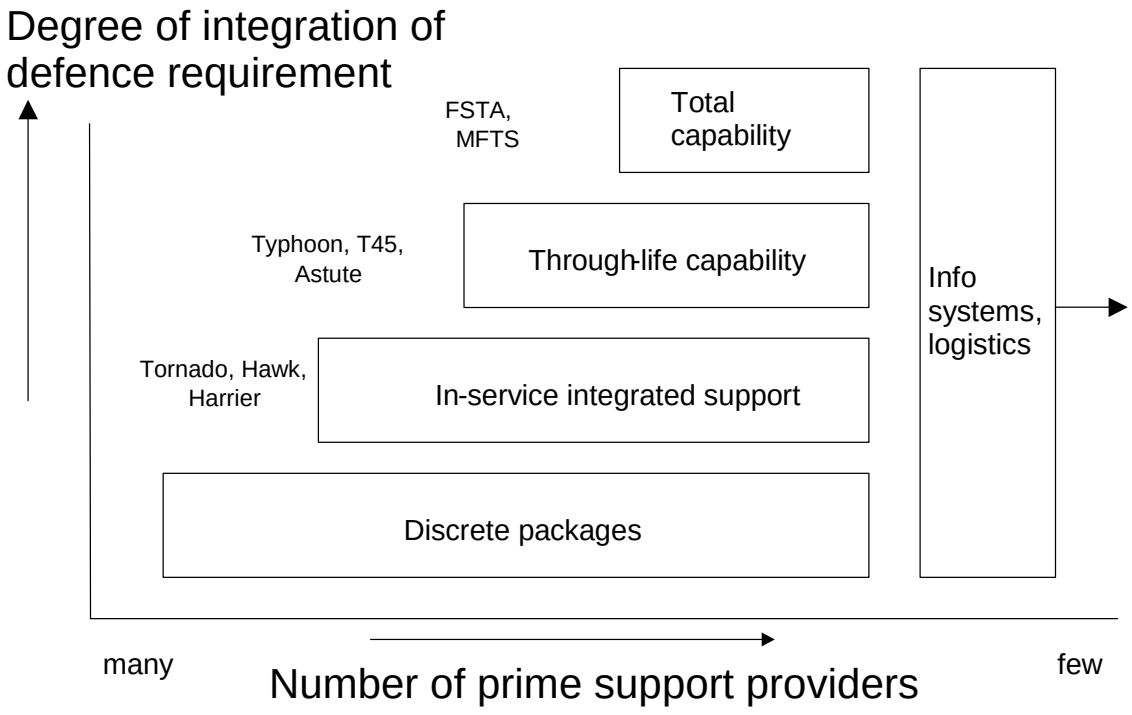
The process of mergers and acquisitions has to some extent changed the character of BAE Systems. In addition, a process of change is underway across the company that is not related to mergers and acquisitions: BAE Systems is in the process of shifting away from its traditional manufacturing activities and towards a more service-based profile. The growth over the last seven years in the

Customer Solutions and Support business group is a clear indication of this transition. Of course, the bulk of BAE Systems' activities in 2002 (some 70% in the UK, and nearly 80% globally) remains loosely in the manufacturing sector, but the transition is clearly underway, and has some way to go.

The transition underway at BAE Systems reflects the changing nature of defence requirements in the UK and elsewhere. The emphasis is increasingly on delivering a complete defence capability, rather than an individual piece of kit – and a 'network-enabled' capability at that. Delivering a network-enabled defence capability means being able not only to design, build and maintain complex pieces of military hardware, but also being able to integrate those pieces of hardware – platforms and components - with each other, with others, with sophisticated IT systems and with military personnel on the battlefield. Modern warfare – such as demonstrated in the recent conflict in Iraq – makes increasingly intensive use of integrated technology so as to minimise military and civilian casualties on both sides.

Those new requirements imply a new kind of defence contractor, and potentially a new kind of relationship between the customer and that contractor. The diagram below is a schematic representation of the relationship between customer needs and industry structure.

Chart I.1.5



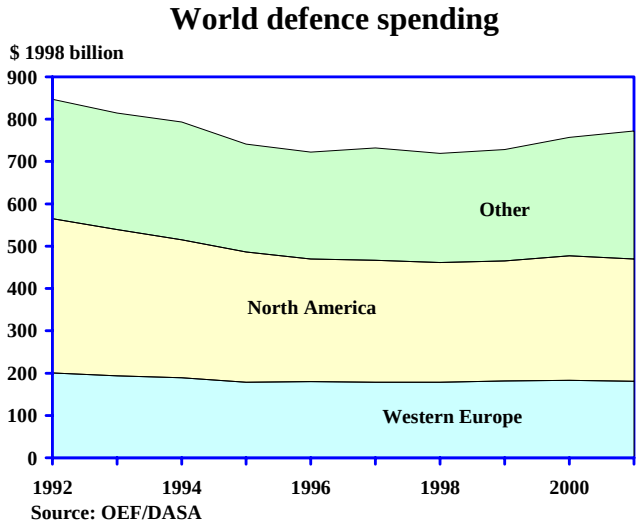
The diagram above requires some explanation. The insight it reflects is that as the defence requirement shifts from discrete packages of manufactured kit towards more integrated systems, supported with through-life servicing and information systems, the number of prime defence contractors is likely to shrink. Being able to deliver an integrated defence capability implies understanding how all of the discrete packages that make it up work, how they best communicate with each other, how they interact, how their design should be adjusted to maximise the ease with which they can be integrated into the complete package, how they should best be serviced or enhanced over time, etc. While many suppliers are capable of delivering an individual piece of kit, relatively few are capable of doing this in tandem with overseeing how all those pieces of kit work together to create a defence capability.

BAE Systems is therefore increasingly a provider of integrated systems, and not just of manufactured platforms or components: a service provider as well as a manufacturer. This change is reflected in a number of respects, some of them nominal, others structural. The name and mission statement of the company - 'BAE Systems: a systems company, innovating for a safer world' - give a clear indication of the direction in which the company is moving.

1.3 Putting BAE Systems in a global defence market context

Global defence spending has fallen sharply in real terms since the end of the Cold War. The declining trend continued until about 1995, since when total defence spending has grown slightly, as the chart below shows.

Chart I.1.6



After 2001 (the latest data point in the chart above), total defence spending has started to grow again, particularly in the US, boosted by the terrorist atrocities of 11 September 2001, and the Iraq war in 2003. The top sources of global defence spending are the US and Western Europe, with the UK in fifth place in the global league, as the table below shows.

Table I.1.2	**World defence spending** US$ billion, constant 1998 prices		
Rank 2001[2]	Country	2001	Share (%) of world military expenditure
1	USA	281.4	36.5
2	Russia (PPP)	43.9	5.7
3	France	40	5.2
4	Japan	38.5	5
5	UK	37	4.8
Sub-total top 5		440.8	57.1
6	Germany	32.4	4.2
7	China	27.0	3.5
8	Saudi Arabia	26.6	3.4
9	Italy	24.7	3.2
10	Brazil	14.1	1.8
Sub-total top 10		565.6	73.3
World Total		772	100

Source: SIPRI

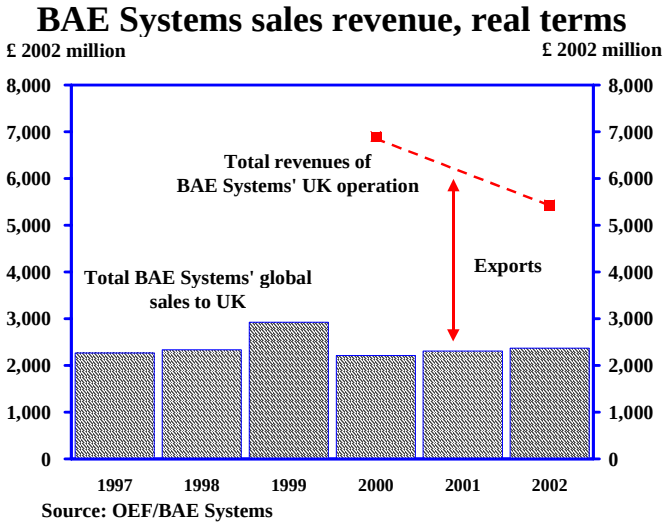
A large proportion of the defence spending in the chart and table above is accounted for by other things than defence equipment procurement: the figures include wages and salaries of defence personnel, for example. It is estimated[4] that the total global defence equipment market is worth around $200 billion per year. BAE Systems' total defence revenues of $14.2 billion in 2002 imply a share of 7.1% of this global defence equipment market. That share makes BAE Systems a significant player in the global defence industry. The other global prime defence contractors include Boeing, Lockheed Martin, General Dynamics, Raytheon and Thales. BAE Systems is the fourth largest defence contractor in the world[5], and the principal prime defence contractor based in the UK.

[4] See 'BAE Systems in the North West of England', Centre for Business Research, Manchester Business School, June 2002

1.4 Putting BAE Systems UK in the UK defence market context

While sales into the UK have been increasing over the last seven years, revenues accruing to that part of BAE Systems located in the UK have been declining. In 2002, total revenues accruing to the UK part of the business were £5,434 million, or 45% of total global revenues. That UK total is down 27% in real terms on 1995, an average fall of 4.5% pa. That decline has continued in recent years, as the chart below shows.

Chart I.1.7



The dotted line in the chart above is the revenues accruing to BAE Systems' UK operation – including sales to the UK and exports. The bars are BAE Systems' total sales to the UK. BAE Systems sales to the UK have remained rather stable, while the exports of the UK operation have decreased sharply. Despite the rapid decline in real turnover, at nearly £5.5 billion in 2002, BAE Systems' UK turnover is still worth 0.26% of UK gross output – though that figure is half what it was in 1995 (0.52%).

BAE Systems' share of the UK defence equipment market has also been stable, as total UK defence equipment spending has been rather flat in real terms.

[5] Defense News, 2002

Chart I.1.8

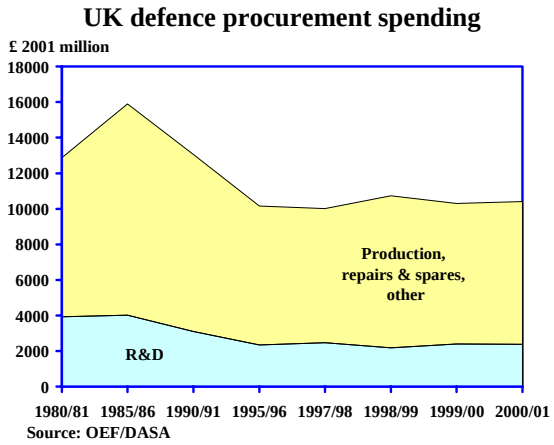
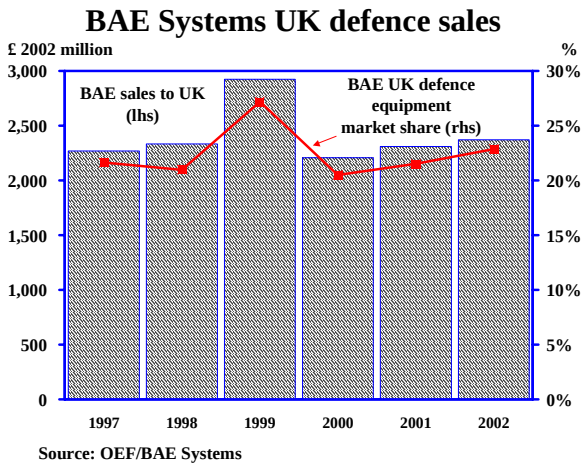


Chart I.1.9



2. The direct economic contribution of BAE Systems

- BAE Systems employed 40,220 people in the UK in 2002 – equal to total employment in the office machinery and computers sector – with a particular concentration of employment in the North West of England.
- BAE Systems invested £500 million in 2002 in fixed capital – 160% higher than the UK average fixed investment per employee.
- BAE Systems exported a total of £3,000 million in 2002 from the UK, 1.6% of total UK goods exports. Net exports of BAE Systems' UK operation were worth £2,000 million, reducing the deficit on the current account of the UK balance of payments by 11%.
- BAE Systems created £2,294 million in value added in 2002, more than two-and-a-half times the total value added of the machine tools sector in the UK.
- BAE Systems contributed £1,150 million to the Exchequer in taxes in 2002.
- In 2002, £1,210 million was channelled into research and development via BAE Systems, 6% of total UK R&D expenditure. The evidence suggests that BAE Systems makes relatively efficient use of this R&D spend in terms of generating higher productivity.

BAE Systems is a major UK employer, contributing particularly to employment in the North West of England. Employees at BAE Systems contribute more than average to total UK value added, thanks

to substantially above-average fixed investment and exceptionally high spending on research and development.

It should be noted that this paper does not seek to capture the full economic benefit the UK derives from Airbus UK[6], as this is not a wholly owned element of BAE Systems. However, it should be noted that the significant contribution Airbus UK makes to UK economic activity (reflected in the Aerospace IGT report) can be attributed to the original corporate decision by the then British Aerospace to invest in the Airbus effort and to develop a centre of excellence in the UK for commercial aircraft wing design and manufacturing.

2.1 Employment at BAE Systems

Total employment at BAE Systems in the UK was 40,220 in 2002, excluding joint ventures. That is roughly equal to total employment in the office machinery and computers sector, and represents 1.1% of total employment in manufacturing industry. The regions in which BAE Systems is most significant in terms of employment include the North West, and Scotland. The table below shows the regional employment totals for BAE Systems in the UK in 2002.

Table I.2.1 Employment at BAE Systems by region (including joint ventures)

Region	**BAE Systems employment, 2002** % of total BAE Systems employment in UK[7]
Scotland	12.4%
North West	41.1%
London / South East	16.2%
South West / South Wales	12.1%
South / South Coast	12.2%
North East / North Coast	5.3%
Midlands	0.7%

[6] Except for the spillover contribution to the UK deriving from the R&D spend channelled through BAE Systems, which includes Airbus and other Joint Ventures.
[7] These shares were calculated using employment figures including Joint Ventures

The table shows that BAE Systems employment is particularly concentrated in the North West, around Barrow-in-Furness, Preston and Manchester. This is an area where other employment opportunities, particularly in high-value-added industries like BAE Systems, is often hard to find.

A recent report for the North West Development Agency and the North West Aerospace Alliance[8] finds that there is evidence of a 'cluster' of aerospace industries in the North West, of which BAE Systems is an important component. This is also borne out by some research undertaken by the Manchester Business School. The development and nurturing of clusters, particularly in high-tech industries such as aerospace, is widely held to be an important intermediate goal in keeping the productivity of the whole economy close to the technological frontier. Where such clusters already exist, that should give Government and industry a head start. As Professor Michael Porter says[9]:

"The challenge for an economy is to move first from isolated firms to an array of clusters and then to upgrade the sophistication of clusters to more advanced activities"

It is likely that, without the activities of BAE Systems in the North West, the local cluster would lack the critical mass that facilitates the innovation and the associated productivity gains, although it can be extremely difficult to quantify exactly what that critical mass is.

2.2 Fixed investment by BAE Systems

BAE Systems is a major contributor to fixed capital investment in the UK – worth £500 million in 2002. Across the UK as a whole, the average level of fixed capital investment per employee was £4,753 in 2002. In BAE Systems, in 2002, that number was £12,431 – some 160% higher than the national average. BAE Systems is a more than usually investment-intensive firm, as the table below shows.

[8] Dr Andrew Mair, 'North West England Aerospace Cluster, Cluster Mapping Project, Final Report', May 2001

Table I.2.2 Investment/head	**2002**
Communication	£19,687
BAE Systems	**£12,430**
Transport	£12,282
Intermediate goods	£5,897
Business services*	£5,096
Total services	£4,468
Finance	£4,144
Agriculture	£3,816
Total manufacturing	£3,707
Non-market services	£3,376
Investment goods	£3,217
Consumer goods	£3,148
Distribution	£2,527
Construction	£1,698
Average	£4,753

*including real estate and renting services

Fixed investment per employee is higher at BAE Systems than in any of the industrial sectors above except for communications.

