



National Audit Office

**REPORT BY THE
COMPTROLLER AND
AUDITOR GENERAL**

**HC 755
SESSION 2010–2011**

2 MARCH 2011

Ministry of Defence

Management of the Typhoon Project

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Management of the Typhoon Project

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Amyas Morse
Comptroller and
Auditor General

National Audit Office

28 February 2011

The Eurofighter Typhoon will form the core of the Royal Air Force's combat aircraft capability until at least 2030. This report assesses how effectively the Department is managing the Typhoon project to achieve full cost and operational value from its continuing investment.

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Contents

Summary **4**

Part One

The capability
Typhoon provides **11**

Part Two

Cost control **23**

Part Three

Governance and
decision-making **28**

Appendix One

Methodology **34**

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This report can be found on the National Audit Office website at www.nao.org.uk/Typhoon-2011

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Summary

Introduction

1 The Eurofighter Typhoon (Typhoon) will form the core of the Royal Air Force's (RAF's) combat aircraft capability until at least 2030. The Ministry of Defence (the Department) is buying 160 aircraft with the first one delivered in 2003 and the last expected to come into service in 2015. On current plans, the Department is likely to spend £37 billion on the capability. Sixty per cent of this is likely to be incurred procuring and upgrading the aircraft with the remainder on support and enabling activities.

2 The United Kingdom is procuring Typhoon in collaboration with Germany, Italy and Spain. Together the four partners have contracted to buy 472 Typhoon aircraft in three stages, or tranches, along with a further 87 purchased by Saudi Arabia and Austria. The collaborative project began in the mid-1980s and, as one of the partners making the most significant investment in the project, the Department played a central role in establishing the collaborative management structures. These arrangements have proved complex and inefficient, but the Department recognises the shortcomings and is working with partner nations to streamline decision-making. The arrangements are replicated by industry with contractors from each nation forming consortia to manage the development, production and support of the aircraft and engine. There are also complicated arrangements for sharing work between countries. Some elements of support of the aircraft are contracted for on a collaborative basis by all four partner nations. The Department is working to improve the efficiency of industry arrangements to make upgrades and support of the aircraft more cost-effective and agile, with some recent improvements in arrangements.

Scope of the report

3 This report assesses how effectively the Department is managing the Typhoon project to achieve full cost and operational value from its continuing investment. Key areas we examined are:

- a** **The capability Typhoon provides** – how the Department is progressively enhancing the capability of Typhoon and how it is managing the factors which affect its ability to make full and timely use of the aircraft as they are delivered (Part One).

- b Cost control** – why the Department has found it difficult to control costs on the project in the past and whether it is now better positioned to manage costs and make well informed decisions in the future (Part Two).
- c Governance and decision-making** – the effectiveness of the collaborative management arrangements and United Kingdom governance and whether they enable timely and cost-effective decision-making to progress the project (Part Three).

Main findings

The capability Typhoon provides

Typhoon is performing important operational tasks

4 The 70 Typhoons already in service are protecting the air space around the United Kingdom and the Falkland Islands. Typhoon was conceived in the 1980s during the Cold War, mainly for use as an air-to-air fighter and the aircraft is highly capable in this role. But the operational environment has changed significantly, making the ground attack role more important and so the Department is upgrading Typhoon to become a fully multi-role aircraft which can conduct both air-to-air and ground attack missions.

The full multi-role capability will not be available for some years

5 In 2004, the Department decided to withdraw its Jaguar aircraft. In the same year, it decided to spend £119 million to upgrade its early Typhoons to replace the Jaguar's ground attack capability. The upgrade was successfully introduced in July 2008. In 2009, a corporate decision was taken to retire early the other air defence fighter, the Tornado F3, to save money. As a result, Typhoon aircraft have been prioritised to take over the air defence role that the Tornado F3 fulfilled. The Department can currently deploy a small number of Typhoon multi-role aircraft but in the majority of cases, such as Afghanistan, the Tornado GR4 remains the Department's preferred ground attack aircraft. Newer Typhoon aircraft will have progressively enhanced multi-role capability with, for example, laser guided Paveway IV bombs and Storm Shadow cruise missiles by 2018. By this time Typhoon is likely to be the aircraft of choice for both ground attack and air defence.

Problems with spares availability and flying hours must be addressed if Typhoon capability is to be fully utilised

6 Some elements of the aircraft support such as the supply of spares and repair of equipment are done within the collaborative arrangements. In parallel, each nation also has individual contracts to support and maintain the aircraft and these are independent of the other three partner nations. The Department has built on its experience introducing innovative commercial support arrangements for its Tornado and Harrier fleet and placed an independent United Kingdom only contract for the maintenance of the aircraft with BAE Systems. The contract requires BAE Systems to provide maintenance and support services to deliver a set number of aircraft to the RAF and the performance targets are largely being achieved. The Department has a similar arrangement with Rolls-Royce for engine support including the supply of engine spares and again the company is largely meeting the performance targets. Separate to these two support contracts, there are indications of problems with the collaborative contracts for the supply of spares and repair of equipment. There have been shortages of spares and long timescales for equipment repairs on some of these contracts. To compensate, the Department has had to take parts from some of its Typhoon aircraft to make other aircraft available to fly.

7 The problems with spares have been a contributor to the Department's inability to meet its target for annual flying hours, with a 13 per cent shortfall in 2009-10. As a result, the Department has limited pilot training to maintaining Typhoon's primary role of air defence at the expense of training in more complex tasks. For example, between November 2009 and August 2010, an average of 15 per cent of pilots had sufficient training hours to perform tasks beyond air defence. While this is sufficient at present it will not be so in future. The Department's recently announced plan to accelerate the growth of RAF squadrons that fly Typhoon is likely to increase demand for pilots and place additional strains on the supply of spares. By 2016, the Department aims to deliver sufficient flying hours to train enough pilots to undertake the full range of planned tasks.

Delivering sufficient fast jet capability in future will require the Department to make tough choices

8 Following the Strategic Defence and Security Review the Department plans to move, by 2021, to a fast jet fleet comprising two aircraft types: Typhoon and Joint Strike Fighter. The number of Typhoons will fall to 107 as the older aircraft in the fleet are taken out of service by 2019. Deciding what the combined size of the two future fast jet fleets should be will require the Department to make difficult judgements on the balance between affordability and the operational risk it is prepared to accept. As this report highlights, such decisions are complicated by the number of factors influencing the delivery of fast jet capability. We plan to examine these strategic considerations in a future study.

