

## 1 Introduction

Modern weapons are complex systems, whose purchase is surrounded with difficulties. Their acquisition and procurement involve defence departments making and implementing hard choices, usually given a set of challenging options, in an uncertain environment, with limited information and budget constraints. The uncertainty can be such that when the requirement is specified the technology does not exist; it has to be invented. These difficulties are rarely fully surmounted and as a result new weapons tend to be delivered late, over budget and unable to meet their performance targets. These failures in the acquisition and procurement of most, though not all, systems are repeatedly documented in reports by the US Government Accountability Office (GAO) about the Department of Defense (DOD); the UK National Audit Office (NAO) about the Ministry of Defence (MoD); and government auditors in many other countries about their defence departments, the generic term that will be used when not referring to a specific country. While some other countries will be discussed, the examples will largely be taken from the UK and the USA. The projects discussed include, from the USA, the F-35 Lightning II Joint Strike Fighter and the Future Combat Systems of armoured vehicles; the European A400 M military transport; and, from the UK, the Ajax armoured vehicle, Warrior upgrade and nuclear projects.

Procurement involves buying weapons designed to kill or incapacitate their targets, usually people. The weapons are being used in the many current conflicts around the world. This raises a range of moral and ethical issues. The fact that this Element does not address the moral and ethical issues does not mean that they are unimportant. They are important; it is just that economists have no special expertise in judgements about the moral and ethical dimensions. So this Element will just discuss the issues and leave it to the readers to make their own judgements.

Acquisition and procurement are just one aspect of defence, or defense, economics. Sandler and Hartley (1995) provide a more technical treatment and Smith (2009) a less technical treatment of the wider subject. There is a, probably apocryphal, story that US President Harry Truman asked for a one-armed economist, who could not say ‘on the one hand . . . on the other hand’. There will be a lot of ‘on the one hand . . . on the other hand’ in this Element; there are no simple answers. The Element examines the economic reasons for the failures in procurement, hence the subtitle ‘how (not) to buy weapons’, and emphasises the role of incentives and institutional structure. There are books about the engineering and contracting skills needed in military procurement, for instance in the UK *Conquering Complexity* (DEG 2005) and in the USA the

*Defense Acquisition Guidebook* of the Defense Acquisition University. This is not one of those books. Instead it looks at the economics of the process, broadly following the *structure, conduct, performance* framework, often used in industrial economics. The *structure* of the market, the nature of the demand by the military and the supply by the arms firms, determines their *conduct* in interacting within a fraught contractual relationship, which determines the *performance* of the industry, in terms of time, cost and quality. These issues are timeless. Although recent examples are mainly used here, similar examples can be found in the classic books by Peck and Scherer (1962) and Scherer (1964).

Although acquisition and procurement are usually synonyms, in defence it is common to distinguish between procurement, which refers only to purchase, and acquisition, which also includes other aspects of ownership. Just as someone purchasing a house has to think about living in it for a long time, someone purchasing a weapon has to think about operating it for a long time. The B-52 bomber has been in service with the US Air Force since 1955 and, in September 2021, Rolls-Royce won a contract to supply aero-engines as part of an upgrade that it is hoped will keep the bombers flying till 2050. The C-130 Hercules military transport aircraft entered service in 1956 and is still in production.

The military love acronyms and the stages of ownership are described in the UK as a CADMID cycle: Concept, Assessment, Demonstration, Manufacture, In-Service and Disposal. Procurement covers ADM, though in the USA the Research, Development, Testing and Evaluation (RDTE) stage is sometimes distinguished from the subsequent procurement stage. In-service operation of equipment is covered by the acronym TEPIDOIL: Training, Equipment, People, Infrastructure, Doctrine, Organisation, Information, Logistics. While most of the elements are self-explanatory, doctrine refers to how the equipment is used and often new technologies are introduced before the military really know how to use them so there is a long period of learning and reorganisation before they are successfully integrated into military doctrine.

The equipment is intended to provide a military capability, though there are many different definitions of capability. Broadly, capability will be used to mean the ability to meet a military objective. There is the difficulty that the primary military objective, prevailing in combat, is difficult to measure in advance, so more quantifiable characteristics of capability are often used. The National Audit Office (NAO 2020b) says the MoD develops and operates military capabilities in order to meet its strategic requirements and objectives. A military capability is not simply a piece of equipment such as a tank. Rather, it is a tank with a trained crew that can: communicate with others on the battlefield; meet identified threats; and be properly maintained and repaired during its

lifetime. Giry and Smith (2020) emphasise the role of equipment support in the provision of capability and the different meanings different actors attach to capability.