2.3 Exports of BAE Systems

BAE Systems' UK operation is a highly export-oriented business. BAE Systems contributed around £3 billion to UK exports in 2002 – over 1.6% of total UK goods exports in that year. And the trade balance also benefited: the UK part of BAE Systems imported just under £1 billion in 2002, leaving a positive contribution to UK net trade of just over £2 billion. Without that contribution, the UK deficit on the current account of the balance of payments would have been £16.9 billion in 2002 rather than

[9] Michael Porter and Christian Ketels: 'UK competitiveness: moving to the next stage': DTI Economics Paper #3, May 2003

the £18.9 billion it was – an improvement of over 10%. It is noteworthy that the contribution to exports from BAE Systems is supported to some extent by the activities of the ECGD.

2.4 Value added of BAE Systems

Value added is calculated as the difference between total pre-tax revenue and total bought-in costs (costs excluding wages and salaries). In 2002, the total value added of BAE Systems to the UK economy was worth £2,294 million – more than two-and-a-half times the total value added of the machine tools sector in the UK.

With 40,220 UK employees, value added per head at BAE Systems was £57,000. That is 63% higher than the UK average value added per employee in 2002, of £34,957. The table below shows value added per head in 2002 in different industrial sectors and at BAE Systems.

Table I.2.3 GDP/head	**2002**
Business services*	£57,428
BAE Systems	**£57,000**
Communication	£51,745
Intermediate goods	£48,842
Transport	£41,496
Total manufacturing	£39,242
Consumer goods	£38,699
Investment goods	£35,269
Total services	£34,408
Finance	£30,091
Construction	£29,259
Non-market services	£28,649
Distribution	£23,565
Agriculture	£22,698
Total	£34,957

*including real estate and renting

This table shows that value added per head at BAE Systems is higher than in all but the business services sector. Of course the sector averages mask a distribution of companies within each sector, some of which will be more productive and others less so. But still, the evidence suggests that BAE Systems generates a substantially higher than average value added per head.

Value added per head at BAE Systems is also higher than in many of its European competitors. The table below shows value added per employee in a number of European aerospace/defence companies in 2001/02.

Table I.2.4 Value added per employee	**2001/02**
EADS (Netherlands)	£58,400
BAE Systems	**£53,100**
Finmeccanica (Italy)	£50,700
Rolls Royce (UK)	£50,600
SAAB (Sweden)	£49,800
Snecma (France)	£48,200
Thales (France)	£48,000
Cobham (UK)	£46,900
Smiths (UK)	£46,100
Zodiac (France)	£45,200

BAE Systems has the second highest productivity in this table, behind EADS who benefit from high volume manufacture of Airbus.

In general, the level of labour productivity achieved within a particular firm reflects a number of factors, of which the most important include:

- The level of fixed investment in that firm
- The level of research and development spending by that firm
- In-house staff training
- The education and skills that the labour force brought with them into that firm

Only the first three can rightly be attributed to the company itself. If higher productivity at BAE Systems reflects higher skill levels in its workforce than elsewhere, and these skill levels are pure endowments of the BAE Systems' workforce (not the result of in-house training), then in principle they, and the higher productivity associated with them, would be transferable elsewhere. The data suggest that BAE Systems does contribute to the productivity of its own staff – with fixed investment, R&D and in-house training - by more than the national average, ie by more than could be expected elsewhere – see R&D section below.

2.5 Tax contribution of BAE Systems

In 2002, BAE Systems directly contributed a net £1,150 million to the Exchequer via taxes. Net VAT payments amounted to £240 million, partially offset by negative corporation tax of £90 million on account of the losses incurred by the company in that year. In addition to that, BAE Systems' employees contributed around £1 billion via income tax and National Insurance. The total tax contribution of £1,150 million was around 0.3% of total government revenues in 2002.

Table I.2.5 Tax	**2002**
VAT (net)	£240 million
Corporation tax	-£90 million
Income tax and National Insurance	£1,000 million
Total	£1,150 million

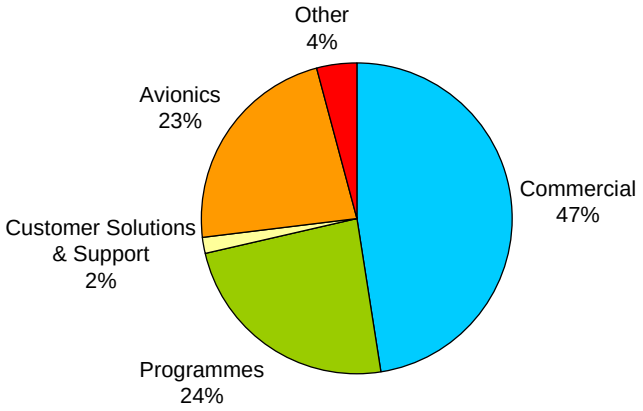
£1,150 million is equivalent to a third of a penny on the basic rate of income tax[10], or 1p on the higher rate of income tax.

2.6 Research and development spending via BAE Systems

In 2002, a total of £1.21 billion was channelled into research and development through BAE Systems in the UK[11], with a further £200 million in the North America operation. Within the UK total, 47% was devoted to R&D in the commercial business group, with the remainder being split largely between programmes and avionics.

[10] See Inland Revenue direct effects of illustrative tax changes
[11] Including R&D spent by BAE Systems on Joint Ventures, and Airbus

Chart I.2.1 Research and Development investment by BAE Systems in the UK, 2002



£1.21 billion represents 7.5% of the R&D investment undertaken by the top 600 firms in the UK in 2002[12], and 6% of total R&D in the UK – a far higher proportion than might be expected given the proportions of total UK value added and employment accounted for by BAE Systems. That reflects the fact that BAE Systems' output is highly R&D intensive compared to the rest of the economy. Across the whole economy, on average, £22 thousand is spent on R&D for every £1 million of sales. At BAE Systems, the number is £223 thousand – more than ten times the national average. BAE Systems' R&D intensity, at 22.3%, compares favourably not only with the UK national average (2.2%) but with the much higher average in the pharmaceutical industry (14.6%). Moreover, the data suggest that R&D intensity normally declines as the size of firm increases, which – given the size of BAE Systems – makes the R&D intensity of BAE Systems stand out even more. BAE Systems is the third largest source of R&D spending in the UK, after Glaxo SmithKline and Astra Zeneca. The table below shows R&D intensities by industrial sector in the UK in 2002.

[12] See DTI R&D scorecard 2002

Table I.2.6 R&D intensity by sector	2002
BAE Systems	**22.3**
Pharma & biotech	14.6
IT hardware	7.1
Aerospace & defence	6.5
Health	6.5
Software & IT services	5.8
Automotive	4.8
Electronic & Electrical	2.6
Chemicals	2.2
Engineering	1.5
Food processors	1.5
Telecomms	1.0

Source: DTI R&D Scoreboard 2002

Table I.2.7 Top 12 UK-owned R&D companies in 1992 and 2002

1992	2002
1. ICI (includes Zeneca) £596m	1. Glaxo SmithKline £2,651m
2. Glaxo	2. AstraZeneca
3. Shell	**3. BAE Systems**
4. GEC	4. Unilever
5. SmithKline Beecham	5. Marconi
6. Unilever	6. BT
7. BP	7. Rolls Royce
8. British Aerospace	8. Reuters
9. BT	9. Shell
10. Wellcome	10. BP
11. Rolls Royce	11. Invensys
12. Lucas	12. Amersham £174m

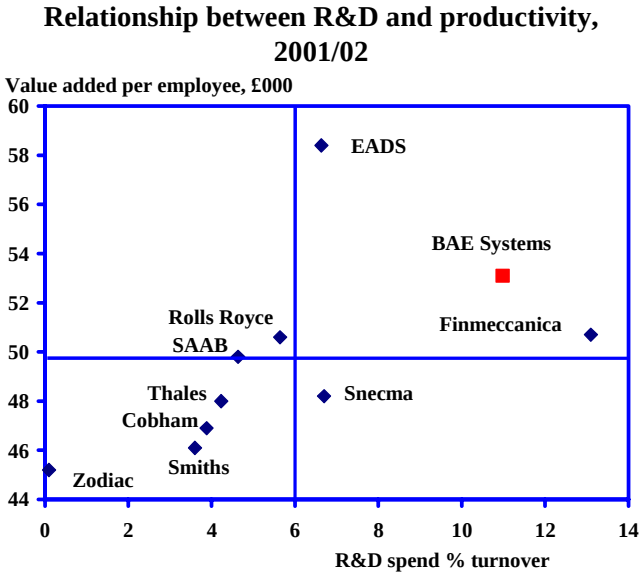
Source: DTI R&D Scoreboard

Most of the R&D spend by BAE Systems is sourced from the MoD. But there are two points worth noting.

- BAE Systems appears to make relatively good use of those R&D funds in terms of generating higher productivity in its own staff.
- BAE Systems is itself an important source of funds, particularly at the Research and Technology end of the R&D spectrum: R&T is the pre-main-gate research, before the requirement has been fully specified.

The chart below shows the value added per head in different European aerospace/defence companies, related to the R&D spend as a percentage of sales in each company in 2001/02. The chart shows that firms with higher than average R&D spend tend to generate higher than average levels of productivity. BAE Systems, along with EADS and Finmeccanica, is in the top right quadrant. This implies that, whatever the source of funds for R&D (whether BAE Systems itself or the Government), BAE Systems appears to make relatively efficient use of these funds, compared to its European competitors.

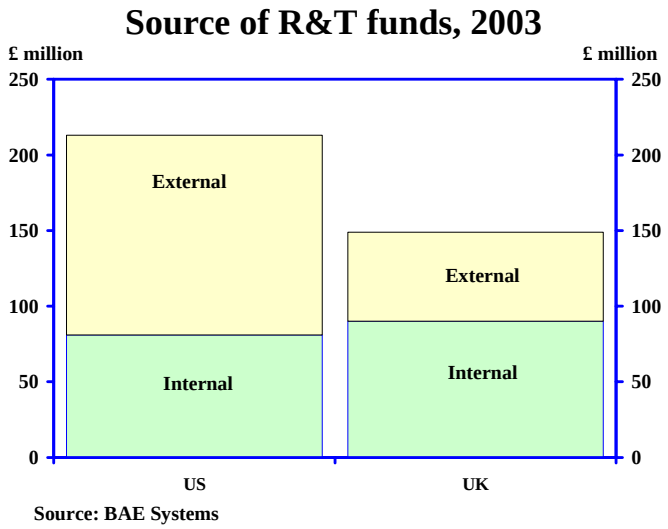
Chart I.2.2



The chart below shows the proportion of BAE Systems research and technology spending (a subset of total R&D) that was internally versus externally funded in 2003 in the UK (65%) compared to the US (37.5%). This chart suggests that there is at least a significant proportion of R&D spend by BAE

Systems in the UK that is internally funded, and which might in principle be lost if BAE Systems were to cease its operations in the UK.

Chart I.2.3



3. The indirect economic contribution of BAE Systems

- BAE Systems indirectly supports the employment of a further 49,060 people in the UK, with that indirect employment concentrated in the service sector.
- BAE Systems indirectly supports £211 million of fixed investment.
- BAE Systems indirectly supports a contribution of £1,403 million to the Exchequer via taxes.
- BAE Systems indirectly supports £2,044 million of value added further down the supply chain.

In addition to its own activities, and its own employees, BAE Systems is indirectly responsible for supporting activity and employment in other firms, to the extent that those firms rely on sales to BAE Systems as part of their total revenues. Moreover, those firms that do benefit from sales to BAE Systems will in turn buy in goods and services from a range of other firms. In proportion as a firm sells to BAE Systems, so its own bought-in costs can be said to be indirectly attributable to BAE Systems. The overall reliance of other firms on initial demand from BAE Systems can be thought of as the 'indirect' contribution of BAE Systems to the economy.

3.1 Indirect employment supported by BAE Systems

Each year, BAE Systems spends about £4 billion on procurement of equipment, components, raw materials etc from its suppliers, with about half of that total devoted to procurement on major projects. Of that £4 billion, about 78% is sourced in the UK. How does that translate into employment indirectly supported by BAE Systems?

According to the MoD, the UK had a total of 300,000 jobs in defence-related industries in 2000/01 – of which 155,000 were 'direct' employment and 145,000 'indirect' – jobs further down the supply chain. So, on average, if the MoD methodology is correct, every 10 jobs in a typical defence firm should support a further 9.3 jobs further down the supply chain – a 'multiplier' of 0.93.

Table I.3.1 Total direct and indirect employment in the UK defence industry

Employment in defence industry, thousands								
		1980/81	1985/86	1990/91	1995/96	1997/98	1998/99	1999/00	2000/01
Total employment		**740**	**625**	**555**	**410**	**360**	**350**	**295**	**300**
Direct		405	345	295	205	180	175	150	155
Indirect		335	280	260	205	180	175	150	145
Employment from MOD expenditure		**600**	**515**	**405**	**265**	**240**	**240**	**225**	**230**
Direct		330	285	220	135	125	125	120	125
Indirect		270	230	185	130	115	115	105	105
Equipment expenditure									
Of which	Direct	230	200	140	85	75	75	65	70
	Indirect	190	160	130	90	75	75	65	65
Non-equipment expenditure									
Of which	Direct	100	85	80	55	50	50	50	55
	Indirect	80	70	60	40	45	40	40	40
Source: DASA									

The table shows that within total MoD spending, the employment multiplier for equipment expenditure (at 0.93) is rather higher than that for non-equipment expenditure (at 0.73). However, there are a number of other sources of estimates for this ratio of direct to indirect employment:

- A paper by Dowdall, Braddon and Hartley (2000) puts the multiplier at between 1.2 and 1.4 for aerospace and defence industries.

- The Society of British Aerospace Companies (SBAC) suggests that UK direct employment in the aerospace industry in 2001 was 147,000, and that a further 200,000 jobs were indirectly supported – making a multiplier of 1.36 – towards the top end of the Dowdall et al range.

- The recent Aerospace Innovation and Growth Team (AEIGT) report states that the 147,000 UK Aerospace jobs support a further 350,000 in the rest of the economy – making a multiplier of 2.4 – substantially above the top end of the Dowdall et al range.

- Our own (two-tier) analysis, distributing BAE Systems' UK procurement spending across industrial sectors and examining the impact of that spending on total sales of different industries, using input/output tables in the UK suggests that a typical job in BAE Systems in the UK supports a total of 1.22 jobs elsewhere in the economy – consistent with the Dowdall, Braddon and Hartley estimates cited above. The main sectors where employment is supported in the first tier by the weapons and aerospace sectors are the following:

    - Weapons and aerospace. If we were calculating the multiplier of the industry as a whole then it would be appropriate to exclude jobs supported in this sector. But since we are calculating the multiplier for a particular firm within the sector, then it is appropriate to include jobs supported elsewhere in the sector.
    - Metal products
    - Office machinery and computers
    - Basic metals
    - Precision equipment

Taking into account the first and second tiers together, the 40,220 UK jobs at BAE Systems in 2002 supported a further 49,060 jobs further down the supply chain – a multiplier of 1.22. Those jobs were distributed across the sectors as in the table below.

Table I.3.2 **Sector**	**BAE Systems indirectly supported employment 2002**
Investment goods	25,570
Business services*	9,990
Intermediate goods	3,850
Non-market services	1,960
Consumer goods	1,810
Distribution	1,590
Finance	1,430
Transport	1,420
Communication	660
Construction	380
Other industry	360
Agriculture	30
Total	49,060

*including real estate and renting services

3.2 Indirect investment supported by BAE Systems

To the extent that BAE Systems supports the activities of other firms in the supply chain, it also supports the investment expenditure undertaken by those firms. The two-tier employment multiplier above is 1.22. It turns out that the investment multiplier is substantially less than that: BAE Systems itself invests substantially more than average per employee, as we described above. In fact, looking at the propensity to invest on the part of the various industrial sectors, for every £1 invested in fixed capital by BAE Systems directly, further investment worth £0.42 is supported further down the supply chain, making a total of £211 million of indirectly supported fixed investment in 2002.

3.3 Indirect contribution to taxes supported by BAE Systems

To the extent that BAE Systems supports the activities of other firms in its supply chain, it also supports tax contributions from those firms. As a result, total tax revenues indirectly supported by BAE Systems in 2002 were worth £1,403 million[13] - equivalent to a further half a penny on the basic rate of income tax.

3.4 Indirect value added supported by BAE Systems

To the extent that BAE Systems supports employment in other firms down the supply chain, it also supports the value added that they create. Since value added per head at BAE Systems is higher than average, the value-added multiplier is lower than the employment multiplier: in fact, it turns out that for every £1 of value added created at BAE Systems, a further £0.89 of value added is indirectly supported further down the supply chain, making a total of £2,044 million of indirectly supported value added in 2002.