Cost control

Costs have increased significantly

9 The development costs of Typhoon have more than doubled to £6.7 billion from the original approval in 1987. These costs are fixed regardless of the number of aircraft the Department buys. The production cost of Typhoon is £13.5 billion, which is within the original approval from 1996. However, the Department is buying 72 (30 per cent) fewer aircraft than it originally planned when the investment decision was made, reducing numbers of aircraft bought from 232 to 160. If the development and production costs are taken into account, the unit cost of each aircraft ordered has risen by 75 per cent. Since 2005, control on the parts of the project where the Department has entered into contractual commitments has improved with costs stable. The development and installation of progressively enhanced capability across the project is delivering a more capable aircraft than originally envisaged, and as a result, the Department is confident that it will meet required military tasks with fewer aircraft.

Key investment decisions were made on the basis of over-optimistic cost estimates

10 Analysis by our consultants shows that the current unit production costs (excluding the costs of the collaborative development phase) for the aircraft are similar to comparable types of aircraft. Part of the cost increase on the project can be explained by the fact that the production phase of the project started on an unrealistic basis. The balance between costs, numbers of equipments and the importance of the operational capability to be provided are important factors when the Department decides whether a project offers sufficient value for it to invest in. Not having a realistic understanding of any of these factors can adversely affect the perceived value of the project.

The collaborative arrangements and complexity of the technology have increased costs

11 Out of the £3.5 billion cost increase, £2.2 billion is due largely to the inefficient collaborative commercial and managerial arrangements, obligations to international partners and the complexity of the technologies being developed, a challenge compounded by the rigid collaborative workshare requirements. The Department did not anticipate the potential of these arrangements to drive additional cost into the project. A further £332 million of the cost increase reflects necessary steps to evolve the capability of the aircraft in the face of the changing operational needs. The remaining £1 billion largely reflects cost of capital charges mainly incurred due to delays in the project. Where the Department has contracts in place, cost control has improved in recent years.

The Department's understanding of future Typhoon costs drivers is improving

12 The Department now has a better grasp of the costs of the Typhoon project. By the time the aircraft goes out of service, on current plans, the Department estimates that it is likely to spend some £37 billion on the capability, although £2.6 billion of this has not yet gone through the Department's approval process and so is open to change.

13 The Strategic Defence and Security Review decisions to retire the Harrier aircraft and reduce the size of the Tornado fleet mean there will be less work for industry. There is a risk that the costs of under-utilised industry assets will be passed on to the Department on its remaining contracts – notably Typhoon. The Department is alert to the risk and has developed better financial and performance information than it has often had in the past to underpin its negotiations with industry.

Living within the support cost budget will be challenging

14 While the cost of supporting the aircraft has remained the same in overall terms, it has increased per aircraft. Funding was approved on the basis of immature estimates before there was any experience of operating the aircraft. The original approval did not include costs such as those for major maintenance and obsolescence which the Department estimates will cost £900 million. The Department is confident that it can deliver the full range of support for the reduced number of aircraft within the originally approved figure of £13.1 billion. The number of aircraft being bought has fallen by a third and compared on a like for like basis the unit cost of support per aircraft has risen by approximately a third. Risks remain as the aircraft will be in service for another 20 years and it is unsurprising that 84 per cent of forecast support costs are not yet on contract. The proportion of the commitments still to be entered into highlights the importance of the Department generating robust data upon which to make future investment decisions and negotiate with its international partners and industry.

Governance and decision-making

Collaborative decision-making is inefficient

15 The main aim of collaboration was to reduce the cost to each partner nation in designing, producing and supporting a highly complex and technologically advanced new aircraft. While there have been some successes in achieving these aims, the objectives of the partner nations on the project are not fully aligned and decision-making is slow, for example, key decisions require consensus from all four partner nations. It has taken up to seven years to agree and deliver some key upgrades. The problems pose a particular risk to the United Kingdom because the RAF is flying more hours in its Typhoons than the other partner nations and the RAF is more likely to use the full multi-role capability in the future. The track record of the procurement phase of the project suggests that, unless partner nations find new ways to work together, the collaborative arrangements present serious challenges if the Department is to upgrade and support the aircraft quickly and cost-effectively.

The Department's decision-making structures are operating well but risks remain as accountability, budgetary and managerial authority are not aligned

16 The Department has appointed a Senior Responsible Owner for Typhoon who chairs a Programme Board which brings together those responsible for delivering all the components of capability that must be in place if Typhoon is to operate effectively. These components are training, equipment, personnel, infrastructure, doctrine and concepts, organisation, information and logistics. While the introduction of the Programme Board is a step forward, there remain risks to effective cost control and decision-making. Budgetary and managerial responsibility is split between different parts of the Department. The Senior Responsible Owner is accountable but can only influence these groups and cannot compel them to take action or to make cost or performance trade-offs between components. Nor does the Senior Responsible Owner attend key meetings making strategic decisions, such as those related to exports, which affect the delivery of Typhoon operational capability.

Conclusion on value for money

17 The Department has not yet secured value for money from its investment in Typhoon. The aircraft are fulfilling some key defence tasks but is unlikely to become the aircraft of choice for most ground attack missions for some years. Key investment decisions were taken on an over-optimistic basis, the project has been adversely affected by corporate decisions to try to balance the defence budget and costs have risen substantially and at a rate the Department did not predict. None of these factors suggest good cost control, a key determinant of value for money. Where there are contracts in place, costs have been stable in recent years.

18 There is the opportunity to secure increased value for money in future. The Department has successfully put some of the building blocks in place to enable this. But there is more to do to improve the collaborative support arrangements, develop a timely and cost-effective way of upgrading the aircraft and to ensure greater certainty over national cash flows to enable sensible long-term planning. The measure of success will be that the full multi-role capability can be deployed and supported affordably and when required.

Recommendations

19 Procuring and supporting expensive defence equipments jointly with other nations is a sensible way to reduce costs in a time of constrained budgets. But such agreements will only deliver the benefits if management and decision-making arrangements are timely and cost-effective. On Typhoon, the Department and its partners set up arrangements which did not meet these criteria. To support the establishment of future collaborative projects and to inform its attempts to reform the Typhoon arrangements, the Department should build on the analysis in our report and undertake a more comprehensive analysis looking across its portfolio of collaborative projects to understand what has worked and the effect of shortcomings with existing collaborative arrangements.

20 The Department is making progress generating better financial data to support decisions. However, the reporting of key performance data is more patchy, particularly for flying hours achieved. The Department should determine exactly why flying hours are falling short even though aircraft are available and establish meaningful metrics to enable the Board to instigate corrective actions including exploring options to incentivise industry to take a broader role in addressing the underlying causes.