The various procurement failures have prompted many attempts to fix the problem. Taylor (2019, p. 259) lists eight major reports relating to UK defence procurement between 1961 and 2012, each of which recommended reforms. Fox (2011, p. xi) lists twenty-seven major studies of US defence acquisition. The National Audit Office (NAO 2021) contains recent recommendations for reform in the UK.

While there have been many attempts to fix the problem, the titles of books like *British Weapons Acquisitions Policy and the Futility of Reform* (Chin 2004) and the US study *Defense Acquisition Reform, 1960–2009: An Elusive Goal* (Fox 2011) suggest that the fixes have not worked. The UK Public Accounts Committee (PAC 2021b, pp. 5–6) says of the MoD, ‘The Department’s system for delivering major equipment capabilities is broken and is repeatedly wasting taxpayers’ money. ... The Department continually fails to learn from its mistakes.’

The Foreword to Fox (2011) by Richard Stewart notes how acquisition reform initiatives have been DOD perennials over the past fifty years. Reforming the acquisition process is a high priority each time a new administration comes into office and many studies have reached the same general findings with similar recommendations. But the difficulty of the problem and the associated politics, combined with organisational dynamics that are resistant to change, have led to only minor improvements. He concludes that the problems of schedule slippages, cost growth and shortfalls in technical performance have remained much the same throughout this period.

Fox (2011, p. xiii) lists the built-in cultural aspects that resist change. The workforce frequently does not have the training, experience and stable tenure to monitor and manage huge defence acquisition programmes. The senior, politically appointed acquisition officials average a mere eighteen months in office. There is an irregular and erratic flow of weapons systems appropriations. Risky Research and Development (R&D) and an ill-informed requirements process mean that contracts get changed over time. There are incentives for contractors to bid low. He concludes, ‘These cultural challenges within the current acquisition system have great value to many key participants in industry, the services, and Congress and predispose them to be generally resistant to change.’

For the UK, RAND Europe (2021), discussing the underlying causes of equipment procurement problems, highlights a range of issues. A lack of skills and capabilities in industry and the MoD results in poor requirement setting and production inefficiencies. There are problems with supplier performance

incentives and contracting. These result in misaligned assumptions and a poor understanding of risk. There is poor programme management, budgeting and delivery. This results in imbalances between the armed services, frequent adjustments to programme delivery management and insufficient risk provision. There are cross-cutting problems like a conspiracy of optimism, lack of institutional memory and moral hazard, issues that will be discussed.

Defence procurement is at a unique interface of politics, technology, war-fighting and commerce which can produce conflicting, often perverse, incentives and complicated bureaucratic politics. The account in this Element will emphasise incentives, the interests of the actors, and institutions, the frameworks within which they act.

One incentive shared by nearly all the actors is to be optimistic. This is often called the conspiracy of optimism, but does not require any conspiracy. All the actors – politicians, the military, civil servants and industry – have good reasons to under-estimate the cost and time required for the project and under-state the difficulties it faces. The politician wants to announce an exciting new project, particularly if it generates jobs. The military want the weapon. The civil servants need to spend their budget. The firms want the contract. Thus, it is in their joint and individual interests to make the project look sufficiently attractive to get it into the budgeted plan. Optimism also avoids, or at least postpones, conflicts. The parties may have incompatible demands. For instance, one wants a light armoured vehicle that can be transported by air, one wants it well protected. Rather than exposing the conflict, which may endanger the project's entry into the plan, the parties may agree to avoid the hard choice in the optimistic belief that time or technology will resolve the contradiction. Once the project is in the plan, the hope is that cancellation will be difficult, even if the project fails to meet time, cost and performance targets, and that the system will eventually get into service. Most troubled procurement projects do get into service and turn into operational systems.

It is said that 'where you stand depends on where you sit'; your position on an issue will depend on the organisation that you belong to. In this context, the conspiracy of optimism is an example of 'motivated beliefs'; people believe things that it is in their interests to believe. Their interests influence the way evidence is gathered, the arguments are processed and the memories of past experience are recalled. If salary and promotion depend on believing that 'this time will be different' – that, unlike in the past, high-quality equipment will be procured quickly and cheaply – then there is a good reason to believe it. If, in addition, all the principal actors share this optimism, reinforcing each other's belief, then it is likely that, despite past experience, all will become believers. This effect is likely to be particularly strong if these beliefs will only be proved

wrong many years after the crucial decisions have been made, by which time the actors will have moved to other jobs. This is partly the reason that so many reports complain that there is too little institutional learning from experience.