Table I.3.3 **Sector**	**BAE Systems indirectly supported value added, £million, 2002**
Investment goods	1,053
Business services*	443
Intermediate goods	168
Consumer goods	75
Finance	67
Transport	61
Non-market services	51
Other industry	49
Communication	33
Distribution	28
Construction	15
Agriculture	1
Total	2,044

*including real estate and renting services

[13] If we assume that the tax multiplier is the same as the employment multiplier.

The indirect contributions calculated above probably understate the role of BAE Systems in supporting its supply chain, since it attributes indirect jobs to BAE Systems only in proportion as BAE Systems makes use of physical inputs to the production process from its suppliers. In fact, there are a number of suppliers to BAE Systems for whom the company is their largest single customer, accounting for perhaps one third of their total sales. In these cases, it is possible that if demand from BAE Systems were to dry up, then not just one third but all of the jobs in that company would also go.

This is borne out in a number of interviews with suppliers to BAE Systems. The three suppliers that we talked to in this project all felt that their relationship with BAE Systems was very important to the financial health of the company as a whole.

Their responses underline the fact that the contribution of a large company like BAE Systems cannot be captured simply in the resources that it employs directly or indirectly. It has a much wider importance than that, interlocking in numerous ways with local communities, many of which would become 'ghost towns' were it not for the activities of BAE Systems.

3.5 Altra Electronics

One of BAE Systems' suppliers is a company called Altra Electronics. Altra employs some 2,600 staff, and has a turnover of around £250 million pa. 95% of their business is in aerospace and defence electronics. Around 20% of their revenues come directly from BAE Systems, with a further 5% to 10% coming indirectly from BAE Systems, with another supplier in between.

Altra manufactures a range of products, including:

- Cockpit equipment such as HOTAS (Hands On Throttle And Steering), switches, indicators etc
- Undercarriage controllers
- Software embedded in on-board computers
- Wiring harnesses, for example for Airbus
- Ship consoles
- Weapons control systems on submarines

- The sonar buoy suite mission system on Nimrod – 'absolutely pivotal' for the entire anti-submarine military dependency of the UK armed forces

These products are very high-tech, with a great deal of R&D and capital investment embodied in them. Usually they are bespoke products designed expressly for the British armed forces, but there are exports too.

The MD of Altra, Frank Hope, is on the whole very positive about the relationship between his company and BAE Systems. He describes it as very good at all levels. There are some difficult moments, but BAE Systems generally makes a lot of effort to work well with their suppliers. That collaboration extends to exchanging teams, and generally taking a joint approach to solving problems.

For example, Altra and BAE Systems worked together on developing and implementing the PFQM model, the experience of which has fundamentally affected the whole of Altra Electronics' business, including significant improvements to processes, to management techniques and even to products and product design. Moreover, BAE Systems were instrumental in helping Altra to adopt 'lean manufacturing' techniques such as cellular structures on the shop floor.

In Mr Hope's view, "BAE Systems is in the vanguard of trying to change how people do business". As a result, they have had a bigger impact on the UK defence industry than they are often given credit for. And their benign influence does not extend merely to areas that will benefit BAE Systems: Mr Hope has himself participated in a joint presentation with BAE Systems to another UK defence manufacturer, disseminating the message of how to improve productivity, which was perceived as very helpful by the audience, who proceeded to implement many of the recommendations in their own business. And joint workshops of various kinds are a frequent occurrence.

The relationship is characterised by:

"… a lot of partnership, a lot of collaboration, with BAE Systems leading the way on productivity and good practice, where the UK in general often takes a very short-term approach."

However, the difficulties that BAE Systems have run into in recent months have contributed to a deterioration in the relationship in some respects. There is a sense in which they seem to have taken their eyes off the ball, and are not now so innovative as they used to be. Mr Hope gave recent

examples of occasions when BAE Systems have changed the terms of contracts – including reducing the price significantly – after the contract had been agreed, and in a more confrontational style than might have been adopted in the past. This new approach risks changing the nature of the relationship to something much less co-operative.

But that should not detract from the main message, that:

"BAE Systems is one of the last vestiges of high-tech manufacturing in the UK who continue to champion productivity improvements – and who back their words with actions."

One of the benefits of working with BAE Systems for Altra has been the extent to which the technologies and products developed together with BAE Systems have been transferable into other applications. An example of this is the Grips business – the interface between the human and the machine. Originally developed with BAE Systems for the Eurofighter and the Hawk, Altra have since transferred the technology into the land systems market, which has created export opportunities into Germany, France and elsewhere.

If the relationship with BAE Systems were to come to an end, it would have a severe impact on Altra. BAE Systems helps to provide Altra with the continuity of business that keeps them going in an environment where demand is otherwise either "feast or famine". Without that continuity, there is a risk that a lot of the key expertise in Altra would disappear during the lean times. With it, the expertise can be retained, indeed enhanced, allowing Altra to exploit new market opportunities when they arise.

3.6 Cobham Plc

Another of BAE Systems' suppliers is Cobham Plc, a major UK quoted company operating in the Aerospace and defence industry. Cobham has a turnover of around £750m and employs 8,000 staff worldwide. Sales to BAE Systems are just under £20m, less than 3% of turnover. There are additional sales to the Eurofighter Typhoon fighter project. Most sales are subject to medium term contracts and thus production can be planned for without large stocks being held. The volatility in the business can come from variations in BAE Systems' government contracts. Cobham is a global company with over 29 facilities in North America and as such they have several contracts with BAE Systems North America.

Cobham is involved in areas such as aerospace systems, avionics and flight operations. Their range of products includes:

- Fuel systems
- Oxygen and life support systems
- Cryogenic cooling
- Search and rescue and survival systems
- Satellite communications
- Antennae
- Weapons carriage and release
- High technology Composite components

The main products sold to BAE Systems include, antennae, fuel systems, oxygen and life support systems and a range of outsourced services. Some of these sales are going into key defence products such as Tornado, Nimrod and Hawk. The products are high-tech and capital intensive but also need considerable skilled labour for both manufacture and R&D. R&D is over 6% of turnover.

Cobham's chief executive Allan Cook said that the two companies had a strategic partnership in place and had both worked hard to develop this ongoing relationship, which was working well. The aim of this partnership included improving productivity and ultimately growing the business.

Although to date there had been little in the way of knowledge transfer between the companies, they do work jointly on projects and this had resulted in some sales. The Cobham/BAE business was supporting a key centre of knowledge for significant parts of the UK defence industry. Cobham and BAE work together in attempting to improve international standards in areas that they are jointly involved in. They also collaborate on offset opportunities worldwide.

An important link between the companies had come from a number of BAE Systems' businesses that Cobham had bought and further developed. These included the early 2003 purchase by Cobham's Chelton business of the Blackburn, UK based land platforms communications business (LPC) and the earlier purchase of BAE's power and controls business by Cobham's Flight Refuelling Ltd. Cobham had also purchased a Stevenage based radome business from BAE. Cobham had grown employment in these businesses since purchase.

If the relationship with BAE Systems were to come to an end, then Cobham would lose a certain amount of turnover in some strategic areas. It could put pressure on their UK employment, although as a global company with a diverse product and service portfolio the effect would be minimal. The bigger problem would be in the overall UK Aerospace Industry where BAE Systems is the largest UK owned company.

3.7 Smiths Plc

Smiths Industries Plc, a large UK multinational, is another of BAE Systems' major suppliers. The group employs 32,500 people worldwide of whom over 11,600 are in the aerospace business. Smiths is also involved in specialty engineering, medical and detection businesses. In 2001/02 turnover was in excess of £3bn, with aerospace sales of £1346m accounting for 44%. Sales to BAE Systems are currently running at £66m or 5% of aerospace sales. An equivalent amount of annual business at least through to 2007 is expected based on secured and follow on contracts.

A wide range of products is sold to BAE Systems including

- Advanced Avionic Systems and Aircraft Equipment
- Aircraft Displays including Head-Up Displays
- Mission and Utilities Computers
- Stores Management Systems
- Navigation and Flight Management Systems
- Fuel Systems and System Components
- Electronic Line Replaceable Equipment
- Primary Flight Control Actuators
- Utility Actuation Valves and Reservoirs
- Structural Components
- Aircraft Panels and Cockpit Transparencies
- Design services and consultancy (e.g. Prognostic Health Monitoring)
- Ground Support Equipment and Software

While most of these products are high tech aerospace products needing major R&D and capital investment, there are also important support businesses such as logistics management support.

Alan Raine, Smiths' business director for BAE Systems and UK MOD said that Smiths' relationship with BAE Systems is based upon a long history of contracting together on a breadth of Air Systems programmes, in particular, but also on Land and Sea Sector programmes. He is responsible for the relationship between the companies, which he said, was currently transactional and contractually based, ie focused on individual contracts and deliverable items (e.g. current Hawk relationship). There was also occasionally joint development through integrated project teams conducting specified tasks (e.g. Hawk IPT for LIF development programme or RHGS development for Eurofighter). They had also partnered in pursuit of programmes with a common interest and research programmes. They were developing a more strategic relationship but this was yet to bear fruit. Relationships in the US were less rigid than those in the UK, which allowed them to develop better.

He praised BAE Systems 'Major Equipment Supplier Programme' as an excellent way forward. This promotes

- View of Smiths as a single supplier rather than a view based on individual contracts.
- Discussion and development of an optimum strategic relationship to mutual benefit
- Co-ordination of a strategic approach to improving business across a range of contracts
- Identification of opportunities to do business and co-ordination of investments in future technologies

There is some knowledge transfer between the companies but this has not been of major importance. He would rate BAE Systems much more highly in R&D than in management methods and feels that the research links are well worth developing.

Joint process initiatives include

- Supply chain initiatives, infrequent but an effective method of developing relationships. Alan said that he felt the supply side links in the US were stronger than in the UK.
- E-Business in the supply base including electronic transfer of orders
- Specific Kaizan or Lean activities. Smiths are deploying Lean through the organisation and have set up Lean and change programmes in most businesses
- Joint Improvement Programme. Newly founded and supported by Smiths' existing Lean deployment programmes / activities

- Joint research programmes partly funded by MOD, DTI, and EU etc.

Smiths are moving towards structured reviews of capability and sharing programme / technology investment plans through proposed business plan alignment sessions within the Major Equipment Supplier Programme, initiation of Team Hawk initiative and potential collaboration on UAV.

Very few if any products developed for BAE Systems have sold to other customers in the same form.

- BAE Systems prefer to specify exact solutions for specific requirements
- Tend not to engage sufficiently with the supply base to develop cost effective solutions
- As a result are not aware of capability within the supply base
- Late engagement introduces schedule risk which discriminates against innovation

Smiths' products tend to be:

- Developed incrementally using either customer or internal development funds and targeted at multiple applications or at particular time periods
- Developed in close collaboration with a particular customer but with a view to general application (e.g. C130 AMP Common Computing System, Auxilliary Power and Cooling System, ISIS, 5ATI AMLCD Display, 767 Re-fuelling System, Boeing Electrical Load Distribution System, etc. etc.)

Examples of products, which have been developed with BAE Systems as initial customer however and have subsequently been significantly adapted to meet the needs of other customers include:

- Head Up Display products
- CRT and AMLCD Head Down Display products

In summing up the importance of BAE Systems to Smiths Industries Alan said that apart from providing over 5% of Smiths' aerospace sales, Smiths and BAE Systems mutually benefit from:

- Prominent positions in the UK supplier base
- Working relationship built up over time and a wide range of programmes
- Ability to work together effectively to win UK programmes in particular

BAE Systems products also compete in the international market and this provides Smiths access to additional sales. This is demonstrated by recent sales of Hawk and Eurofighter. It is vitally important that there is a UK company active in this area. BAE Systems are also important to Smiths' links with the MOD.

Historically the potential benefits to Smiths of shared technology development and shared practices have not been optimised, although there are good examples where both companies have benefited significantly from working closely together.

Looking forward Alan anticipates that both companies will benefit from working closely together in support of:

- UK Legacy Platform support
- Development of UAV capability
- Development of System partnerships to address new and existing Air, Land and Sea platforms

These systems solutions would be more applicable to other international customers and would provide Smiths with benefits over and above annual sales to BAE Systems that would be missed if there were no BAE Systems.

4. Induced economic contribution of BAE Systems

- Direct and indirect employees of BAE Systems 'induce' (support with their expenditure) employment of a further 22,316 people in the UK
- Induced value added is worth £1,086 million, 0.1% of UK GDP

Employees supported by BAE Systems (whether directly or indirectly) use their income to purchase goods and services for their own consumption, and this spending then helps to support the jobs in the industries that supply these purchases. Estimates based on simulations conducted on Oxford Economic Forecasting's Macroeconomic Model of the UK economy suggest that this so-called induced employment may be around 22,316 people in the UK (ie around 25% of direct and indirect employment attributable to BAE Systems). This does not mean that these additional jobs would not exist in the long run without the support of BAE Systems, but they would be likely to do so only at somewhat lower real wages and living standards for those workers.

5. The spillover or catalytic contribution of BAE Systems

- R&D spending channelled through BAE Systems adds around 0.1% points to UK GDP growth each year, by improving productivity across the whole economy. In the long run (after ten to fifteen years), the total contribution could reach 1.5% points. In 2002, that would have been worth £15 billion.
- The catalytic contribution of the R&D spending channelled through BAE Systems is the main positive externality that would be lost if those funds were spent outside the UK.

The 'spillover' or 'catalytic' contribution of BAE Systems is the extent to which the activities of BAE Systems contribute to increased productivity in other industrial sectors, and therefore in the UK as a whole. Is it possible to quantify this contribution? There is a substantial literature on this subject – not specific to BAE Systems, but to the defence industry as a whole. The literature is not conclusive, but there are some generalisations that can be drawn from it:

- Military spending overall can be either positive or negative for the growth of the whole economy, depending on the extent to which it 'crowds out' other forms of activity.

- There is widespread agreement that spending on R&D as a whole is either neutral or positive for the growth rate of the whole economy.

The literature in this area has been heavily influenced by a seminal paper by Emile Benoit, which argues that military spending boosts the economic growth of the whole economy: this became known as the 'Benoit hypothesis'. One possible explanation of this in the UK might be that the defence industry, since it makes intensive use of research and development, is at the forefront of the 'knowledge-based economy' in the UK. The gradual transition towards a progressively more knowledge-based economy is a stated aim of the government, based on the idea that knowledge intensive industries are characteristically high value-added high-growth industries that contribute positive externalities to the rest of the economy.

In Appendix 2 we review in detail the literature on the relationship between defence spending and growth. Next, we quantify the impact the R&D channelled through BAE Systems on UK macroeconomic performance. There is a huge body of literature in this area, and different studies are not always in agreement.

5.1 Relationship between defence spending and growth

Faced with this enormous and inconclusive body of work (reviewed in Appendix 2), we have examined one very narrow question, as part of the research for this project:

Is there a significant role for defence and non-defence R&D spending in explaining productivity in advanced economies?

We find that there is. To summarise, both defence and non-defence R&D appear to boost productivity, controlling for the size of the capital stock, the number of people employed, the quality of that labour, the hours they work, and the tendency for productivity to grow over time. The impact of non-defence R&D appears to be larger than that of defence R&D, but defence R&D is nevertheless significant and positive for productivity.

To explore this question, we have taken a dataset produced by the Bureau of Labour Statistics in the US, which gives defence and non-defence research and development expenditure in the G7 economies as a proportion of their GDP, on an annual basis between 1981 and 2001. Then we have constructed

an annual time series of total factor productivity for each country over the same period – all measured in US dollars in 1995 prices.

Total factor productivity is estimated as a residual from a production function of the following form:

$$Y = AK^{\alpha}L^{(1-\alpha)}$$

Where Y is (in this case) GDP in constant 1995 prices in US dollars, K is the value of the capital stock[14] in constant 1995 prices in US dollars, L is the total hours worked by the employed labour force, and A is total factor productivity (TFP) – a measure of how efficiently the different 'factors' (capital and labour) are employed in the production technology.