21 Typhoon investment decisions were made using over-optimistic and immature cost data. The Department should use the current learning phase of its national support contracts to generate robust cost and performance data to build cost models before it approves and contracts the next phase of support.

22 Governance arrangements on the project follow the Department's standard approach and the introduction of a Programme Board is a step forward. But the Department needs to better empower those charged with delivery to enable more timely and cost-effective decision-making. In particular it should:

- simplify decision-making and improve the Department's ability to respond to changing needs in an agile way by clarifying the respective roles of the project sponsor and the Senior Responsible Owner so that each has sufficient managerial and budgetary authority to decide investment priorities within a set budget and across all of the components of capability within their area of responsibility; and
- increase the tenure of officials in key posts to ensure they see through the implementation of their decisions.

23 Typhoon has been successfully exported to two countries, and industry, with the support of government, is seeking further opportunities. To help effective decision-making, exports need to be considered as an integral element of each project from the outset, a ninth component of capability. Doing so would require closer consultation with industry and other parts of government to make sure the benefits and potential downsides of decisions are clearly understood and the project managed to maximise returns.

Part One

The capability Typhoon provides

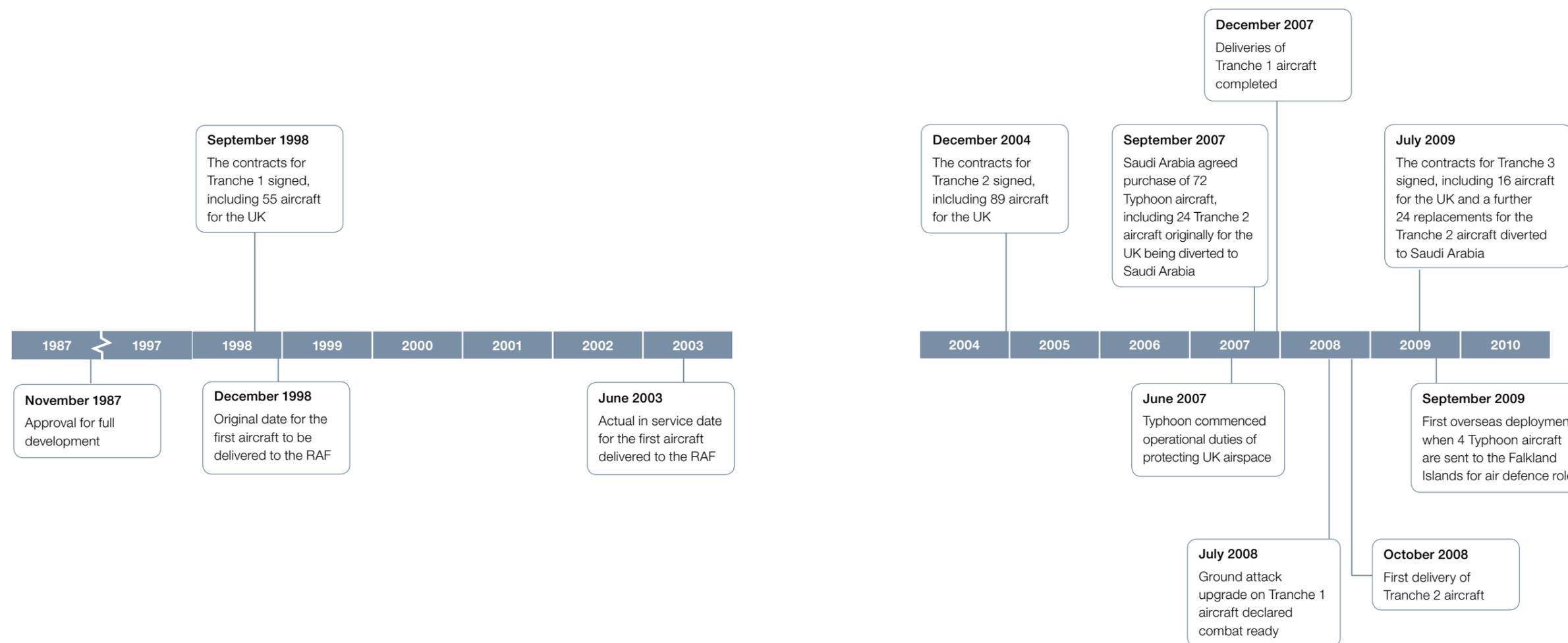
1.1 Typhoon is a twin engine, single seat fighter aircraft that can perform both air-to-air and ground attack missions. This multi-role capability will be further enhanced by planned upgrades and integration of new weapons to make it swing-role – which means Typhoon will have the flexibility to switch between missions while still in the air and so respond to changing operational demands. As **Figure 1** overleaf and Figure 3 on page 15 show, the Department is procuring 160 aircraft in three phases, or tranches, the first one entered service in 2003 and the last is expected in 2015. This part of our Report examines how the Department is progressively enhancing the capability of the Typhoons it has in operational use and how it is managing the other components of capability to ensure it can make full and timely use of the aircraft as they are delivered.

How Typhoon will be used

Typhoon is performing important operational tasks

1.2 Typhoon was conceived in the 1980s during the Cold War as a collaborative project with Germany, Italy and Spain. Primarily intended to operate as an air-to-air fighter, around 70 Typhoons are already in service, as at December 2010, and are mainly used for this role, protecting the air space around the United Kingdom and the Falkland Islands. As **Figure 2** on page 14 shows, sufficient Typhoons are now routinely available to meet these tasks and undertake the required pilot training. Our consultants assessed the relative quality of the current Typhoon aircraft compared to other air-to-air combat aircraft. Their analysis shows that Typhoon compares well with its peers in its air defence roles.

Figure 1
Timeline showing key events of Typhoon procurement and delivery



NOTES

- 1 The forecasted in service date of December 1998 for the aircraft to be first delivered to the RAF was revised a number of times since 1987, with the key revisions occurring in 1993 (to August 2000), in 1994 (to December 2000), in 1995 (to December 2001) and in 1998 (to June 2002) before it was actually delivered in June 2003.
- 2 Actual deliveries will be 53 Tranche 1, 91 Tranche 2 and 40 Tranche 3 aircraft, with 24 of the Tranche 2 aircraft being diverted to Saudi Arabia. A total of 160 aircraft will therefore be procured by the United Kingdom.

Source: National Audit Office analysis

Figure 2

Aircraft available to squadrons against requirement



NOTES

- 1 Achieved aircraft is adjusted performance taking account of factors outside contractors' control.
- 2 The number of aircraft available to squadrons does not include any aircraft being maintained and repaired by industry hence is lower than the total number of aircraft in service.