There are many forms of organisation that can be used to perform an economic function such as buying weapons. For instance, the function can be provided within a hierarchical organisation like a firm or government, or provided through an arm's-length market relationship. A firm may have a choice between making a component itself or buying it from an outside supplier. Economists often explain the make-or-buy choice in terms of what they call 'transaction costs'. The perceived transaction costs associated with negotiating with outside parties influence the form of organisation that the government chooses to provide the weapons.

Transaction costs are likely to be low if the procurement involves the frequent purchase of a standard commodity from a competitive market. High transaction costs provide incentives to produce in-house, through arsenals or state-owned arms firms. Transaction costs will be higher if there is 'asset specificity' – the facility can only be used for supplying the defence department – which creates mutual dependency between the defence department and the firm. Transaction costs increase with uncertainty, which makes it more difficult to write a contract with a private firm that will cover all eventualities. As transaction costs fall, the weapons may be produced in partnership with a private firm under a cost-plus profit partnership; they may be produced in government-owned facilities by a private firm; or they may be procured competitively with a fixed-price contract, as is common in commercial markets. The Department of Defense (DOD 2022, p. 3) notes that in 2021, by number of contracts, 90 per cent of the contracts awarded were competed for, but most of them were small; by value of contracts, only 52 per cent of the dollars awarded followed competition; and in major weapons systems, competition rates ranged from 15 to 40 per cent.

### 1.1 Market Structure

The structure of the market reflects the nature of demand and supply. On the demand side is the government defence department that buys the weapons. How much it wants to spend on weapons will reflect its budget constraint (its ability to pay); its perception of national interests and threats to those interests; and the opportunity costs of the military expenditure (what has to be given up to fund defence). Defence departments buy a very wide variety of products. There are standard civilian products like fuel, food and clothing; military products like small arms, major conventional weapons systems and weapons of mass destruction; and dual-use products like communications, crypto- and cyber-systems.

The focus of this Element is on major weapons systems, like aircraft, ships and armoured vehicles. Defence departments are major buyers of oil products – aircraft, ships and armoured vehicles use a lot of fuel – but oil does not raise any special issues because there is a large civilian market for oil. Like civil airlines, defence departments outside the USA have to consider whether they should hedge against variations in the price of oil and equipment, both of which are usually priced in dollars. The UK MoD uses forward (swap) contracts to hedge against the oil price and hedges equipment import costs with the Bank of England. But such hedging choices are not specifically military. The special issues arise in the market for major weapons systems, which has characteristics that are different from civilian markets.

The government is usually the only national buyer for major weapons systems, though there may be export markets. Having a single buyer is called monopsony. Not only are governments usually the only domestic customer but they are also often: an investor, financing R&D; an export regulator, determining where the weapons can be sold; a marketing manager for the overseas sales; and an owner, since many arms companies are state-owned.

On the supply side is the arms industry that makes the weapons. Defining the arms industry is difficult and arms are not a category in any of the standard lists, such as UN Standard International Trade Classification (SITC). Both military and civilian items are included in many of the relevant categories, such as aerospace and electronic equipment. There is also a large amount of dual-use equipment, which can have both military and civilian applications. These measurement issues are sufficiently difficult that what seem like simple quantities, such as the number employed in the arms industry or the value of defence exports, are difficult to measure. There may be no measure available or many conflicting measures differing with respect to the exact definition or the method of calculation.

At one level major weapons systems are relatively easy to identify as an aircraft, tank or warship. Yet at another level they are complex products which combine a lot of elements. There is a platform, such as the aircraft; its armaments, such as missiles; its avionics, such as communications and radar; and its logistics, which ensure its supplies and keep it operational. An aircraft needs a large team on the ground. This means that there may be considerable uncertainty about exactly what is being purchased and what it costs, depending on what is included in the total.