That gives us a time series for TFP for each country over the period, in addition to the defence and non-defence R&D spending as a proportion of GDP. To these we have added a proxy for labour quality, derived from the OECD. There are numerous such measures that could be considered: average educational attainment; average spending on education; average literacy/numeracy levels, and many more. We have used the average numbers of teachers per pupil at all levels of education (primary, secondary and tertiary) as a proxy for the educational standards and therefore the labour quality in different economies. Clearly this is a very broad indicator with many faults, but the same could be said of almost every other such series. Finally, we add a time trend for each country, on the basis that total factor productivity tends to grow over time for reasons that may not be related to any of the explanatory variables that we are considering (this is the concept of exogenous technical progress that goes back to the work of Robert Solow).

For estimation, we have created a pooled panel data set: stacking the time series information for each country on top of each other.

[14] The way capital stock is measured varies widely across countries. To get around this issue, we take the US capital stock in 1995 as given, and assume that the capital stock to GDP ratio in other countries stands in the same proportion to that in the US as the investment to GDP ratio does. Then we assume the capital stock grows before and after 1995 as the officially measured capital stock for the relevant country did.

Table I.5.1 Estimation Results: log of total factor productivity equals:

Dependent Variable: LOG(TFP) Method: Least Squares Sample: 1 139 Included observations: 139			
Explanatory variable	Coefficient	Standard error	T-statistic
Constant	-0.333	0.2048	-1.628
Time trend	0.013	0.0006	20.317
Defence R&D % GDP	0.159	0.0185	8.577
Non-defence R&D % GDP	0.199	0.0084	23.879
Labour quality*	0.940	0.0752	12.492
France/Italy dummy	0.247	0.0093	26.458
R-squared	0.921		
Adjusted R-squared	0.918		
S.E. of regression	0.042		
Sum squared residual	0.233		

*log of teacher/pupil ratio

The equation has a high explanatory power, with 92% of the variation in total factor productivity between and within countries explained by the variation in the set of explanatory variables. The residuals are normally distributed but do display signs of serial correlation, not uncommon in panel regressions of this sort. All the variables are 'correctly' signed and significant.

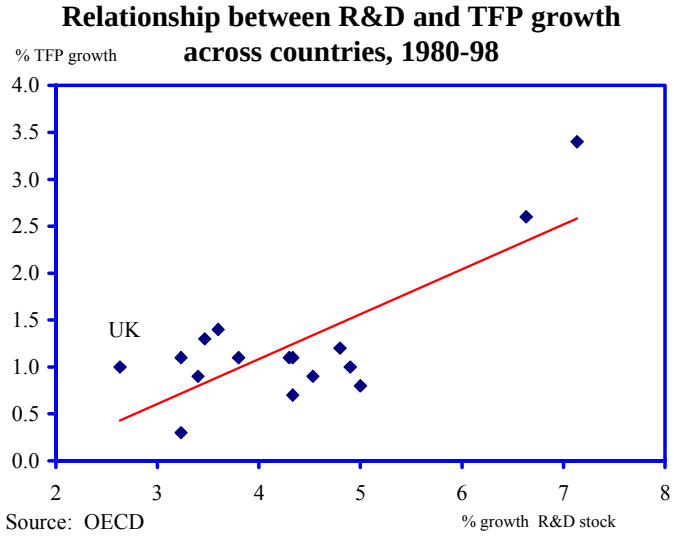
The coefficients suggest the following. Total factor productivity in all advanced economies tends to grow 'exogenously' at 1.3% a year on average, for reasons unrelated to any of the other explanatory variables above. A 1% point increase in the proportion of GDP spent on defence R&D will on average boost total factor productivity (and therefore GDP) by 15.9%. A 1% point increase in the proportion of GDP spent on non-defence R&D will have a bigger effect, boosting TFP by 19.9%.

Labour quality is also highly significant and positive. And it appears that French and Italian TFP are surprisingly high, controlling for all of these factors.

These results suggest that the R&D defence expenditure that is channelled through BAE Systems may be responsible for boosting UK productivity by around 1.5% in the long run. Defence R&D in BAE Systems was around £1 billion in 2002, or 0.095% of GDP. Reducing defence R&D by 0.095% point of GDP would, according to the equation above, reduce UK TFP by 0.095 * 0.159 = 1.5% in the long run. It is worth emphasising, as noted above, that these are long-run results: the boost to productivity could easily take 10 or even 20 years before it is fully reflected in actual GDP. In other words, removing the R&D channelled through BAE Systems might reduce the growth rate of the UK economy by around 0.1% per year for a period of ten to fifteen years, by the end of which time, the full impact – a 1.5% reduction in GDP relative to what would otherwise have happened – would be in place.

These findings are consistent with the results of an OECD study. Across the OECD, there appears to be a reasonably well-defined relationship between the amount of R&D spending in an economy and the growth rate of total factor productivity in that economy (see chart below).

Chart I.5.1



According to the OECD, the relationship in the chart above implies that a 1% increase in the stock of business research and development expenditure is associated with an increase of 1.3% in the average growth rate of total factor productivity: hold such an increase in place for 10 to 15 years and the

impact on GDP will be close to the long-run impact consistent with our own estimates detailed above. Note that the UK is towards the bottom/left of this chart, with low R&D and low TFP growth. It is the government's intention to improve the UK's productivity performance, and encouraging R&D spending would appear to be a good way to facilitate this.

The empirical evidence we have examined does suggest that R&D expenditure in general and defence R&D expenditure in particular yields benefits to the wider economy by boosting total factor productivity. That is also consistent with at least some of the theoretical literature from Benoit onwards.

Moreover, it is borne out by recent research published by the DTI, looking at the key factors that contribute to productivity. A recent DTI Discussion Paper[15] cites low labour productivity as a key area of weak performance in the UK in recent years, and suggests that relatively low spending (by both government and business) on R&D and innovation may be partly to blame. A DTI Economics Paper[16] suggests that low R&D in the UK may be responsible for at least a quarter of the 'productivity gap' between the UK and the US, and one sixth of the gap between the UK and France/Germany. These numbers are very significant: UK labour productivity per hour is more than 20% below that in the US, France and Germany.

Overall, the evidence from our own research and from the wider literature is suggestive of a strong positive relationship between R&D and productivity. Exactly how strong is clearly uncertain – any estimates of the size of the relationship (including our own) must be subject to wide confidence intervals, given the degree of uncertainty about how productivity is measured across countries. But the stylised fact that R&D contributes positively to productivity to some degree is not in dispute.

The recent DTI document 'Prosperity for All' emphasises the positive externalities that derive from R&D spending. The literature cited in this document suggests that the social return to R&D may exceed the private return by a factor of between 2 and 5.

[15] DTI Discussion Paper #6, 'UK productivity and competitiveness indicators, 2003', November 2003.
[16] DTI Economics Paper #7, 'Competing in the Global Economy – the innovation challenge', 2003

Table I.5.2: Private and Social Returns to R&D

Author (Year)	Estimated private rate of return (%)	Estimated social rate of return (%)
Nadiri (1993)	20-30	50
Mansfield (1977)	25	56
Terleckyj (1974)	29	48-78
Sveikauskas (1981)	10-25	50
Goto-Suzuki (1989)	26	80
Bernstein & Nadiri (1988)	9-27	10-160
Scherer (1984)	29-43	64-147
Bernstein & Nadiri (1991)	14-28	20-110

Source: DTI 'Prosperity for All'

A recent report by CHI-research[17] confirms that the aerospace sector is more-than-usually efficient in producing technological innovations – measured by the number of new patent filings – compared to the UK average, thanks to the quantity of R&D that it undertakes. The UK aerospace sector is the market leader in the UK in terms of innovation measured on this basis, and a large proportion of that must be attributable to the spending channelled through BAE Systems. If anything, that suggests that the estimate of a 1.5% contribution to UK TFP growth from the R&D spending channelled through BAE Systems over 10 to 15 years may be conservative.

6. Other economic contribution of BAE Systems

- 21,800 staff at BAE Systems received some training during 2002
- BAE Systems employs 1,100 full-time apprentices in the UK – 5% of all the engineering apprenticeships in the UK

In 2002, a total of 21,800 employees of BAE Systems in the UK (56% of total UK staff) received some kind of training from BAE Systems – a combined total of 44,600 hours of training. Those numbers significantly understate the extent of training within BAE Systems since they do not include the 'on-the-job' training, which is by far the most important part of the training effort.

[17] CHI-Research, New Jersey, quoted in the Financial Times, 26 August 2003

Moreover, BAE Systems employs 1,100 apprentices in the UK – nearly 3% of their UK workforce. That is a significant proportion – nearly 5% - of all the engineering apprenticeships in the UK: 23,000 according to the Engineering Employers' Federation.

The effort that BAE Systems put into enhancing the human capital of their staff is reflected in staff satisfaction surveys and in the perceived desirability of working for BAE Systems. Two thirds of BAE Systems' staff are satisfied with their job[18], and BAE Systems was ranked second (after McKinsey) in the league table of most desirable employers according to new graduates in the UK[19].

[18] According to a survey of BAE Systems' staff reported in the 2002 Corporate Social Responsibility Report
[19] According to a survey by a Swedish research firm called Universum Communications, published in the Guardian of 24 May 2003

7. Total economic contribution of BAE Systems

- BAE Systems total contribution to UK employment was 111,578 in 2002
- BAE Systems total contribution to UK fixed investment was £711 million in 2002
- BAE Systems total contribution to UK exports was £3 billion in 2002
- BAE Systems total contribution to UK tax revenues was £2.6 billion in 2002
- BAE Systems total contribution to UK value added was £5.4 billion in 2002
- UK R&D spend channelled through BAE Systems was worth £1.2 billion in 2002
- That R&D spending channelled through BAE Systems contributes around 0.1% points to UK productivity growth each year. In the long run, the total contribution could reach around 1.5% of UK GDP.

BAE Systems is a substantial contributor to the UK economy, supporting the employment of over 110,000 people, and value added of over £5 billion in 2002 – excluding the beneficial impact on whole-economy productivity deriving from the extremely high levels of R&D spending channelled through BAE Systems. The table below summarises BAE Systems' economic impact in the UK.

Table I.7.1 Summary of BAE Systems' economic impact on the UK economy (2002)

	Direct contribution	Indirect contribution	Induced contribution	Total contribution
Employment	40,220	49,060	22,320	111,600
Investment	£500 m	£211 m	-	£711 m
Exports	£3,000 m	-	-	£3,000 m
Taxes	£1,150 m	£1,403 m	-	£2,553 m
Value added	£2,300 m	£2,044 m	£1,086	£5,430 m

Catalytic contribution from R&D: 0.1% points on GDP growth pa, 1.5% on the level of GDP in the long run.

8. Conclusions: how does BAE Systems benefit the UK economy?

- BAE Systems is the principal prime defence contractor based in the UK. It represents a substantial base of intellectual capital in the UK, and continues to invest in maintaining and upgrading that capital.
- Staff employed at BAE Systems benefit from that capital base since it enables them to have a higher than average level of productivity.
- Firms who currently supply BAE Systems also enjoy productivity benefits that they draw from that relationship, and rely on BAE Systems as a source of stability in their order book.
- The R&D funds channelled through BAE Systems – and those internally funded by BAE Systems itself - have a catalytic effect, improving productivity in other industries in the UK.

BAE Systems is the principal prime defence contractor based in the UK. It represents a substantial base of intellectual capital in the UK, and continues to invest in maintaining and upgrading that capital. The character of BAE Systems has been changing in recent years, and is likely to evolve further in future, with the emphasis shifting from the manufacture of discrete pieces of hardware, towards providing integrated, network-enabled defence systems.

Employees at BAE Systems benefit from the higher than average levels of fixed investment and R&D spending that is undertaken by BAE Systems. As a result, they are more productive on average than they would be if they were employed in some other capacity. Of course, a large proportion of the funds for the R&D spending comes from the taxpayer. But there is evidence that BAE Systems makes at least as effective use of those funds, from whatever source, as do its European competitors, in terms of generating a high level of value added per employee.

Suppliers to BAE Systems benefit from a close working relationship that can result in productivity improvements on their part (as borne out by the interviews with those suppliers that form part of this report). Moreover, demand from BAE Systems for their goods and services provides a key source of stability in an otherwise lumpy and unpredictable market: stability that helps make their businesses financially viable in the long run.

The R&D funds channelled through BAE Systems – as well as the significant proportion of R&D spend that is internally funded by BAE Systems - have a catalytic or spillover effect, improving the productivity of other industries in the UK by advancing the technological frontier. There is a risk that these benefits could be lost to the UK if funds for R&D were instead channelled through another, non UK-based prime defence contractor, since in that case the R&D funds might be spent outside the UK.

Overall, it is likely that there are significant economic benefits to the UK economy deriving from BAE Systems as the unique UK-based prime defence contractor – benefits that perhaps should be one factor influencing defence procurement strategy in the UK, which we assess in the next Section.

SECTION II: IMPLICATIONS FOR DEFENCE PROCUREMENT STRATEGY

1. Introduction

Section 1 above described the contribution that BAE Systems makes to the UK economy. In this section, we explore the question of how the defence industry as a whole in the UK (and the economic contribution to the UK associated with it, and with BAE Systems within that) is influenced by the way in which defence procurement is done in the UK.

2. What are the principles of UK defence procurement strategy?

- Prior to the Levene reforms of the 1980s, competition in defence procurement was rare, and cost-plus contracts were the norm. Post those reforms, competition and fixed price contracts were the norm.
- The current principles of UK defence procurement strategy are most recently published in the MoD publication 'Defence Industrial Policy' (DIP) of 2002. Competition is the bedrock of defence procurement.
- However, there remain important problems with the current principles of defence procurement strategy:
    - The current strategy is based on assumptions about the structure of the global defence industry that may not be valid. The government is a monopsonist while BAE Systems – as the principal prime defence contractor based in the UK - is involved in a kind of oligopoly with a handful of foreign prime defence contractors competing on an unequal footing. That structure can result in unsustainably low profits for BAE Systems.
    - One reason for this is that foreign competitors for prime defence contracts often enjoy a competitive advantage over BAE Systems since they are not required to compete for their home market, and indeed can often be heavily subsidised by their domestic taxpayers.
    - UK defence procurement strategy does not provide the appropriate incentives to prime contractors to ensure that the desired defence capability is delivered. Because the contractor bears such a high proportion of the financial risks in a defence contract, its incentives to deliver quality are undermined.

The current approach to defence procurement is most recently published in the MoD's 'Defence Industrial Policy' document of 2002. This approach can be summarised as follows:

2.1 Defence procurement in the UK

2.1.1 Objectives

The DIP recognises the potential tension between two primary objectives:

- Providing the Armed Forces with high quality equipment at best value for money (VFM) for the taxpayer; and
- Promoting a strong and competitive UK defence industry, bringing economic and technological benefits to the nation.

It also acknowledges that the UK defence market alone is not enough to support a comprehensive defence industrial base, and recognises that the defence industry is increasingly internationalised, with the UK industry including subsidiaries of overseas-owned companies as well as indigenous firms.

Whatever the constraints, however, the Government's defence industrial policy is based on seeing project performance as the root of the relationship with the industry, pointing out that it is not in the interests of the taxpayer or the Armed Forces to dilute this fundamental principle. It is only within this context that the Government seeks to maximise the economic benefit to the UK from defence expenditure.

2.1.2 Factors for consideration

So the key factors taken into account in acquisition decisions are:

- The cost and operational effectiveness of project options
- The solution must be affordable
- Long term value for money, going wider than the individual project

- National security, where in a few cases a high priority is put on retaining a capability within the UK industrial base.

Wider factors taken into account may include:

- Security of supply
- Investment in key technologies
- Export potential
- Retaining industrial capabilities within the UK for wider economic reasons
- Foreign and security policy interests.

2.1.3 Competition

Ultimately, 'competition remains the best procurement strategy to deliver value for money for the defence budget…. [and] will therefore remain the bedrock of our procurement policy' (DIP). The Government sees competition, at both prime contractor and sub-contractor levels, as encouraging innovation, efficiency and skills development. However, the policy acknowledges that VFM is not just about accepting the lowest price – it also involves looking at performance, timeliness of delivery, risks, sustainability, and support costs. And there is recognition that with limited resources it is important not to carry on the competitive process beyond the point at which it delivers long-term benefits. Equally, where wider national interests are likely to be involved in the decision, the Government recognises the need to declare and explain these to potential bidders for a project at the outset, as far as these can be foreseen.