Source: National Audit Office analysis of Ministry of Defence data

The full multi-role capability will not be available for some years

1.3 Since the Typhoon project began, the operational environment has changed significantly. **Figure 3** shows how the Department is planning to progressively enhance the multi-role capability of the aircraft. For example, from 2012, Tranche 2 aircraft will be adapted to enable them to carry laser guided Paveway IV bombs and, further in the future, there are plans to develop a new radar.

Figure 3

Delivery and progressive enhancement of the capability of each Tranche

Tranche	Number of Aircraft	First delivery date	Baseline capability at production	Additional capability upgrades
Tranche 1	53	June 2003	Air-to-Air	Integration of laser guided Paveway II bombs and laser designator pod for ground attack capability
Tranche 2	67	October 2008	Air-to-Air with upgraded avionics	<p>Stage 1: Integration of further weapons such as the laser guided Paveway IV bombs along with laser designator pod for ground attack capability. Also a new pilot interface for multi-role operations (delivery from 2012)</p> <p>Stage 2: Further weapons integration including Storm Shadow cruise missiles (not yet approved, but planned delivery is 2018)</p> <p>Future: Plans to upgrade radar</p>
Tranche 3	40	2013	As Tranche 2 baseline, but with the multi-role upgrade already included	As Tranche 2
Total	160			

NOTE

¹ For Tranche 2, the United Kingdom will have 91 aircraft delivered, but 24 are being diverted to Saudi Arabia as part of the export deal for 72 Typhoons. The United Kingdom is purchasing these 24 under Tranche 3 instead.

Source: National Audit Office analysis of Ministry of Defence data

1.4 In 2004, the Department decided to withdraw its Jaguar aircraft. In the same year, it decided to spend £119 million to upgrade its early Typhoons to replace the Jaguar ground attack capability. The upgrade was successfully introduced in July 2008. In 2009, a corporate decision was taken to retire early the other air defence fighter, the Tornado F3, to save money. As a result, Typhoon aircraft have been prioritised to take over the air defence role that the Tornado F3 fulfilled. The Department can currently deploy a small number of Typhoon multi-role aircraft but in the majority of cases, such as Afghanistan, the Tornado GR4 remains the Department's preferred ground attack aircraft. The Department has spent an estimated £48 million on urgent upgrades on the Tornado GR4 specifically to enable it to conduct its role in Afghanistan from June 2009. Newer Typhoon aircraft will have progressively enhanced multi-role capability with, for example, laser guided Paveway IV bombs and Storm Shadow cruise missiles by 2018. By this time Typhoon is likely to be the aircraft of choice for both ground attack and air defence.

1.5 All four of the partner nations are contractually committed to the first stage of upgrading Tranche 2 aircraft.¹ The forecast cost to the United Kingdom of the upgrade is £445 million (excluding the cost of the new weapons) and it is scheduled to be delivered in 2012. The October 2010 Strategic Defence and Security Review² underlined how Typhoon is a core of the RAF's combat aircraft capability and emphasised the Government's commitment to develop Typhoon into a fully multi-role aircraft which can conduct both air-to-air and ground attack missions.

Making the best use of Typhoon capability

1.6 For the Department to make the best use of the Typhoon aircraft it is buying, it must progress all eight components of capability (known as Defence Lines of Development) in a coherent manner. These components are training, equipment, personnel, infrastructure, doctrine and concepts, organisation, information and logistics. Overseeing this is the job of the Programme Board (see paragraphs 3.10 – 3.11). We assessed the status of each of the components to understand both the effect of problems on the delivery of current capability and risks to the timely delivery of future capability. Given that the aircraft is still being introduced into service and experience of its operation is growing, it is unsurprising that we identified risks against six of the components: equipment, logistics, information, infrastructure, training and personnel (**Figure 4**). In the majority of cases the Department has plans to manage the risks, although in some, such as the provision of spares under the collaborative arrangements, the Department is reliant on others outside of the Ministry of Defence if it is to address the risks successfully.

¹ All nations have also agreed in principle to a second stage of upgrades, but these are currently at a very early stage of concept.

² HM Government: *Securing Britain in an Age of Uncertainty: The Strategic Defence and Security Review*, CM 7948, October 2010.

Figure 4
Risk rating for component of capability

Component	Rating	Reason for rating
Equipment		<p>The Major Projects Report 2010 shows aircraft development and manufacture costs are forecast as £3.5 billion higher than the original approved forecast cost (paragraph 2.2)</p> <p>Analysis by our consultants demonstrates that the amount that the Department is paying for Typhoon is in line with that expected for similar kinds of aircraft</p>
Logistics		National support arrangements are working well, but there are problems with the timely supply of spares and repair of equipment under the collaborative support contracts (paragraph 1.7 below) which are contributing to the RAF failing to achieve its flying hours
Training		<p>Limited flying hours may affect the RAF's ability to maintain pilots' currency, as explained further in paragraphs 1.9–1.11 below</p> <p>The synthetic training device will not be available at RAF Leuchars until approximately 2013-14 at the earliest although this has been mitigated by using a simulator of a lesser capability</p>
Personnel		There are shortfalls in ground crew, with the Typhoon squadrons up to 6 per cent below planned levels in some specialisms compared to only 1 per cent across the RAF as a whole. The numbers of experienced ground crew within those available is also an issue
Infrastructure		Overall performance is good with minor issues mainly relating to the second operating base at Leuchars. Minimum infrastructure was provided because the timescale for delivery was short (approximately two years) and some mitigations are still in place. Furthermore funding for the building for synthetic simulators has still not been approved
Information		Problems generating and validating specific mission data. System upgrades to match aircraft development not yet contracted
Organisation		No indication of issues
Doctrine and Concepts		No indication of issues

Source: National Audit Office analysis of Ministry of Defence data

There have been problems with spares availability

1.7 Some elements of aircraft support, such as the supply of spares and repair of equipment, are done within the collaborative arrangements and agreed by all partner nations through a complicated suite of 11 contracts (soon reducing to three new support contracts, see paragraph 3.8). There are indications that performance needs improving. For example:

- In 2008, the Department placed an order for spares to support the deployment of Typhoon to the Falkland Islands in September 2009. By August 2010, 70 per cent of the spares ordered had been delivered when required, 18 per cent were delivered late and 12 per cent were outstanding. The Department has been forced to take parts from other aircraft to make up the shortfalls. The spares procurement contract does not include penalties for late delivery.
- An international equipment repair contract was placed in 2009 and includes provisions for guaranteed repair times for 65 critical items for failures in specified ways. The guaranteed repair times range from 30 to 120 days, depending upon the item. Nearly half of the items the United Kingdom has submitted for repair to date did not meet the criteria for them to be repaired within the guaranteed times. In addition, only 71 per cent of items which met the conditions were actually repaired within the agreed timescale. Industry has committed to reducing the repair times for 36 of the 65 items. We estimate that if these revised targets are met, repair times may be reduced by a third by 2013.