The development of new major weapons systems often involves the use of untested technologies against uncertain and evolving threats. Smaller, simpler military contracts have fewer failures or fewer failures that get publicity. Production of weapons systems usually involves large R&D expenditures and

there are other fixed costs which have to be spread over each unit. Thus, the average cost of each unit falls with the number produced. There are also learning curves, where the marginal production cost of each additional unit falls. Both result in increasing returns to scale, which can make competition not viable. The more a firm can produce, the lower its costs, making smaller producers uncompetitive, leaving only a single seller that can profitably survive. Increasing returns to scale also make exporting attractive, to spread the fixed costs and gain the benefit of learning curves.

## 1.2 Conduct

The main elements of conduct involve the behaviour of the buyers and sellers in the procurement and acquisition of weapons. Given the long time-horizons, uncertainty is central. The uncertainty may be about supply – will the technology work? – or about demand – what will the future requirement be? The Eurofighter Typhoon was designed for air superiority in the early 1980s, reflecting Cold War needs. When it came into service in the mid-2000s it was re-equipped for ground attack roles. It could still be operating in the 2040s, facing quite different demands. The uncertainty complicates decision-making, both for the buyer, about what is wanted, and for the buyer and supplier, about how it should be provided.

The interaction between a single buyer and relatively few potential suppliers involves a lot of political economy issues, the nature of the defence department and any military-industrial complex, as well as what are called *principal-agent problems*. These include asymmetric information, risk aversion, moral hazard and adverse selection. They are discussed in Section 5. The terms *moral hazard* and *adverse selection* are taken from insurance. Providing fire insurance might create an incentive for the insured to start a fire to collect on the insurance. That is moral hazard. The insurance may attract only those at most risk of being subject to fires. That is adverse selection. In economics, they are used in a wider sense, as will become apparent.

Whereas the principal-agent issue is a two-level problem, between government and firm, there is a three-level problem: government, defence department as regulator and firm. Regulatory capture is the term used by economists for the process by which special interests, such as a military-industrial complex, capture the regulator, the defence department, so the regulator is not necessarily doing what the government intends. Dal Bó (2006) reviews regulatory capture.

Neither the government nor the defence department are unitary decision-makers. Within the defence department, procurement and acquisition involve a large number of complex coalitions of different warring tribes with different

interests and cultures. The tribes, which are discussed in Section 6, include the politicians, the different armed services and civilian government employees. The civilians may be administrators, trying to keep the projects running smoothly; strategic specialists in the intelligence community forecasting future threats; scientists and engineers, designing the weapons; lawyers, advising on the contracts with the firms; financial experts, advising on the terms; and many other specialists. Inter-service rivalry between the army, navy and air force for an increased share of the budget is continuous. Each tribe will have its own language and experience, making it difficult for them to communicate with each other even when they do not strategically hoard information in their own silo. Watters (2019) has a nice description of the cultural competition between the tribes in the UK MoD and Akam (2021) between the tribes in the UK army.

Many of the government actors in the procurement process, including the military, may be in post for relatively short times since it is common to rotate personnel through different two-year postings. For different reasons, the people in charge may also have short tenures. In the twenty years to November 2021, the UK had eleven Secretaries of State for Defence, the USA nine Secretaries of Defense plus five acting Secretaries of Defense. The US Secretaries mostly had a background in defence. Many of the UK Secretaries, who have to be chosen from Members of Parliament, had relatively little knowledge of defence before taking up the role. In some countries, the elected representatives have a detailed role in budgeting, as in the US Congress. In other countries, the elected representatives have a relatively limited role, as in the UK Parliament.

Other institutions are involved, like the NAO in the UK and GAO in the USA, who have auditing functions. Another institution of particular importance is the finance ministry. There is usually tension between the defence department, which spends money, and the finance ministry, which tries to control spending. In the UK, the finance ministry, known as Her Majesty's Treasury, has always been seen as the number one enemy in the MoD. Hennessy (2003, p. 196) describes how, in the event of a nuclear war, Project Turnstile would evacuate, to a bunker beneath the Cotswolds, the 210 people thought needed to keep the UK running. Project Turnstile was organised by the MoD, which did not include anyone from the Treasury on the passenger list.

Inter-service rivalry, political-military tensions and disputes between the defence department and other organisations like the finance ministry and auditors all complicate decision-making about requirements and timing.