2.1.4 Market access

The Government sees wider market access as an important element of its DIP, since it is crucial to the efficiency of an industry with insufficient domestic customer demand. It is therefore pursuing initiatives to improve the operation of transatlantic defence business, and the future performance of the European defence market. And it will support exports by the UK defence industry whenever this is consistent with the UK's national security interests.

2.1.5 Research and technology

The DIP recognises that investment in research and technology is ultimately the most critical factor determining the future prosperity of the UK defence industry. But, more than that, the commercial exploitation of the UK's technology base is a major contributor to the health of the overall national economy. In addition to looking at investment in key technologies as one of the wider factors in procurement decisions, therefore, the MOD has established schemes to facilitate the pull-through of particular technologies into defence equipment. Ultimately, the DIP recognises that the economic benefits of exploiting a strong science and technology base will best be achieved by creating a UK climate that attracts technology investment from both UK and overseas firms. It also recognises that utilising new technologies for defence equipment involves significant risk, and aims to reduce these risks by spending a higher proportion of available funds on the earlier phases of projects including technology demonstration.

2.1.6 Summary

The Government's DIP recognises both the value of competition and the potential wider benefits to the UK of a strong defence industry. Although competition is seen as the bedrock of procurement policy, the explicit allowance for other factors in the decision process means that trade-offs can continue to be made where there are other UK interests at stake.

2.2 How have the principles of UK defence procurement strategy changed?

The current official model of defence procurement in the UK is that most recently codified in the DIP. However, that official model is not set in stone: it is the most recent published manifestation of a continually evolving strategy, which has changed radically over the last two decades.

The diagram below presents a highly simplified representation of how defence procurement strategy has evolved in the UK.

Table II.2.1	**Pre-1980s**	**Post-1980s**
Typical contract design	Cost-plus	Fixed-price
Principal source of R&D spend	Government	Industry
Typical prime contract tendering process	'Beauty contest'	Competitive
Number of UK-based prime defence contractors	Many	Few

The sea change in defence procurement strategy came in the mid-1980s with the set of reforms associated with the then Chief of Defence Procurement Peter (now Lord) Levene. Prior to these reforms, nearly all the risks associated with defence procurement were borne by the government: the government undertook most of the research and development spending in any project; the government decided to whom it would let a contract without really assessing whether competition would yield a lower price or a better product; the government took the financial risk by offering a cost-plus contract; and, of course, then as now, the government took the military risk - the risk that the required military capability would not be delivered on time or to specification.

At that time, the defence industry in the UK was made up of a relatively large number of defence contractors, each of which tended to specialise in a few types of contract. The focus in industry was very much on the manufacturing side: the design and testing would largely be undertaken by the MoD itself, so that by the time the contract was let, the task for the contractor was relatively (at least by modern standards) clearly defined.

The Levene reforms were predicated on the view in government at the time that the relationship between government and the defence industry was excessively 'cosy' – that the government could get a better deal for the taxpayer by opening defence procurement to genuine competition, by passing the responsibility for research and development to industry (even if the costs of that R&D were still met by the Government), and by letting contracts on a fixed-price rather than a cost-plus basis. In principle, three of the four main risks in defence procurement were passed – at least in part - from government to industry: some of the risk associated with R&D; the risk that a better price and a better product might be achievable from a competitor, and the financial risk once the project had been let. The military risk is unavoidable, however, and remains with the government.

The defence industrial structure that had grown up around the pre-Levene procurement strategy was not appropriate to the new strategy. Substantial changes in the structure of the defence industry were inevitable, and they quickly followed.

- Defence contractors had to develop the capacity to undertake substantial R&D in any contract themselves.
- Defence contractors had to develop strategies for managing the new risks associated with defence contracts.

The new strategy for defence procurement created an incentive in the defence industry to consolidate: consolidation offered economies of scale in R&D and – in principle – would help defence contractors to secure a margin on their contracts sufficient to compensate them for the risks that they were now bearing. The Levene reforms triggered a process of consolidation in the defence industry that continues today.

But the Levene reforms were not the end of the evolution of defence procurement strategy, and nor were they the only factors driving the process of consolidation. Three other significant changes have also occurred since then.

- The nature of the military requirement has changed. The typical defence contract for a prime contractor is now not always a well-defined and tested piece of kit, but instead is tending towards a more loosely defined and open-ended (continually evolving) military capability. The risks inherent in such a contract are substantially larger than they were before.

- The defence budget has contracted substantially in real terms since the mid-1980s.
- The election of the Labour government in 1997 saw a rethink of defence industrial policy that to some extent reformulated the Levene strategy and introduced the concept of 'Smart Acquisition' and the new strategy reflected in the DIP document of 2002 (summarised above). Essentially, the new strategy recognises some of the limitations of competition in defence procurement, accepts some of the implications of the changing defence requirement for procurement strategy, and sees the need for partnering and risk-sharing between government and the defence industry.

Smart Acquisition was one of the main policy initiatives that arose as a result of the 1998 Strategic Defence Review. The aim of Smart Acquisition is:

'*To enhance defence capability by acquiring and supporting equipment more effectively in terms of time, cost and performance.*'

Smart Acquisition has a number of key features to help to achieve that aim:

i. A whole-life approach embodied in a single Integrated Project Team (IPT);
ii. Clearly identified customers;
iii. A willingness to identify trade-offs between system performance cost and time;
iv. An open and constructive relationship with industry;
v. A streamlined process for project approvals; and
vi. New techniques for the management of risk on acquisition projects.

These key features are supported by a number of values and beliefs:

i. An empathy with the customer;
ii. The drive to deliver a high level of performance;
iii. A desire to work co-operatively with fellow team members and others;
iv. A predisposition to share ideas and information and the resolve to overcome problems; and
v. A wish to challenge convention and improve processes.

The DIP is the most recent published account of defence procurement strategy in the UK as it currently stands, taking into account the new priorities set out in the Smart Acquisition framework.

As we argue in Section 2.4 below, there are numerous ways in which the practice of defence procurement departs from this official strategy. However, there are also some reasons to argue that the DIP might not be entirely the appropriate procurement strategy both in principle and in practice, which we elaborate in the next section.

2.3 What are the problems with the principles of UK defence procurement strategy?

The strategy outlined in the DIP might be appropriate in a world where the UK government was one amongst many similar customers for defence contracts, and where there were also many similar defence contractors competing for a number of different contracts. However, the real world is not like that. In the next section, we set out the economics of UK defence procurement, showing how it differs in principle from the model for which the DIP might be appropriate.

2.3.1 The economics of UK defence procurement: monopsony and oligopoly

The economic textbooks suggest that firms engaged in perfect competition all produce identical goods, and each firm faces a flat demand curve: firms are 'price-takers' in the sense that they have no choice about the price they charge. If they charge higher than the market price they will not sell anything, and if they charge lower they will make losses (or less than normal profits). Each firm can sell as much or as little of the good as it wants without affecting the market price (each firm is small compared to the total market). That means that each firm will choose the quantity it produces to minimise the average cost of production, thereby maximising its profits. No firm can make 'super-normal' profits, since that would attract new entrants to the industry (perfect competition assumes that there are no barriers to entry) until profit margins were reduced to their 'normal' level. Moreover, as well as there being many firms in perfect competition, there are also many customers: all individual firms and customers alike are assumed to be price-takers, accepting the market price as given.

However, in practice there are very few markets for which the model of perfect competition is even a close approximation, and the UK defence market is certainly not one of them. It departs from this model in several important respects:

- The government is a monopsonist – the unique customer for prime defence contracts in the UK.
- There are only a handful of global prime defence contractors – not the thousands that perfect competition would assume.

- The handful of prime defence contractors that do exist are not all on the same footing: outside the UK, they are not expected to encounter foreign competition for their home market.
- Sunk R&D costs channelled through existing defence contractors raise significant barriers to entry for potential new prime defence contractors – whether the source of funds is the government or industry. As a result, in equilibrium, profits accruing to prime defence contractors will be larger than in a perfectly competitive market.
- At the critical point in the procurement process, the customer does not know the quality of the defence capability that will eventually be delivered.

2.3.2 The UK government is a monopsonist

The MoD has the ultimate responsibility for defence procurement in the UK, and as such is a monopsonist for UK prime defence contracts. A monopsonist is a firm, institution or government department that is the only source of demand in a given market. It is the demand-side equivalent of a monopolist (the unique supplier).

Of course there are many other governments around the world who also let prime defence contracts. But that does not imply that UK-based defence suppliers can sell to those governments as a prime contractor. Most governments with their own national champion(s) in the defence industry will always or nearly always offer that/those champion(s) the role of prime contractor. The world defence market is segmented broadly as follows:

- National governments letting prime defence contracts to national champions.
- National governments with no national champion, letting prime defence contracts to foreign prime contractors.
- Prime contractors letting sub-contracts to other defence contractors.
- National government letting sub-prime defence contracts to defence contractors around the world.

The first of these does not really allow for international competition among prime contractors. The third and fourth do allow for genuine competition, but not for prime contracts (it is worth pointing out here that these sub-prime contracts can nevertheless be relatively profitable, and BAE Systems itself wins a reasonable amount of business at the sub-prime level). Only in the case of the second is there a

genuine possibility of competition for prime defence contracts. And even here, the 'competition' is a long way from what the economics textbooks would think of as such.

- The purchase of a defence capability from foreign contractors tends to be highly politicised: there is a sense in which the purchaser is buying not only (perhaps not even mainly) the defence capability itself, but an implicit or explicit security relationship with the government of the defence contractor. Prime defence contracts come with strings attached. Many of the important attachments to a defence contract are not under the direct or indirect control of the defence contractor. A UK defence contractor cannot commit the UK government to a diplomatic or security policy – the government has to take that decision itself.
- An important element in being selected as the prime contractor for a foreign government is that the company should be a prime contractor for its own government. It is difficult to know exactly how important this factor is, but it is likely to exert some influence at least.

So there is on the whole little or no genuine international competition for prime defence contracts, with one exception: the UK. UK-based prime defence contractors have only one source of prime defence contracts that are open to genuine competition: the UK government. As the unique source of these contracts, the UK government is a monopsony.

A monopsonist has market power: that means it can influence (in the extreme case, dictate) the price of goods and services by its own decisions. Where a monopolist will tend to set prices at the level that maximises its own profits in the long run, the monopsonist will tend to set prices at a level that minimises its own costs in the long run. Where there is competition on the supply side, it will tend to result in profits for suppliers being forced down towards zero.

2.3.3 The global industry is oligopolistic

If monopsony violates the assumptions of perfect competition on the demand side in the defence industry in the UK, then it is also violated on the supply side: there are only a handful of global prime defence contractors, not the thousands assumed in the model of perfect competition. This situation is known as oligopoly. Firms in oligopoly are engaged in a strategic relationship with each other and with the market – a relationship where the strategic choices that each firm makes reflect and feed back on the choices of other players in a way that may not be predictable in advance, and may not relate closely to the competitive objective of short-run profit maximisation.

In the global defence industry, no two firms (at least at the prime contractor level) produce identical goods: the differences between goods are pronounced. In the economic jargon, goods and services produced by different firms in the defence industry are imperfect substitutes for each other – and sometimes they are not substitutes at all but complements.

As a result, each firm engaged in oligopoly faces a downward sloping demand curve. It has market power since it can change the price it charges for its goods by changing the quantity of those goods it produces: each firm is large compared to the total market. If it charges a higher price, it will sell a smaller (but still positive) quantity: the goods and services it produces are imperfect substitutes for those produced by other suppliers. In these respects, oligopoly is similar to monopoly – where a single firm supplies the whole market for a particular good or service.

However, oligopoly is different from monopoly in that there is more than one firm in the market. If there are no barriers to entry then new entrants will come into the market (each producing a good that is an imperfect substitute for other goods already on the market) until profits are reduced to their 'normal' competitive levels – this outcome is known in economic parlance as monopolistic competition. Monopolistic competition will see normal profits in equilibrium – ie, the same level of profits that would be achieved under perfect competition. But the global defence market has avoided monopolistic competition because of the presence of barriers to entry – see section 2.3.5 below.

Even an oligopoly allows in principle for competition between firms, to the extent that the goods and services that they produce are substitutes (albeit imperfect substitutes) for each other. But the global market for prime defence contracts is not a level playing field.

2.3.4 Non UK-based prime defence contractors do not encounter foreign competition for their home market

Outside the UK, if a country has its own prime defence contractor, prime defence contracts in that country are not typically opened to foreign competition. This puts the UK-based prime defence contractor at a distinct disadvantage. It faces international competition for its home market, but its international competitors do not (though it should be pointed out that the presence of some foreign competitors in the UK defence market has only been achieved at substantial cost to them in terms of inward investment to the UK). That dramatically changes the structure of the strategic game between

the global prime defence contractors: having a secure home market effectively subsidises many of the fixed costs that these defence contractors encounter, a subsidy not extended to the UK prime defence contractor. Foreign competitors can bid for UK prime defence contracts at a price that makes sense for them, but might be unsustainably low for the UK prime defence contractor. In a sense, of course, no contractor is obliged to put in unsustainably low bids for defence contracts, and it is not necessarily sensible for them to do so. But in practice, the lumpiness and long lifetimes of prime defence contracts can create a situation in which a prime contractor feels it 'must win' a contract if it is to remain in business in the long term, even if winning comes at the cost of making very low or no profits.

2.3.5 Potential new entrants face barriers to entry

Prior to the reforms to UK defence procurement of the 1980s, prime defence contractors in the UK enjoyed a long-term stable relationship with the government. This relationship, and the years of close liaison between government and industry that it reflected, presented a significant barrier to entry to potential new entrants to the defence market, ensuring that the industry in the UK remained an oligopoly rather than moving towards monopolistic competition.

The reforms of the1980s aimed to re-cast the relationship between government and industry, to get a better deal for the taxpayer by making industry more efficient, and moving closer to the model of monopolistic competition. However, one change introduced with those reforms has since helped to prevent monopolistic competition from being the outcome: prior to the reforms, a large proportion of defence R&D was undertaken by and funded by the government, in the guise of the MoD. After the reforms, the responsibility for R&D was largely passed on to the private sector (even if the funds for R&D still came in large measure from the Government). This created problems initially since the private sector did not have the expertise to undertake R&D on that scale. Later on, it created a different kind of 'problem': sunk R&D costs channelled through industry represented a new kind of barrier to entry.

While removing one barrier to entry, in the form of 'cosy' relationships that might take decades to build, the reforms introduced another, the sunk costs of R&D. If barriers to entry in this form are introduced to an otherwise competitive market, they will naturally create an incentive for firms to consolidate in search of higher profits – safe in the knowledge that new firms cannot enter the market and erode those higher profits. That is exactly the process that has been underway in the UK since the

1980s. If the barriers to entry are everywhere high enough, and super-normal profits are not available to each firm in the oligopoly, an unregulated market will eventually deliver a monopoly on the supply side – something that has already happened for UK-based prime defence contractors. Normally, each further consolidation will yield higher prices and higher profits. In the UK, the government as a monopsonist has been able to resist this, and has been helped in doing so by opening the market for prime defence contracts to international competition. That has ensured that the UK government still faces an oligopoly of prime defence contractors rather than a monopoly – an oligopoly now made up of a handful of global prime defence contractors not a handful of UK prime defence contractors as in the past.

2.3.6 Quality of defence capability is not known at main gate

Perfect competition assumes that all the characteristics of the goods for sale on the market are simultaneously visible to both suppliers and customers at the point of sale (and that all goods are identical no matter which firm produced them). There are few goods at all like this in reality – commodities like sheet steel or crude oil probably conform most closely to that model.

In the defence market, the point at which the customer makes the critical procurement decision (the 'main gate') is typically a point at which the good itself has not yet been produced. This is particularly true of prime defence contracts. The procurement decision is a decision to get the prime contractor to design and produce the required defence capability.

This immediately raises a whole set of new issues, treated in the economics literature under the headings of informational asymmetries, principal/agent problems and other market imperfections. In general, since the information set available to the customer is different to that available to the supplier, and the interests of the customer and the supplier are not identical, these markets can often result in a mismatch between the value the customer wants and what it eventually gets, and between the cost the supplier anticipates and what it eventually incurs. These mismatches, if they are pronounced, can sometimes lead to 'market failure', when the customer and the supplier cannot agree on any price for which a certain product should be sold.