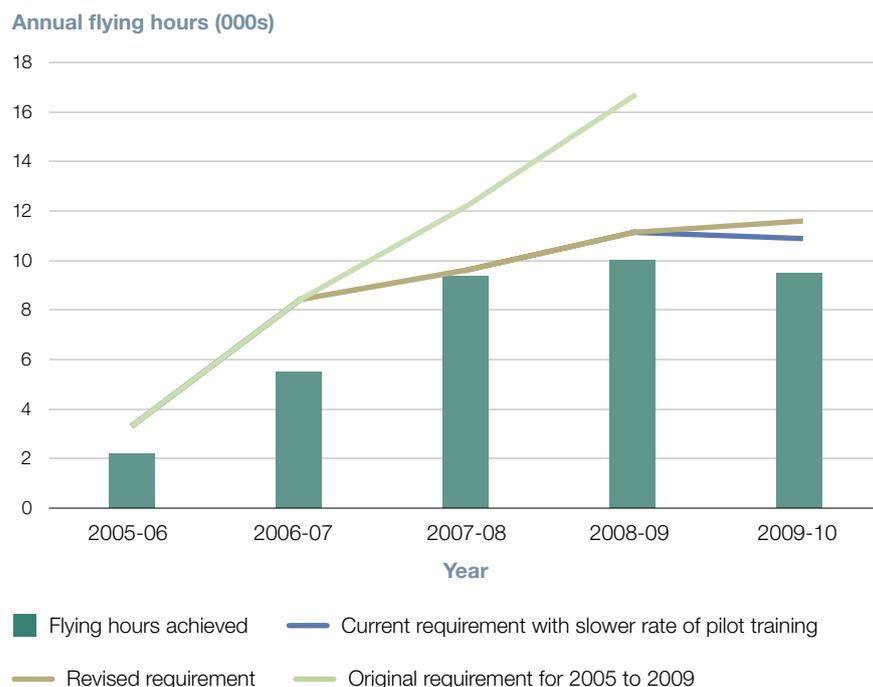
1.8 In parallel, each nation also has individual contracts to support and maintain the aircraft and these are independent of the other three partner nations. The Department has built on its experience introducing innovative commercial support arrangements for its Tornado and Harrier fleet and placed contracts for the support and maintenance of the aircraft with BAE Systems and Rolls-Royce in 2009. These are outside of the collaborative arrangements. The contract with BAE Systems requires the company to provide maintenance and support services to deliver a set number of aircraft to the RAF and, up to the end of September 2010, performance targets are largely being achieved. The contract with Rolls-Royce for engine support also includes the supply of engine spares, unlike aircraft spares which are supplied through the collaborative arrangements. To the end of October 2010, the company is largely meeting the performance targets.

Shortfalls in flying hours must be addressed if Typhoon capability is to be fully used

1.9 The RAF specifies an annual number of aircraft flying hours which it requires to fulfil operational tasks and for training and development purposes, most notably to ensure it has sufficient pilots with the full range of required competencies to operate the aircraft now and in the future. In 2009, the Department slowed down the pace with which it planned to introduce new Typhoon squadrons to cut costs. As a result, it reduced the requirement for flying hours by a total of 21,100 hours over the seven years to 2015-16 (including 700 hours in 2009-10). In response to fewer hours being available for pilot training, the Department has prioritised pilot training on air defence roles which is currently its key task.

1.10 As **Figure 5** shows, the Department has consistently failed to meet the specified targets for annual flying hours, despite reducing its targets. Problems with the timely supply of spares and repair of equipment under the collaborative support contracts have been a contributing factor to this failure, with the number of flying hours achieved in 2009-10 being 13 per cent lower than the RAF's requirement for training and operational needs. The Department has several workstreams in place to deal with the causes of reduced flying hours. Shortfalls in the number of hours available for training reduce the range of flying competencies of pilots and increases flying risks. In 2010, the RAF temporarily grounded five pilots as a result.

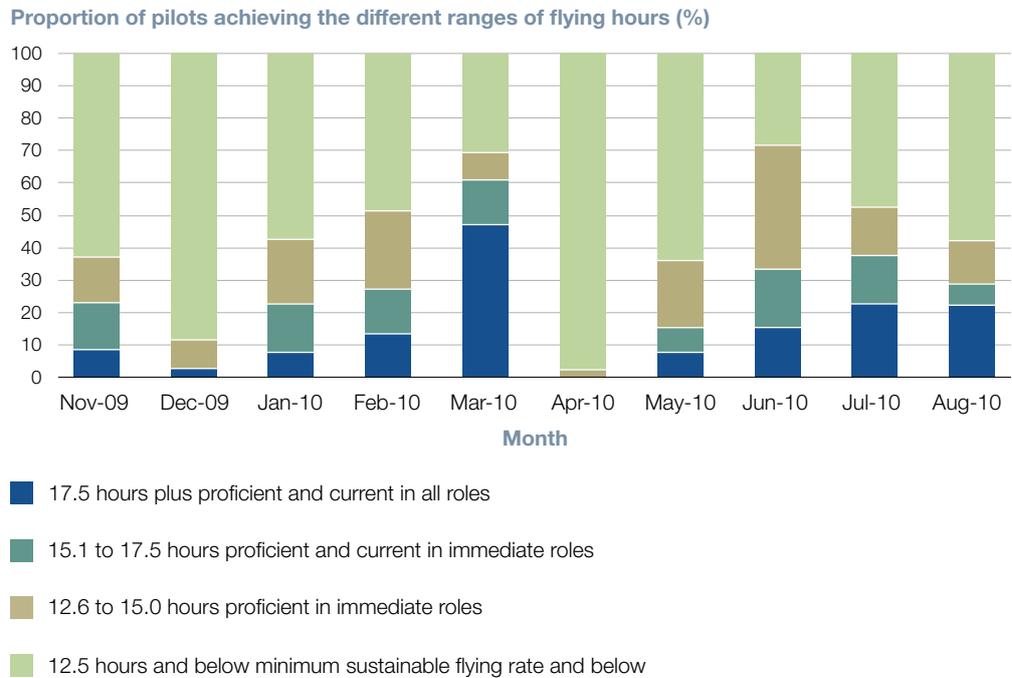
Figure 5
Annual flying hours achieved against the RAF requirement



Source: National Audit Office analysis of Ministry of Defence data

1.11 Between November 2009 and August 2010, on average 15 per cent of pilots had the levels of training to be able to perform more complex tasks such as ground attack (Figure 6). As a result, the RAF currently has eight pilots who are capable of undertaking ground attack missions on Typhoon. Whilst this is sufficient at present, it will not be so in future. The number of flying hours required is likely to increase as the Department’s Business Plan 2011-15 set out its intent to accelerate the growth of RAF squadrons that fly Typhoon.³ The Department plans to have sufficient numbers of trained pilots to conduct a small scale ground attack mission by 2014 and aims to deliver sufficient flying hours to train enough pilots to undertake the full range of planned tasks by 2016.