### 1.3 Performance in Procurement

Consider now some examples of poor performance in the procurement of major weapons systems. The F-35, for which Lockheed Martin is the prime contractor, began development in 2001 and first flew in 2006. In the USA, the Nunn-McCurdy Act requires the DOD to report to Congress whenever a Major Defense Acquisition Program experiences cost overruns that exceed certain thresholds. The F-35 breached these thresholds in 2009, when costs had doubled. There are three variants. The conventional F-35A entered service with the US Air Force in 2016; the short take-off/vertical landing F-35B with the Marine Corps in 2015; and the carrier-based F-35C with the US Navy in 2019. Concurrent production and development caused problems and there is still a large number of technical problems. In July 2021 the GAO (2021) said, ‘Currently, the program is 8 years delayed and \$165 billion over original cost expectations. As the program progresses towards completing operational testing of the aircraft’s baseline capabilities, it still faces risks.’ By the end of 2021, 753 had been produced, even though it had not completed the operational testing usually required before an aircraft goes into full production. Its much higher operation and support costs than the aircraft it replaced were also a source of concern. The Congressional Research Service (CRS 2022) provides a history of the development of the F-35.

The US Future Combat Systems (FCS) was launched in 2003. The vision was to create army brigades equipped with new crewed and autonomous vehicles linked by an unprecedented, fast and flexible battlefield network. Thirty-two billion dollars were expended on this programme, with little to show for it. In 2009, it was cancelled. Although a number of examples of cancellation will be mentioned, it is quite rare for a major failing project to be stopped. Projects are easy to begin but difficult and expensive to stop. The pattern is for things to go wrong, the project is reviewed, some changes are made and the project proceeds in the hope that the problems are not sufficiently serious to stop the system going into service.

Armoured vehicles have been equally problematic in the UK with programmes also cancelled. The House of Commons Defence Committee (HCDC 2021) produced a report, *Obsolescent and Outgunned: The British Army’s Armoured Vehicle Capability*, which ‘reveals a woeful story of bureaucratic procrastination, military indecision, financial mismanagement and general ineptitude, which have continually bedevilled attempts to properly re-equip the British Army over the last two decades’. Frequent changes in personnel within project teams and a lack of ingrained technical knowledge and understanding of armoured vehicle development resulting from the transfer of design

authority to industry in the 1990s were also cited as contributing factors to the failure to deliver new vehicles to the Army.

The Warrior infantry fighting vehicle came into service in 1984. In February 2010, the Warrior programme team sought approval from the MoD Investment Approvals Committee (IAC) to proceed to the demonstration phase of an upgrade. The upgrade was ultimately approved in October 2011. During this period, the estimated date of entry into service slipped from 2014 to 2020. In response to updates in 2016 and 2018, the IAC asked the team to provide a clear statement of the programme's value for money (VFM) in the forthcoming request for approval to manufacture but this submission continued to slip. In February 2019, the accounting officer provided an assessment of the programme to the Committee of Public Accounts. This stated that it was too early to conclude on the programme's VFM, but the available evidence was that the current solution still offered the 'best VFM'.

In the UK the Infrastructure and Projects Authority (IPA) was set up in 2016 to provide expert project delivery advice, support and assurance to government departments and work with industry to ensure projects are delivered efficiently and effectively, and to improve performance over time. In October 2020, the IPA advised that a proper VFM assessment was still not possible and it was therefore still too soon to seek approval for the manufacture stage. As at December 2020, the programme team expected to achieve initial operating capability in 2026 and full operating capability in 2028, and expected to have spent over £580 million on the programme by March 2021. The upgrade involved fitting a new turret equipped with a cannon supplied under a separate contract. This left the MoD with the challenging task of integrating the contribution of a range of suppliers and providing key components as Government Furnished Assets to the lead contractor, Lockheed Martin. The lead supplier and the supplier of the cannon were not in a contractual relationship although their work was interdependent. In March 2021, the government announced in the Integrated Review of Security, Defence, Development and Foreign Policy that it had cancelled the upgrade programme.

There were also problems with another UK armoured fighting vehicle, Ajax, which was a development of an existing vehicle used in other countries. The MoD signed a contract with the US defence contractor General Dynamics (GD) in March 2010. The contract was for a family of 589 vehicles worth £5.5 billion in total, which would be assembled in South Wales and GD promised 10,000 jobs. As of 2021, when the problems were publicised, £3.5 billion had been paid. Delivery should have started in 2017 but trials were halted over concerns that noise and vibration were damaging crews' hearing. Again there was an issue with a separate contract for the cannon and the MoD required further