There is one generalisation that can be made about both value V and cost C: they are both increasing in quality, ie:

$V = f(Q)$
$C = g(Q)$

Where Q is the quality of the defence capability. Quality can be thought of as a mixture of characteristics including:

- Lead time from main gate to delivery
- Reliability
- In-service life
- Technical capability

In general, the higher is the quality, the higher is the cost to the producer and the higher is the value to the customer.

The problem is that it is difficult for the customer to observe the quality of the defence capability it is procuring until it finally reaches the battlefield – ie, quality is an 'experience good' not a 'search good'. The supplier knows the quality of the defence capability in either case (though it does not know the value of the good to the customer). The customer knows the value of the defence capability it requires. But with a search good, quality is observed by the customer before purchasing, while with an experience good, quality is observed by the customer only after purchasing.

Moreover, the interests of the customer do not coincide with those of the supplier: the customer wants to maximise $V - P$, while the supplier wants to maximise $P - C$.

How should procurement contracts be designed in order to overcome the asymmetry of information and the incongruence of interests between government and industry?

As a first approximation, for all contracts, if the net transfer to the supplier after the reimbursement of any costs (P-C) is t, then:

$t = a - bC$

Where a is a constant and b is the extent to which the net transfer to the supplier falls as cost C rises.

One option here (one form of contract design) is for the customer and the supplier not to fix P until the customer can observe Q, or can at least observe the cost C which is an increasing function of Q. That implies choosing the prime contractor, and getting it to design, produce and deliver the required defence capability before deciding on P, the price for which that capability is sold. This form of contract design is often described as 'cost-plus'. A cost-plus contract implies that b = 0, so that t = a: the net transfer is fixed irrespective of cost, so that changes in cost pass through one-for-one into the price. Note that in this case the price can in principle exceed the value to the customer.

Another option for contract design is that the customer and the supplier agree on a price for a particular defence capability at the main gate, before the goods have been produced or delivered. This form of contract design is often described as fixed price. In the nomenclature above, a fixed price contract implies that b = 1, so that the net transfer t decreases one-for-one as costs increase, keeping the final price to the customer unchanged. Note that in this case the net transfer to the supplier can be negative.

A simple characterisation of the way defence procurement has been done in the UK is to say that prior to the Levene reforms of the 1980s the typical defence procurement contract was cost-plus, while since then it has been fixed price. The reality is more complicated: before Levene there were fixed price contracts to some degree, and after Levene there remain cost-plus contracts of various kinds. But the broad picture is of a shift from cost-plus to fixed price.

In a fixed-price contract, industry bears the financial risk after main gate. In a cost-plus contract, that risk is borne by the government. Of course, by switching to a fixed-price contract the government cannot avoid all risk: it is inevitably left with the risk that the required defence capability will not be delivered on time or to specification. It can in principle impose financial penalties on industry if it fails to deliver, but those penalties can only partially compensate for the loss in expected defence capability.

In a fixed price world, the incentive for the supplier to increase the quality of the goods it supplies is related to its reputation in the context of repeat purchases. For a one-off fixed price contract, the supplier's financial interests would lead it to minimise quality in order to minimise cost and maximise profits. But in a world of repeat purchases, the supplier will face a trade-off between maintaining or

enhancing its reputation for delivering quality on the one hand and minimising its costs on the other: the incentives to supply quality and to reduce cost are inherently in conflict.

As Laffont and Tirole[20] argue:

'The contractor has fewer incentives to maintain his reputation for being a high-quality contractor when he bears a high fraction of the cost of maintaining this reputation.'

What are the costs that the supplier incurs when it is trying to improve quality and protect its reputation? Essentially, they fall under the umbrella of R&D.

R&D is critical to understanding how the defence industry in the UK operates (just as it is critical in understanding the contribution that the defence industry makes to the UK economy). The sunk costs of past R&D channelled through a particular contractor (whether funded by that contractor or by Government) represent a barrier to entry to the defence industry, which creates an incentive for consolidation in search of higher profits. The future costs of R&D associated with new defence projects are the key control variable for industry seeking to minimise its costs but protect its reputation.

In particular, the fact that government has handed over responsibility for defence R&D to industry has had damaging effects for government because of the way it has affected incentives for industry. On the one hand it has increased the incentive for industry to consolidate – the logical conclusion of which process is monopoly and higher prices to government for a given defence capability. And on the other it has reduced the incentives for industry to maintain or enhance its reputation by increasing the quality of the defence capability that it delivers – leading to procurement projects being late or not meeting the defence requirement.

So, in economic terms, the current UK defence procurement market is approximately characterised as a monopsonist letting fixed price contracts to firms engaged in oligopoly who face substantial barriers to entry in the form of sunk costs: a long way, even in simplified form, from the textbook model of perfect competition.

[20] Laffont and Tirole: 'The determinants of quality in defence procurement'.

2.4 Conclusions

Since the global defence market is not really competitive, or at any rate does not conform closely to a perfectly competitive model as argued above, a defence procurement strategy that assumes otherwise is unlikely to be appropriate. If competition is the bedrock of UK defence procurement decisions, that is likely to favour foreign competitors who do not need to compete for their home market. Moreover, foreign competitors will also enjoy a competitive advantage over UK-based contractors to the extent that R&D costs are to a larger extent directly met by the taxpayer in other countries. And a structure in which fixed price contracts are let by a monopsonist to firms engaged in oligopoly – particularly when the domestic prime contractor faces competition from foreign contractors who enjoy a competitive advantage – is likely to result in unsustainably low profits for the domestic contractor. This is a reasonably accurate description of how the UK defence market has behaved in recent years.

But it is not a complete description. That is because, in practice, defence procurement decisions do not conform to the strategic principles set out in the DIP. The next section explores how they differ, and what problems that can cause.

3. How does the practice of UK defence procurement differ from the strategic principles?

- In practice, the process of letting a prime defence contract in the UK rarely conforms closely to the strategic principles set out in the DIP:
    - The procurement decision tends to reflect a host of factors and the views of a host of interested parties, rather than a 'pure' decision based on the principles in the DIP. Industry often focuses on influencing the various interested parties rather than delivering the best possible product to the final customer.
    - The MoD is not organised in such a way as to maximise the chances of achieving the desired defence capability for the UK. In particular, there is often an absence of co-ordination between the different elements of a procurement project for a given defence capability, and sometimes a lack of communication between the MoD and industry that undermines the need for co-operation and looking after the health of British industry identified in the DIP.
- Although the DIP stresses the advantages of de-risking defence projects before they reach main gate, and the benefits of partnering and risk-sharing throughout the contract, this is rarely done in practice to the extent that would be consistent with the DIP. The principles of Smart Acquisition – particularly de-risking before main gate – are still not being fully implemented.

Above we outlined the principles of UK defence procurement strategy, and described some problems associated with those principles. However, it is often the case that the practice of defence procurement differs markedly from those principles. In this section, we describe the problems associated with how defence procurement is carried out in practice.

3.1 What are the problems with UK defence procurement in practice?

The DIP sets out the government's official defence procurement strategy. As we have seen, there are a number of problems with that strategy even in principle. And there are a number of other problems in practice: the clarity of the DIP belies the true complexity surrounding all major defence procurement decisions, including the following.

3.2 Complications in the decision-making process

There are a number of interested parties in any procurement decision, each with its own voice and its own role in the decision-making process. These include:

- The Ministry of Defence (MoD), the ultimate consumer of the defence capability delivered by each procurement project.
- The Defence Procurement Agency (DPA), a branch of the MoD with the responsibility for managing procurement projects.
- HM Treasury (HMT), with responsibility for allocating government spending across all the different departments of Government, including defence.
- The Prime Minister, with responsibility for ensuring the security and determining the strategic direction of the country as a whole.
- The Foreign & Commonwealth Office (FCO), with responsibility for managing the diplomatic relations with other countries around the world.
- The Department of Trade and Industry (DTI), with responsibility for maximising the health of and prospects for British Industry.
- Members of Parliament, with responsibility for attending to the interests of their constituents.
- The House of Commons Defence Select Committee, with responsibility for overseeing and making accountable the process of defence procurement and defence strategy more generally.
- The National Audit Office (NAO), with responsibility for reporting to parliament on value for money for all kinds of government procurement including defence.
- The defence industry, in the UK and elsewhere, with responsibility for delivering the required defence capability.
- The media, in the UK and elsewhere, with responsibility for commenting on the news.
- Members of the public, on whose behalf defence procurement is undertaken.

All of these parties are in one way or another stakeholders in the defence procurement strategy, and each exerts its own influence on the debate, and indeed on individual procurement decisions. In practice that means that defence procurement in the UK rarely conforms exactly to the norm set out in the Defence Industrial Policy. Or, to put it another way, a subtle and complex set of interlocking and overlapping interests, constraints and objectives is the characteristic background to any defence procurement decision. Take for example the recent debate over Hawk.

The recent decision by the MoD to purchase another tranche of Hawk trainer jet fighters from BAE Systems is a very clear illustration of the complex issues surrounding defence procurement in practice. A number of arguments were brought to bear on this decision:

- The starting point was a defence capability required by the MoD.
- The DIP suggests that the contract should be open to competition to ensure value for money.
- Jobs in Brough depended on the decision.
- There were rumours that an Italian contractor could undercut BAE Systems by £1 billion, but there were also suggestions that the Italian contractor was heavily subsidised by Italian taxpayers, raising issues of unfair competition.
- Sales of Hawk to India (and potentially elsewhere) depended in part on the decision – sales that are related to important foreign policy objectives, and which also raised a set of ethical issues.

These arguments and others were employed, and the debate involved a wide range of interested parties: the MoD and BAE Systems, the Foreign Office, the Treasury, the Prime Minister's Office, the DTI, national and local newspapers and other media, and the general public. And the ultimate decision – to purchase Hawk – will in due course need to be defended in front of the Defence Select Committee, and stand up to the scrutiny of the NAO. The decision by MoD to purchase Hawk was quickly followed by that of the Indian government, again in favour of Hawk.

The Hawk example illustrates the practical complexity of not taking competition further than will be advantageous in accordance with the prescription in the DIP.

However, the ultimate responsibility usually rests with the MoD and DPA, even if other parties get their voices heard along the way.

3.3 Problems in the organisation of the MoD and their relationship with industry

The MoD, while it has many merits, also appears to have some problems too. First, it appears that is often the case that the MoD fails properly to co-ordinate its procurement projects with each other and with the rest of its work. A recent example is provided by the purchase of Apache helicopters. While the procurement of the kit was in this case broadly a success, when it arrived there were very few pilots capable of flying it – so the defence capability in the round was not there. That is one example,

but there are many more. The structural problem is that there is no division within MoD responsible for ensuring that the procurement process is 'joined up', and hence capable of delivering the desired defence capability when it is needed. As the NAO state in their report on the procurement of Apache:

"*The introduction to service of a new capability typically involves the co-ordination of a large number of interested parties both within and outside the Department. The experience of the Apache programme reveals the importance of appointing – at an early stage – a senior-level individual with specific responsibility for directing and co-ordinating such a programme.*"

Second, it sometimes appears that those responsible for procurement decisions in the MoD may not pay sufficient attention to the impact that their decision might have on the defence industry in the UK, in a manner inconsistent with the principles laid out in the DIP. While those at the top of the MoD are keen to stress that the procurement decision takes into account wider issues than just price, looking also to the impact on jobs and the health of industry, those in direct control of each project sometimes have a narrower view, for example regarding low or no profits as a problem for industry but not for the MoD. One option would be to adopt a seventh line of strategy – industrial development - in addition to the six lines of strategy that currently inform defence procurement.

In the next section below, we summarise the NAO submission to the AEIGT on the relationship between the MoD and the defence industry, which throws light on some of these issues.

3.4 NAO conclusions on MoD/industry relations

The National Audit Office's submission to the DTI Aerospace Innovation and Growth Team summarises relevant NAO and Public Accounts Committee recommendations from earlier reports into defence procurement issues. The key focus is on greater co-operation between the MOD and the defence industry.

The NAO analysis starts from the tension between procurement policy and developments in the industry:

- Competitive procurement is still the foundation of the Government's approach to obtaining value for money; but
- Rationalisation in the industry has reduced the scope for competition within the UK.

The resulting tension between what in many cases may be a single buyer and a single supplier is not surprising. As the NAO sees it:

- Some members of the MOD suspect industry of trying to make excess returns out of their work for the department; while
- Some members of the industry suspect the MOD of trying to exploit their position to demand unreasonable contractual terms or to force the industry to accept delays and uncertainties in the ordering process.

Since the reality of defence procurement is that scope for competition within the UK is likely to remain limited in a number of areas, however, the NAO believes both MOD and the industry should take steps to improve their relationship. The recommendations cover a number of areas:

3.4.1 Communications

- The industry needs to help the MOD demonstrate value for money, since this is a fundamental requirement of public procurement.
- Co-operation is needed to help quantify industrial and economic implications of decisions, so that these can be given due consideration in the decision-making process rather than assessed in a more ad hoc way towards the end of the process.

3.4.2 Contracts

- Since the NAO believes that 'the commitment of capable industrial prime contractors is likely to be a key success factor in the future', it is important to identify the most appropriate contractual framework. This may not always be based on fixed cost and time budgets, since these can provide a perverse incentive to shift risk into future stages of the project.
- There may be greater need for open book accounting and pricing, while sub-contractor competition can still demonstrate VFM for the large proportion of costs often accounted for by sub-contractors.

3.4.3 Risk management

- Technical difficulties during development are consistently highlighted as the primary reason for time or cost overruns on major projects. This risk can be reduced by spending a greater proportion of total procurement costs on assessment work prior to development, including early investment in technology demonstrators.
- Industry and the MOD must work together to develop a better appreciation of the potential for technical and programme difficulties at the outset of a programme, with risk management seen as a joint responsibility.
- More realism is required with programme timescale estimates, including the time taken to negotiate non-competitive prices and contracts.

4 How is defence procurement done in other countries?

Other countries that have a domestically based prime defence contractor (or more than one, in the case of the US) have a strong tendency not to put prime defence contracts out to international competition. Instead, the governments in each of those countries has a long-term relationship with their own prime defence contractor(s) based on the expectation that all prime defence contracts will go to the domestic contractor(s). This may result in relatively expensive defence procurement, compared to what the UK government can achieve. But that is offset to some extent by a typically healthier domestic level of profitability for the prime defence contractor(s) than in the UK: one that is sustainable in the long run. Even in the US, where more than one domestic prime defence contractor exists, the government does its best to ensure that all the domestic prime defence contractors make healthy profits (this is partly reflected in the fact that only just over half of prime defence contracts by value in the US are let on a fixed price basis, with the remainder on other kinds of contract including variants of cost-plus).

Of course, there are other countries letting prime defence contracts than just the handful that have a significant domestic defence industry of their own. But, as noted above, the procurement decision in such cases often rests on a host of factors not under the direct (or sometimes even indirect) control of the defence contractors: political/security relationships with the government of the defence contractor for example.

The UK government is formally committed to extending the principle of genuine international competition in prime defence contracts beyond its own borders. It has to be noted, however, that thus far it has had strikingly little success in this respect, and there seems little immediate prospect of that changing.

As a result, BAE Systems, as the UK's principal prime defence contractor, is in an asymmetric position vis-à-vis its international competitors: having to compete for its home market as well as for markets abroad.

To some extent there is a trade-off between the level of profits available to defence contractors and the value for money in defence procurement delivered to the taxpayer. And it is also true that even in countries where the domestic defence industry is protected, certain firms can still get into trouble. But we would argue that, in the UK defence market, there is a possible cooperative outcome that delivers both healthy profits to prime defence contractors and high quality and value to the taxpayer, and an uncooperative outcome that delivers neither, and furthermore that the UK has been closer to the latter than the former in recent years: indeed that is the central argument of this Section. Some other countries, notably the US, seem to be closer to the cooperative outcome than does the UK.

5 How is procurement done in the private sector?

In the sections above we have examined the issues around defence procurement strategy in the UK, identifying a set of problems with current procurement strategy, both in practice and in principle. What lessons can be learnt from the way that procurement is done in the private sector? Appendix 1 contains a detailed set of case studies of private sector procurement projects. The key transferable lessons from these case studies are as follows:

- As far as possible, the risks involved in a project should be 'managed' up front, before the terms of the contract are finally decided. That means deciding who will bear the risks (client or contractor), and how they will be compensated for doing so.
- The contractor is more likely to accept a high proportion of the risks in a project if they can be sure of a long-term relationship with the client.
- There is a clear trade-off between the risk that the client bears and the cost of the project to the client: contractors will take risks if they are properly compensated.