Figure 6
Monthly training flying hours being achieved by RAF pilots



NOTES

- 1 The hours required are based on an ‘average’ pilot. More experienced pilots may require fewer hours of training to be proficient in various roles. Therefore these requirements act as a guide and are not fixed targets that have to be achieved by a pilot each month. Other factors such as experience will also be used in determining what role a pilot can undertake.
- 2 The drop in flying hours by all pilots in April 2010 is due to the volcanic ash cloud.

Source: National Audit Office analysis of Ministry of Defence data

3 Ministry of Defence: *Ministry of Defence Business Plan 2011-2015*, November 2010.

The role of Typhoon in the future fast jet fleet

1.12 The Strategic Defence and Security Review stated that “our fast jet fleet will be made up of two modern and highly capable multi-role combat aircraft, Typhoon and Joint Strike Fighter. This combination will provide the flexibility and strike power to deal with a variety of new and existing threats, while also radically improving cost-effectiveness and efficiency.”⁴ The Department has not yet decided how many fast jets the RAF will finally operate, however the announcement marks a continuation of the trend which has seen the number of fast jet squadrons reduce to 12 in 2010. This number will fall to eight squadrons as the Harrier aircraft is retired and the number of Tornado aircraft reduced. The Department is also planning to retire its 53 oldest Typhoons by 2019 and subsequently operate a fleet of 107 aircraft until their retirement in 2030. The current known changes to the fast jet fleet are shown in **Figure 7** overleaf, with the Department not yet announcing the number of Joint Strike Fighters it expects to purchase.

Delivering sufficient fast jet capability in the future will require the Department to make tough choices

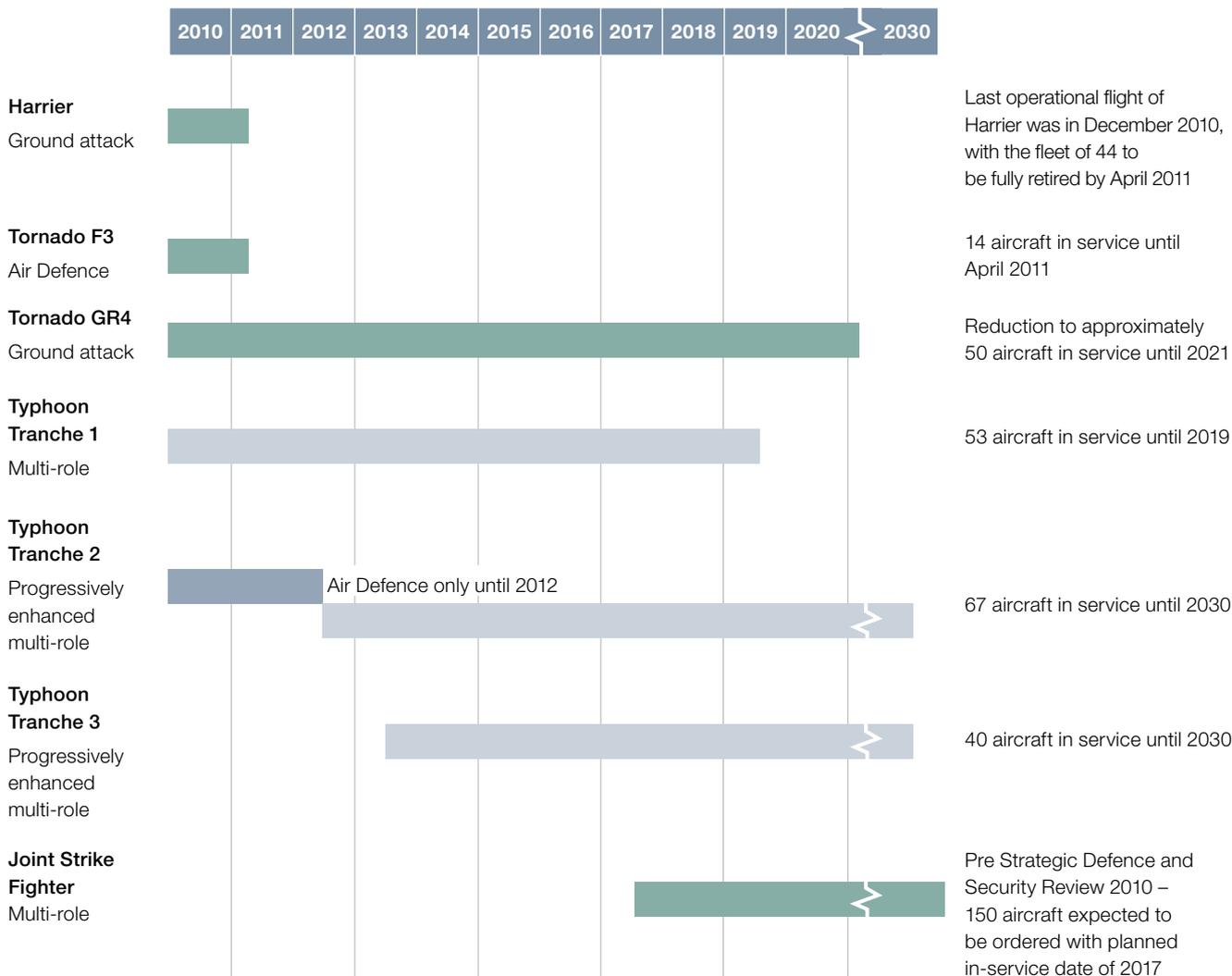
1.13 Deciding what the minimum combined size of the two future fast jet fleets should be to enable the RAF to generate the minimum sustainable capability needed will require the Department to take difficult judgements on the balance between affordability and the operational risk it is prepared to accept. The Department has already had to take such judgements on Typhoon, where it has ordered a total of 160 aircraft against the 232 it originally signed up to buy due to affordability and changing defence requirements for the capability Typhoon provides. The Department has acknowledged that there is risk that the eventual fleet size of 107 Typhoons could result in shortfalls against mandated capability levels. The Department has begun work to see how it can use Typhoons more effectively including reducing the proportion of the fleet undergoing maintenance at any one time to minimise this risk.

1.14 As this report highlights, such decisions are complicated by the number of factors influencing the delivery of fast jet capability. Considerations range across all of the eight components of capability, for example, the balance between simulator training and aircraft flying hours. Finding cost-effective ways to maximise the utility and value of its reduced number of assets will require the Department to innovate in design, support and operations. We plan to examine these strategic considerations in a future study.

4 HM Government: *Securing Britain in an Age of Uncertainty: The Strategic Defence and Security Review*, CM 7948, October 2010.

Figure 7

Timeline of combat aircraft in service with the RAF and Royal Navy



NOTES

- 1 Typhoon fleet numbers are based on the number expected to be delivered and so are the maximum number of aircraft that would be in service after delivery has been completed.
- 2 The number of Joint Strike Fighter expected to be ordered by the United Kingdom and their planned in-service date is based on Departmental assumptions prior to the 2010 Strategic Defence and Security Review. The review has changed these assumptions as the United Kingdom will now purchase a different model of the Joint Strike Fighter and that fewer aircraft will be ordered than the planned 150, but no further details have been announced to date.
- 3 The Tornado GR4 fleet is planned to remain in service until 2021 and the fleet number has been estimated based on the reduction in fleet size announced in the 2010 Strategic Defence and Security Review.

Source: National Audit Office analysis of Ministry of Defence documents

Part Two

Cost control

2.1 Robust cost data underpins good decision-making, planning, performance management and the evaluation of long-term investments. This part of our Report examines why the Department has found it difficult to control project costs on the project in the past and whether it is now better positioned to manage costs and make well informed decisions going forward.

The track record of cost control on the project

Costs have increased significantly

2.2 One of the most straightforward ways of analysing cost control on a project is to consider the cost of each unit being procured as this illustrates the impact of both variations in overall development and production costs and of changing the number of items being procured. For Typhoon, the 2010 Major Projects Report⁵ records the forecast development and production cost of Typhoon as £20.2 billion⁶ (20 per cent higher than the original approved limit made in 1996) although the Department will be buying 72 (30 per cent) fewer aircraft. This equates to an increase in the unit cost of each aircraft ordered of 75 per cent.⁷

2.3 The development and installation of progressively enhanced capability across the project is delivering a more capable aircraft than originally envisaged, and as a result, the Department is confident that it will meet required military tasks with fewer aircraft.

⁵ Comptroller and Auditor General, *Ministry of Defence: Major Projects Report 2010*, Session 2010-11, HC 489, National Audit Office, October 2010.

⁶ Development costs are currently estimated at £6.7 billion (107 per cent higher than the £3.2 billion originally approved) and production costs estimated at £13.5 billion (which is within the original approval level of £13.5 billion made in 1996).

⁷ The unit production cost reported by the Department in the annual Major Projects Report of £73.2 million only includes production costs and so does not include development costs or non-cash costs such as cost of capital.

Key investment decisions were made on the basis of over-optimistic cost estimates

2.4 The cost increases reflect shortcomings in the quality of the cost data upon which the Department made key investment decisions, notably the production commitment for 232 aircraft which the Department made in 1996. Our consultants used Historical Cost Trend Analysis⁸ to assess whether the Typhoon production cost (excluding the cost of development) is in line with what might be expected for such complex aircraft. Their analysis showed that current unit production costs are similar to comparable types of aircraft and that the current cost of the production element of the Typhoon project is realistic. The original cost estimates which informed this decision were therefore over-optimistic and part of the cost increase on the project can be explained by the fact that the production phase of the project started on an unrealistic cost basis. Not having a realistic understanding of the cost of a project can adversely affect the investment decision by the Department particularly as it seeks to balance affordability with operational requirements.

The collaborative arrangements and complexity of technology have increased costs

2.5 Our 1995 report⁹ on the progress of the Typhoon procurement identified the inefficient commercial and managerial arrangements on the project as the root cause of much of the cost escalation and schedule slippage on the project. As Part Three of this report shows, this analysis remains valid today with the 2010 Major Projects Report attributing 22 months of slippage over several years to its in-service date to problems with the collaborative arrangements. The remaining 32 months reflect the complexity of the technologies being developed, a challenge compounded by the rigid workshare requirements.

2.6 Along with obligations to international partners, these factors have driven a £2.2 billion cash cost increase into the development and procurement phases, nearly two-thirds of the total £3.5 billion cost increase forecasted for the project. Given the close linkages between the different causes it is not possible to attribute precise cost increases to each. However, it is clear from our previous report that the Department did not anticipate the potential of these arrangements to drive additional cost into the project despite being one of the larger investors in the project (see paragraph 3.2). A further £1 billion largely reflects cost of capital charges mainly incurred due to delays in the project.

2.7 The Department has sensibly sought to evolve the capability of the aircraft in the face of major changes in operational needs which have arisen during its procurement. The Major Projects Report records the remaining £332 million of cost increases out of the total £3.5 billion, as reflecting changes to the equipment, weapons and sensors to be fitted on the aircraft when they are built. In addition to these costs, the Department is spending a further £445 million on upgrades currently and estimates it may spend up to a total of £2.6 billion on future upgrades to the aircraft until it retires in 20 years time. Where the Department has contracts in place, cost control has improved in recent years.

⁸ This technique uses historical outturn data to generate cost trends for specific types of equipment, which allows an estimate to be compared with the trend in cost of similar past projects.

⁹ Comptroller and Auditor General, *Ministry of Defence: Eurofighter 2000*, Session 1994-95, HC 724, National Audit Office, August 1995.

2.8 Looking ahead, the Department may spend between £300 million and £350 million on managing obsolescence issues¹⁰ on the aircraft while in service, as part of its expenditure on support. This is a reflection of the lengthy timescales of the life of the aircraft from genesis in the mid 1980s to planned retirement from service in 2030.

The Department's understanding of the cost drivers of delivering Typhoon capability

The Department now has a better grasp of costs of all elements of capability

2.9 The Department now has a better grasp of the costs of the Typhoon project covering all of the components of capability. **Figure 8** overleaf shows that by the time Typhoon goes out of service in approximately 2030, on current plans, the Department estimates that it is likely to spend some £37 billion on the capability. Of this, £2.6 billion has not yet gone through the Department's approval process and therefore is open to change. Sixty per cent of the £37 billion is expected to be incurred procuring and upgrading the aircraft with the remainder on support and enabling activities.