- When the risks are substantial, a pure competitive tender, with the contractor bearing the risk and having no guarantee of a long-term relationship can be unsuccessful.
- Managing the risk in a project may mean being innovative and flexible about the design of the contract – not being tied to a model of fixed-price or cost-plus.
- When a client enters into a long-term, risk-sharing relationship with a contractor, it is essential that the contractor should have a track record of expertise in the area.
- A close working relationship between the client and the contractor throughout a project, with the client sharing the responsibility for ensuring the project is delivered on time and to specification, is often the key to success.

SECTION III: SUMMARY OF THE PAPER

- The first section of this report outlined the economic contribution that BAE Systems makes to the UK economy. If BAE Systems, as the unique UK-based prime defence contractor, were to cease its operations in the UK, there would be a significant economic cost to the rest of the UK. That cost would be felt in terms of lower average productivity: the presence of BAE Systems in the UK ensures that there is a store of intellectual capital and a source of innovation located in the UK that contributes positively to the productive potential of the economy as a whole.
- The second section assessed the defence procurement regime in the UK as it currently operates. It identified a number of problems with the principles of UK defence procurement, and also highlighted the ways in which the practice departs from those principles, and the further problems that can ensue.
- Pulling these two elements together, we would argue that a further evolution of the defence procurement regime in the UK – partly to ensure that the practice conforms to the principles of procurement strategy, and partly to modify those principles to reflect the current realities of the global defence market – would be a step towards a cooperative outcome in the UK defence industry. Such an outcome would benefit government and the defence industry alike – with quality and value for money delivered to government, and healthy profits to industry. And it would also benefit the UK economy as a whole, since it would help to ensure that the UK defence industry remains viable, and that the economic benefits accruing from the activities of the defence industry in the UK are retained.

3.1 Some options for UK defence procurement strategy

- The MoD is likely to continue to spend around a quarter of its total defence procurement budget on products and services from BAE Systems into the indefinite future. Both the government and industry should recognise this fact, and try to devise a joint strategy for ensuring that BAE Systems is a healthy, profitable firm and that it delivers the required defence capability to the government. That may involve reviewing the question of whether all prime defence contracts should be open to foreign competition.
- As part of this, the government should focus on de-risking procurement contracts and putting in place joined-up structures in the MoD and elsewhere that have the best chance of delivering the desired defence capability when it is needed. That may imply undertaking or directly funding a

larger proportion of defence R&D itself, and re-organising the MoD to ensure that procurement projects are appropriately co-ordinated.

- A successful defence procurement strategy may also involve reviewing the question of whether fixed-price contracts are appropriate for prime defence procurement decisions. Fixed price contracts place a high proportion of the financial risk on the contractor, and thereby reduce the contractor's incentives to deliver quality.
- BAE Systems should focus on putting in place the most efficient and cost-effective structures in its own organisation, with a view to maximising the value for money and spillover benefits that it delivers to the taxpayer. That may imply less focus on how many jobs are dependent on BAE Systems, and more focus on the quality that BAE Systems ultimately delivers to the UK government, and the advances in technology that its activities yield for the UK economy as a whole.
- The jobs supported by BAE Systems should be an important factor in informing procurement decisions only in so far as they are higher value-added jobs than might be achieved by the same employees elsewhere – on account of the high capital and R&D intensity of BAE Systems compared to the UK average.

APPENDIX 1: PRIVATE SECTOR PROCUREMENT CASE STUDIES

PROCUREMENT CASE STUDY 1

Company: Unilever

Contact: Uwe Schulte -Vice President Supply Management

Uwe works in Home and Personal Care, one of Unilever's two main businesses. This purchasing function is now arranged on a global basis with 20 teams involved in buying production item materials. The interview was given on the basis that the specific product, the region involved and the contractor would not be named and values only given in broad outline.

Background

The project discussed was the consideration of the sourcing of a major packaging item for Region A. Unilever had a team of 10 people working part time on the project for a period of 9 months (equivalent to 4 full time).

Packaging is of different sizes in different regions and therefore while the raw materials can be bought on a global basis the conversion process needs to be regionalised. Unilever looked at the conversion process country by country and while it is difficult to compare prices on a regional basis they could see that margins in Region A were 3 times those in the more open region B. They went to the suppliers in region A and asked for price reductions on an ongoing basis. When these were not forthcoming, they went back to their favoured supplier in region B and set up a project for the manufacturer to build a plant in Region A to make the package.

Success of the Project

The project was a major success. It was completed on time with a multi million € saving. The Unilever procurement function was involved throughout the project.

Project Discussion

Risk management was undertaken up-front. Given the size of the investment, (€millions), it was necessary to share the risk in some way. Unilever gave the contractor the offer of compensation if the project went wrong in the form of sales in other regions. They looked at the contract on a global business basis. The contractor did bear much of the basic risk but was confident because of their long-term relationship with Unilever that it was worth being involved. Unilever has a reputation to keep.

There were penalty clauses in the contract but these tend to cover only short term losses and not the long term cost to the business of lost sales and loss of reputation.

Unilever procurement had to convince the regional business that the project was worth doing and that the risks had been considered. There are always risks to the business when changing supplier.

The long term relationship between Unilever and the contractor in other regions was most important to the credibility of the contract. Client and contractor work together.

Unilever worked on the basis of a preferred contractor from outside the region, given that those in region A would not give competitive quotes.

The links between Unilever's packaging contractor and the subcontractors working on building the plant were not discussed. No major hitches were encountered.

Unilever's procurement people were closely involved with the project from beginning to end. They had to impress upon their own marketing department the problems associated with changes to requirements once the project was underway.

The contractor had considerable expertise based on building and operating similar plant in their home region.

The project saved a very large sum of money and therefore it was worthwhile putting considerable effort into the project to make sure everything went according to plan. Use project management to proactively manage delays. The project was completed when required.

Lessons from the Project.

Ensure that the client and contractor are in close contact throughout. Make sure that as few changes as possible are made to the project once it starts by putting in the effort on both sides before the project starts.

Other Relevant Comment

Take or pay contracts are not normal practice, but there are exceptions. Eg If Unilever come up with a novel formulation that needs investment solely for Unilever benefit.

The contractor currently buys the feedstock for the plant as they are purchasers on a world scale. Unilever are moving towards working with their contractors suppliers.

Contracts tend to be relatively short term to keep flexibility. Look for longer term contracts if you have a good low cost supplier and few alternatives.

Unilever like to price in local currency where feasible to lower exchange risk.

They may buy products forward where they have little influence on the market price.

PROCUREMENT CASE STUDY 2

Company: Foster Wheeler

Contact: Stephen Hoskins Divisional Director Procurement

Stephen works for Foster Wheeler Energy Limited (FW), dealing with purchases on a world basis. Also involved in the meeting were his commercial manager - Bob Kimber - and for part of the time Graeme Lang, who is Divisional Director of Project management. It was agreed that the client would not be named.

Background

The project discussed was the construction of part of a major energy complex in the Far East. It was managed out of their Thailand office. It was started in mid 1999 and finished on time 2 years later. The specific plant FW were involved in cost well in excess of £100m.

Initially FW were invited to tender for the plant but declined as they were not prepared to take the risks involved with a very tight contract spec for a plant in a difficult climate, on a poor site and for a project with complicated links to other parts of the main project and severe time and other penalties. The client did not get an acceptable quote and came back to FW and negotiated a contract based on reimbursing of costs, but with a fee linked to a number of criteria. FW had 250 people working on the project with 80 on site. Around 2000 others employed by subcontractors were working on the site on this project at the peak time.

Success of the Project

The project was a success. It was completed on time within budget and the project had a smooth start up. Most of the criteria that determined the fee part of the contract were met.

The initial estimate was 10% above the desired cost. FW sat down with the client and used value engineering to re-specify the job. Some features of the plant were cut and other cost savings made. This was done up front and saved later arguments about cost overrun or plant redesign too late in the project.

Project Discussion

The relationship was one of risk sharing, but major cost overruns would not be taken by FW. Hours worked on the project were reimbursable at cost. FW's fee was at risk, with penalty clauses set against delays and cost overruns.

FW does have an alliance contract with the client but this is not formal and certainly not binding. They had worked with the client on other projects but had no special inside track as a result.

The contract went to competitive tender but this did not result in a contract offer. FW negotiated the contract at a later date with parts of the contract they did not like amended (see above) There were still tight price, delivery and quality requirements in the contract.

Several major hitches were successfully overcome. Initial design cost was too high, reduced by value engineering early enough in the project by both parties. The fears about site suitability were correct. The site had to be moved a bit and major piling done. These costs were absorbed in the budget. The weather washed away roads and bridges necessitating emergency planning for alternative delivery methods. A major vessel was delivered late but the project was rescheduled to allow for this.

The major changes were made in the value engineering stage at the beginning of the project. Subsequently about 70 changes were requested of which about 2/3 were approved. Cheap labour helped limit the costs. The client put great emphasis on health and safety but the record was excellent.

A very high level of expertise was required but FW had built up an excellent reputation in this area working for other large companies and this was well known.

The value engineering ensured that the project was good value for money. The project design had tight timetables but there was some flexibility to reschedule non-critical path items. The project was completed on time.

Lessons from the Project.

Major changes were designed out during the engineering design phase.
The client made huge efforts to make sure that the project worked. This plant was only part of a major complex and was critical to even larger investment.
Key dates were set along the way to ensure that both client and contractor knew were they stood opposite the finish date
There is a need to have an integrated task force, teamwork is key.
A proper estimating and appropriation phase is needed.
It can be difficult in some overseas organisations and in government departments to get a signature quickly for purchase items. This can cause delays.
The client needs to respond quickly when you address queries to him
The client contact needs the authority and to be willing to take decisions.

Good and effective change control is needed throughout.
There are often local practices, which need to be specifically allowed for.

Other Relevant Comment

FW are bothered about risk especially in overseas contracts such as this with a variety of unknowns.

Reimbursable labour cost contracts are good but beware of similar materials contracts. The client can waste a lot of time arguing about material costs and quality.

PROCUREMENT CASE STUDY 3

Company: ICI

Contact Mark Hall-Procurement Manager ICI Paints

Mark works in ICI Paints business in Slough, ICI has a central purchasing function in London setting policy and dealing with common supplies but the individual businesses are responsible for dealing with buying for their own specific needs. The interview was given on the basis that although a specific case was discussed, reference would be made more to general pointers than specific detail. The meeting was held as a telephone conference.

Background

The project discussed was the purchase of containers for paint for the UK market. It is a £20m a year business. ICI prefers to use one main supplier with whom they can work closely and who has provided a competitive, but not necessarily the cheapest quote.

Although the paint business is global, packaging can be very different in different countries. Moreover it is not feasible on a cost basis to shift empty cans around the world. Therefore the packaging is purchased on a country basis.

Project Discussion

ICI decided several years ago to rationalise its supply of paint containers. They put out to contract among their then current suppliers the contract for supply to the total UK business. A competitive quote was accepted with a key factor being that the company was prepared to work with ICI and accept some flexibility. The supplier accepted the day-to-day risks in the business in return for a long-term contract. A second supplier was selected to work with the main supplier if needed at times of fluctuating peak demand.

There were few problems in the initial set up of the contract because the supplier new the business. ICI works very closely with the supplier and this is key to success.

The main ongoing problems are:

Demand can change very quickly. A major ICI customer such as B+Q can put on a promotion and require 2 or 3 times normal off-take in a week in special packs. ICI will get only a few days notice of this sometimes.

Selling paint is a consumer business and marketing has to keep up with the trends. ICI's marketing people can change the style of the packaging. E.g. the attempt to provide paint in flat packs as opposed to round cans, or the colour range.

ICI's way of dealing with these types of problem is to use the supply function as the managing organisation but to have staff directly involved in the link between themselves and the supplier. So the B+Q account manager will be responsible for providing someone to liase with both B+Q and the can supplier. The marketing department will interface with the can supplier about changing package shape or colour. Attempts are made to provide a basic shaped can and then provide labels for special promotions and for bulk orders.

Minor changes to packaging thus mainly involve the labels and the contractor will be able to do this at little cost fairly quickly. However, changes will be discussed and timetabled as early as possible to avoid wasting stock.

Major changes require more planning. Rectangular flat packs needed new machinery and thus time. The contractor took the risk and bore the set up cost but the unit price was renegotiated by ICI's supply team at the marketing departments expense. ICI pay a packaging expert to help manage these changes.

The long-term relationship between ICI and the contractor is most important. The client and contractor must work together.

Lessons from the Project.

Ensure that the client and contractor are in close contact throughout. Closer contact is obtained by linking marketing directly with the contractor with the supply function acting as a manager to the process. Make sure that as few changes as possible are made to the project once it starts by putting in the effort on both sides before the project starts. If changes are to be made involve the contractor as early as possible. Limit the changes as much as possible to cosmetic changes like labels rather than packaging shapes and sizes.

PROCUREMENT CASE STUDY 4

Company: BT

Contact: Stuart Hickin -Manager Network and Technology Procurement

Stuart works at Swindon and was talking to OEF about procurement for Broadband. The interview was given on the basis that the specific suppliers would not be directly mentioned.

Background

The project discussed was the procurement of the equipment for the BT Broadband project. The project had been ongoing for over 5 years but most of the procurement activity had only started in the last 2 years. BT had initially decided to work very closely with 2 suppliers and to jointly develop the market. The suppliers would have equal shares of a five year contract in excess of £500m in total, under a reward sharing type agreement. BT and the suppliers would jointly work to develop the market giving both sides the chance to benefit from growing the market.

However, less than 2 years into the contract BT's business requirements changed radically. Broadband became higher priority, higher volume business. BT needed to change the risk sharing agreement as BT wanted to put in large amounts of capital to develop the project more quickly.

Benchmarking around the world suggested that the existing suppliers were not competitive and there were problems with the existing suppliers of either quality or unreliability. Although BT has an ethical business practice and does not tear up contracts lightly, it was clear in this instance that new supply arrangements should be sought with no immediate compensation for the 2 original suppliers.

BT therefore put the project out to a relatively normal competitive tender.

Success of the Project

It is clear that the new project has been a success to date. There has been a considerable cost saving and both quality and supply reliability have improved. BT were not the leaders in the new technology, France and Germany were ahead and therefore there were examples to benchmark against. Market conditions were absolutely right, most potential suppliers were financially stretched and would do special deals. BT would have to use more suppliers as there was a chance of one or more suppliers going under.

The project had to be driven by the procurement department with full support from the board. The engineers did not want change and this had to be overcome. However, new technologies were available and there were new suppliers in the market place.

Project Discussion

Whereas, originally the project was being run on a risk sharing basis the new project was run with BT having most of the risk if the project failed, although the suppliers would suffer if they could not sell the products. BT looked for suppliers on a global basis including looking at one who manufactured in China. BT's cost expectation was that savings of well in excess of 50% could be made.

The contract was put out to ten companies all of whom bid at least 25% under BT's benchmark. BT wanted to have a select list of companies and tried to do this by asking for further price reductions, all prospective suppliers met the new targets, and so BT decided to run with 8-10 suppliers but to focus resources on certain areas within this.

All except the Chinese manufacturer had long-term relationships with BT and were major international players. Agreements varied between suppliers but had to have bespoke arrangements for this size of business.

BT attempted to manage the risks by having several suppliers to guard against failure of supply. Using several suppliers also allowed them a lever against poor performance on factors such as quality or delivery. This was considered better risk management than relying on penalty clauses. Extra costs were incurred in moving to multi supply especially on the engineering side.

Software code had to be lodged with BT in case the supplier went out of business.

There are always risks to the business when changing supplier. Also two contracts had been torn up which did leave a legal risk However, BT had tried to keep a long term relationship going with the original suppliers, had not excluded them from the new process and in fact was giving them some of the new business.

The client's requirements changed in a major way between the two stages of the project, changed from a joint risk/reward basis to BT taking the risks but with a considerable saving in costs. BT had a much more aggressive approach with high volume and the energy of the company behind the project.

The project required a high level of expertise. All suppliers were checked out especially the Chinese where their successful installations were inspected sites.

The project saved a very large sum of money and therefore it was worthwhile putting considerable effort into it to make sure everything went according to plan. There was little delay in changing suppliers but considerable BT engineering expertise had to be put in to the project. The huge cost saving meant this could be done. The project might have been completed quicker but BT judged the timetable would lose them little long-term revenue.

Lessons from the Project.

The main lesson was that it is possible to re-examine contracts before they expire.

Major problems that begin to arise can be solved by change.

Having someone from a low cost area, (China) in the bidding process can drive prices down.

A combination of procurement tactics, competitive bidding, negotiation and price hurdles all helped deliver a huge cost saving.

Other Relevant Comment

The exchange rate had little clear effect in the bidding. The contracts are written in sterling.

As no UK company was involved in the initial stage of the project there was no government involvement at the cancellation stage.

Move to multi sourcing helped cover much of the risk.

There can be problems communicating with countries in different time-zones speaking different languages and having different cultures.

BT has moved to a different plane on the cost curve with suppliers going from high margins on low volumes to the other extreme. It is a different ball game.

PROCUREMENT CASE STUDY 5

Company: BT

Contact: Bob Taylor –Head of Engineering Materials Procurement

Bob is based at Swindon and is responsible for the procurement of engineering materials ranging from the cabling for major projects down to items such as screwdrivers. The interview was given on the basis that the specific supplier would not be directly mentioned.

Background

This was the second BT interview. It was felt that it would be interesting to look at two different projects in different areas of the same company. The project discussed this time was the contract for the purchase of all copper cable for BT. The annual spend is £40-£50m on around 500 items ranging from large road cables down to small coaxial cables.

The project was put out to competitive tender and eventually awarded to a sole supplier –company A. While the contract negotiation only took weeks, the need to ensure that the supplier's products were of the necessary standard took around a year.

'A' employ around 200 people at their cable plant and this BT business is over 75% of the output. Initially there was some sub-contracting out to areas such as Eastern Europe. However, because of the importance of the contract, 'A' has built their own facilities at a cost of several £m to bring this work in house. This guarantees quality and availability.

Success of the Project

The project is considered to be a major success. It has won Institute of Logistics awards for vendor managed inventory (VMI).

On the cost side, although there were significant initial savings on the contract negotiation, the second order effects have been substantial for both sides. The supplier now holds the stocks in BT warehouses. This saves BT the stock holding cost and saves the supplier the warehouse cost.

There are very close links between the forecasting of requirements and the supply chain. The supplier is fed this information and decides on the warehouse stocks, They can thus better manage their manufacturing runs, leading to more efficient and cheaper manufacture and despite lower overall stocks, less chance of BT being left short of supply.

The supplier is also responsible for providing individual orders of the required size. With large cable this can avoid wastage and limit stocks. BT does not need the cutting machinery and spare product can now be returned to the supplier for later use rather than left lying around in a BT store. The supplier adds more value, makes a better return, is more committed to the business and thus provides a better service.

There were problems related to 'A' running the warehouses. Initially they were using space for non BT material and this had to be sorted out. The supplier bought the copper, which is the major cost in the cables. Improvements had to be made to the copper purchasing system, which were designed jointly by them and BT. The copper price was locked in by forward purchasing rather than allowing total price variation of the material be passed on to BT.

Project Discussion

The relationship had to be risk sharing. The contract was such a major part of the suppliers' business that BT could not afford failure. It is large volume low margin business and with no fixed volumes to the contract, BT had to have a responsible approach. BT have tried to put other companies business the way of their supplier.

There is an informal but close relationship between BT and the supplier. They work together trying to take costs out of the process by redesigning the product and the manufacturing. The supplier now uses the BT transport system for all their haulage. The supplier has helped BT in improving other BT processes with knowledge gained from cable manufacture.

The project was put out to competitive tender but a sole supplier used. Experience has been so good that the supplier is now considered the prime contractor. The market still needs to be looked at to discuss prices.

The contract had a very tight quality specification, delivery had to be 100% met within either 3 or 5 days and the price had to be competitive. Price was not the only thing considered.

There were few problems with the supplier in the setting up stage. Most of the delays came from needing product approval, especially needing to test products over a period of time. This slowed down the speed at which the commercial benefits could be enjoyed.

There were product enhancements as the project progressed. These came both from BT needs and from suggestions from the suppliers aimed at taking processes out and saving costs which were shared. It was a process of joint working to make sure BT got the products they wanted in a cost efficient way.

The product needed high expertise but it was 'A's business. BT looked to them for research and product development as part of the working relationship. BT used a company known to be experts in the field.

Overall the project was good value for money. There was a benefit sharing agreement, which was good for both sides. First order cost saving was not the sole aim. BT looked for an optimum service, with the chance to keep on pushing down costs.

Despite the time to get product approval the project was completed on time.

Lessons from the Project

Don't look at procurement just on an immediate cost basis. Consider the whole life costs utilising the scope for product and process changes.

Be creative about the whole commercial project. Allowing the supplier to use the BT warehouse led to large savings on both sides.

The customer supplier relationship is the key to success. Use people that understand the product to bring knowledge to the table. Share this success and safeguard the future or both sides.

Other Relevant Comment

Considerable time and effort can be saved by accepting BSI rated products, rather than testing out others.

The link between forecasting and supply chain management is very important. Having one person responsible for overseeing whole service from demand forecasting to final payment helps limit the problems.

APPENDIX 2: Review of the economic literature on defence and economic growth

In his seminal work of 1973[21], Emile Benoit examines the relationship between defence spending and economic growth – measured as the real growth of the civilian, ie non-defence sector - in 44 developing economies between 1950 and 1965. He sets out with the prior view that a higher burden of defence spending is likely to be associated with weaker economic growth, but ends up concluding that the reverse may be true.

He starts by identifying the widely recognised adverse effects of defence spending, breaking them down into the following three categories:

- **Investment effects**. High defence spending could adversely affect growth by absorbing resources that might otherwise have gone into productive investment. This may be done "either directly by purchasing domestic construction or domestically produced equipment or stocks, or indirectly by using foreign exchange that would otherwise have been used to import such equipment or stocks, or to pay for imported construction and technical services, for dividends, interest payments, or other remuneration required to motivate or finance an inflow of foreign investment. Moreover, since investment is the primary engine of growth, it may be assumed that this decline in investment will result in a lower growth rate in future." (Benoit, 1973). For the whole sample of countries, he found that this investment effect was indeed significant – and large. A 1% increase in the defence burden (defence spending as a proportion of GDP) would tend to be associated with a reduction in GDP growth due to lower investment in the non-defence sector of 0.1% per year.
- **Productivity effects**. The productivity effect "arises from the fact that the government sector in general, and the defense sector in particular, show little or no measurable productivity increases. Thus, any enlargement of the defense sector increases the part of the economy which fails to bring about further growth. Shifts of resources from non-governmental activities over to defense would therefore tend to reduce the rate of productivity increase and of growth." (Ibid). This composition effect will vary in size by country, depending on the growth rate achieved in the non-defence sector in that country. Productivity growth is comprised of two elements, as follows:

  G = wnd*gnd + (1-wnd)*gd

[21] Emile Benoit: 'Defence and economic growth in developing countries' (Lexington Books, 1973)

Where G is the whole economy productivity growth rate, wnd is the weight of the non-defence sector, gnd is the productivity growth rate of the non-defence sector and gd is the productivity growth rate of the defence sector. By assumption, in Benoit's work, gd (defence productivity growth) is zero. So an increase in the size of the defence sector must result in a reduction in the whole economy productivity growth rate G as long as the non-defence productivity growth rate is positive.

- **Income shift effects**. The income shift effect is "the implied reduction in the size of the civilian product when a part of GDP is shifted or reallocated to the defense sector." (Ibid). Again, the size of this composition effect will depend on the level (not growth rate) of productivity in the defence sector compared to the non-defence sector. The income shift effect is not a cumulative effect like the investment and productivity effects: it is a one-off step change in whole-economy productivity, without any implication for the growth rate of that productivity (already captured in the productivity effect above).

As Benoit points out, it is not entirely clear whether there is an overlap between these different effects, and there is also a problem of combining cumulative and non-cumulative effects. However, notwithstanding these caveats, the combined adverse effect would appear, prima facie, to be quite strong. A 1% point increase in the proportion of defence spending in GDP could retard the growth rate of the non-defence sector by as much as 0.25% per year: a powerful adverse effect – roughly 70% as strong as the effect of decreasing investment by 1% of GDP.

However, as noted above, Benoit actually finds a positive correlation between defence spending and the growth rate of the non-defence sector, suggesting that the adverse effects, though strong, may be outweighed by the positive effects deriving from defence spending. What are the positive effects? Benoit identifies three:

- Defence programs directly contribute various useful inputs into civilian economies, particularly training, which may considerably improve the productivity of military manpower for civilian occupations after demobilisation.
- Dual-use infrastructure, such as roads, airfields, ports and communications networks, which may sooner or later be used in part by civilians.
- Food, clothing, shelter, and medical services provided by military personnel do to some extent substitute for provision by the civilian economy of comparable goods and services to civilians.

Benoit does not conclude that he can prove that higher defence spending results in net higher productivity growth, but he does assert that the balance of the evidence appears to point in that direction. He does not cite the spillover benefits in terms of innovation via R&D spend as a reason why defence spending might contribute to economic growth. That is probably because the sample of countries that he looks at – developing economies - are on the whole unlikely to undertake significant amounts of ground-breaking defence R&D themselves. Instead, they are likely to purchase defence equipment from the major defence exporting countries around the world (including the UK). But it is likely that the first positive effect that he identifies - the direct contribution of defence programs into civilian economies – covers some of these effects where they exist, and also covers the wider contribution of the defence industry (to the extent that it exists) to the prosperity of the economy as a whole. The most significant contribution of this work was the striking and at that time counter-intuitive positive relationship that was identified between defence spending and growth. This puzzle was the trigger for a large volume of research thereafter.

The literature in this area since Benoit has developed broadly along two lines: the first looking in more detail at the relationship between the total defence burden and the growth performance of developing economies; and the second exploring a new avenue, assessing the possible productivity benefits of defence R&D as well as other forms of defence spending in developed economies. The first, while interesting, is not directly relevant to our research. The second, however, is.

David Saal[22] finds a positive relationship between defence procurement driven R&D and productivity growth in the US: strongly positive within the highly defence-dependent industrial sectors, and weakly positive on average across the whole economy. This result stands in contrast to many of the results from the other studies that he reports[23], which tend to find no relationship or even a negative relationship – a contrast that the author ascribes to his use of industry-specific productivity data rather than just whole-economy data.

Eduardo Morales-Ramos[24] draws a distinction between defence R&D expenditure and non-R&D expenditure, saying that the evidence (theoretical and empirical) suggests that the R&D component of

[22] David S Saal: 'The impact of procurement-driven technological change on US manufacturing productivity growth'; Aston Business School, February 2001
[23] These include Terleckyj, 1974, Griliches & Lichtenberg, 1984, Lichtenberg & Siegel 1991, and Lichtenberg, 1995.
[24] Eduardo Morales-Ramos: 'Defence R&D spend: the crowding out hypothesis', Defence and Peace Economics, 2002

defence spending may have positive effects on growth, while the non-R&D components may have negative effects, so that the total effect of defence spending is ambiguous.

Kelly and Rishi[25] conclude from their empirical research that the case for spin-off effects of military spending may have been exaggerated, suggesting that total defence spending may be neutral for growth.

Shieh, Lai and Chang[26] by contrast find that "a rise in military spending tends to stimulate the sustained growth rate, confirming Benoit's famous empirical findings". While the crowding out effects of defence spending are found to be negative, the spin-off effects on productivity are positive, and there are additional resource mobilisation effects that may also be positive.

Buzan and Sen[27] look at the role of military R&D in developed economies in a longer-term historical perspective. They cite a variety of empirical studies[28] that tend to find a negative relationship between military R&D and productivity growth in the rest of the economy, but go on to describe in detail how certain key technological advances (in aviation, computers, nuclear power, and satellite technology) have been made on the back of what was initially military R&D. They argue that the demand from the military sector in advanced economies for technological innovation can make the civil expansion of certain industries commercially viable. If the civil sector had to bear all the R&D costs (and risks) of developing computer technology or nuclear power (for example) then it is possible that those sectors would never have come into existence, or at least may not have developed as far as they have. They also argue that the beneficial effects of military R&D in terms of advancing the technological frontier for the civil sector may not be confined to the country that undertakes the military R&D – citing Japan as a post-war example of a country that has made huge technological advances on the back of what was originally military technology developed in other countries.

[25] Kelly, Rishi: ' An empirical study of the spin-off effects of military spending', Defence and Peace Economics, 2003
[26] Jhy-Yuan Shieh, Ching-Chong Lai, Wen-Ya Chang: 'Endogenous growth and defence spend: new explanation of the Benoit hypothesis', Defence and Peace Economics, 2002
[27] Barry Buzan and Gautam Sen, 'The impact of military R&D priorities on the evolution of civil economy in capitalist states', Review of International Studies volume 16, 1990.
[28] These include Nils Petter Gleditsch: 'Economic incentives to arms? Effects of military spending on industrialised market economies', PRIO 21, no.86 (1986).

Cuaresma and Reitschuler[29] find that there is empirical support for a positive relationship between defence spending and growth in the US, but that the relationship is strongest for relatively low levels of defence spending – in other words, defence spending exhibits diminishing marginal returns in terms of the productivity increases that it can generate.

It is difficult to draw firm conclusions from this vast body of literature, of which the examples cited above represent just a small (but illustrative) fraction. As Ron Smith says[30]: "…the literature on military expenditure and growth is inconclusive…[because]…the two-way causality between growth and military expenditure can produce both positive and negative correlations between them". Richer countries tend to spend a smaller proportion of GDP on defence (negative correlation), while increased defence spending may have positive effects on growth, both via demand and productivity (positive correlation).

Unsurprisingly, therefore, some researchers (starting with Benoit) find a positive relationship between military spending and productivity growth, while others suggest that military R&D spending can be positive for growth, even responsible for bringing into existence growth sectors like IT etc, but that perhaps military non-R&D spending can be neutral or even negative for growth. Others still suggest that even military R&D spending could be neutral or negative for growth, by diverting resources from other more productive sectors.

The research into the role of military spending in explaining economic performance has run in parallel to another body of research that looks in more general terms at the whole range of factors that influence whole-economy productivity[31]. A detailed assessment of this body of research is beyond the remit of this paper, but suffice it to say that the factors influencing productivity in different countries are generally thought to include the following:

- Fixed capital investment – the higher is the level of fixed capital per worker, the higher will be average labour productivity. This includes the impact of infrastructure – in terms of transport, utilities and communications networks.

[29] Jesus Crespo Cuaresma and Gerhard Reitschuler: 'A non-linear effect of fiscal policy? The special case of US defense policy'; January 2003
[30] Ron Smith: 'Defence expenditure and economic growth', a chapter in 'Making Peace Pay: a bibliography on disarmament and conversion', 2000
[31] See for example Phillippe Aghion: 'Endogenous growth theory', reference

- Per capita GDP. This captures the impact of 'catch-up' – faster productivity growth in less-developed economies.
- Labour quality. Countries with a better educated and more highly skilled workforce should enjoy a higher level of productivity.
- Labour mobility. Countries in which the labour force is highly mobile should benefit from a more efficient allocation of resources, resulting in higher productivity.
- Competition. Economies with a high degree of competition on the supply-side might see an improvement in productivity as a result.
- Research and development spending. Countries where R&D is high as a proportion of GDP might benefit from higher productivity to the extent that R&D encourages technological innovation**.**

The last effect is of most interest to us in this research. There is a great deal of evidence, theoretical and empirical, that countries with a high level of R&D spending tend also to be countries that enjoy a high level of productivity. This is the stated opinion of the government, concerned to try and close the 'productivity gap' between the UK and other countries, and it is borne out by studies from a number of official sources such as the OECD.

There are many controversies in the literature in this area. But one that is relevant to this research is the question of whether R&D can boost the trend growth rate of productivity, or just the level of productivity. However, over horizons like ten years (of interest to us in this paper), this is a purely academic question: a shift to a higher level of productivity is likely to take at least that long, and so would be observationally equivalent to a shift in the trend growth rate over that period.