2.10 The data is not yet complete as the Department does not forecast all costs across the full life of Typhoon, for example, project team costs (£15.2 million in 2009-10) or infrastructure maintenance and utility costs (estimated as £2.3 million in 2009-10 for buildings used by Typhoon only). There is also difficulty in determining the full cost of infrastructure maintenance and utility as Typhoon is not the only consumer of these items at the stations at which it is based. However, these are relatively minor omissions and the Department is planning to make better use of the data it holds to inform decisions, such as whether to reduce flying hours and invest more in simulators.

The Department has a good understanding of industry rationalisation costs

2.11 The Department is starting to generate more robust financial analyses to underpin its negotiations with industry. For example, prices on Typhoon contracts are negotiated with United Kingdom industry on a non-competitive basis under longstanding agreements which enable industry to recover agreed overhead costs. The Strategic Defence and Security Review¹¹ accelerated the retirement of Harrier to April 2011¹² and committed to reduce the Tornado fleet by half by 2015 with consequent reductions on work placed with industry. Unless industry is incentivised to restructure to manage this reduced workflow there is a risk that, under the existing arrangements, the costs of under-utilised industry assets will be re-charged to the Department on its remaining contracts – notably Typhoon.

¹⁰ Maintaining the supply of components given changes in technology and suppliers over the life of the aircraft.

¹¹ HM Government: *Securing Britain in an Age of Uncertainty: The Strategic Defence and Security Review*, CM 7948, October 2010.

¹² The Harrier's last operational flight was December 2010.

Figure 8
Estimated cost of Typhoon

Cost Component	Costs			Approved or Unapproved
	Incurring to end of 2009-10 (£m)	Remaining forecasted costs (£m)	Total (£m)	
Equipment (assessment, development, production and upgrade costs)	14,801	8,149	22,950	£20.7 billion approved, £2.2 billion unapproved
Logistics (aircraft and engine support and RAF fuel and consumables)	2,497	9,069	11,566	Approved – See Note 1
Personnel (RAF air and ground crew)	194	1,295	1,489	Approved – See Note 1
Training (fuel and consumables and synthetic training devices)	327	506	833	£457 million approved, £376 million unapproved – See Note 1
Infrastructure (development and refurbishment of buildings used solely by Typhoon at the two bases it operates from)	66	72	138	£75 million approved, £63 million unapproved – See Note 1
Information (Information Systems)	170	285	455	Approved – See Note 1
Organisation		Costs absorbed within other components		
Concepts and Doctrine		Minimal costs		
Total estimate of all components	18,054	19,376	37,430	

NOTES

- 1 The Department approved a total of £13.1 billion to cover support costs in 1999, which includes not only logistics, but also personnel, information systems, some training and some infrastructure. The costs of these non-logistics elements are currently forecast to be £2.2 billion. Where costs are not included within this £13.1 billion, such as the synthetic training devices and some of the capital works, additional funding has or will be approved to cover these elements.
- 2 Cost of RAF personnel cover only air and ground crew assigned to the squadrons and aircraft maintenance units. Personnel in other units have not been included as only part of their time would be spent on Typhoon.
- 3 Costs exclude any further purchases of Typhoon (an option that the United Kingdom has retained from Tranche 3 negotiations), the impact of Strategic Defence and Security Review decisions and the impact of changes to industry overheads.

Source: National Audit Office analysis of Ministry of Defence data

2.12 The Department is alert to the risk and has developed good financial and performance information, for example, through analysing trends in specific company unit overheads, mapping future levels of demand and benchmarking industry costs. As part of this work, the Department has forecast that without change, industry's hourly charge of direct labour will increase by 19 per cent by 2014 (against 2010 figures). The Department is therefore better placed than it has been in some previous negotiations as it has a clear strategy underpinned by better quality data to challenge United Kingdom industry to reduce overheads.

Living within the support cost budget will be challenging

2.13 In 1999, the Department approved support funding of £13.1 billion to cover Typhoon to its planned out of service date of 2030. The approval was predominantly for aircraft and engine support, but also included other costs such as information systems and some infrastructure (these costs have been attributed to the relevant component of capability in Figure 8). It excluded costs for items such as major maintenance and obsolescence which the Department estimates will cost £900 million. As the aircraft did not enter service until June 2003 and was not used operationally until June 2007, there has been little actual flying data in existence on which the Department could base its decision. Further estimates in 2004 and 2008 concluded that support could cost up to £16.6 billion. The Department is confident that it can deliver support within the £13.1 billion, including those elements not within the original approval. However, as the number of aircraft has fallen by a third to 160 (albeit more capable aircraft than originally planned), this means that the unit cost of support per aircraft has risen by approximately a third on a like for like basis.

2.14 The extent of the challenge facing the Department in living within its original approval is illustrated by the fact that, given the aircraft will be in service for another 20 years, 84 per cent of forecast support costs are currently not contracted for. While this gives the Department useful flexibility in how it develops its future support arrangements and opportunities to make further savings, thus decreasing costs, costs could increase as well. It highlights the importance of the Department generating robust data upon which to make future investment decisions and negotiate with its international partners and industry.

Part Three

Governance and decision-making

3.1 Even by the standards of defence projects, Typhoon is complicated. There are multiple international and export partners, and complex industrial and commercial structures. In the United Kingdom there are a number of different areas of the Department and other government departments involved in delivering Typhoon. The project is important, not just in terms of providing a vital military capability for the next two decades, but also because it supports broader military, diplomatic and industrial relationships. This part of the Report examines decision-making on the project and the effectiveness of the international collaborative arrangements and United Kingdom governance.

International collaboration

The collaborative arrangements are complex

3.2 The United Kingdom is procuring Typhoon in collaboration with Germany, Italy and Spain and together the four partners are contracted to procure 472 Typhoon aircraft¹³ out of 620 originally agreed on. Of those, the United Kingdom had agreed to order 232 (37 per cent) therefore making it one of the major investors in the project at the time, and even now with a reduced fleet of 160, the Department remains the largest purchaser. As a result, the Department played a central role in establishing the collaborative management structures that still exist today.

3.3 The main aim of collaboration was to reduce the cost to each partner nation in designing, producing and supporting a highly complex and technologically advanced new aircraft. Other aims were to encourage greater military cooperation and to further the development of the industrial aerospace capability of the partner nations. The project has had some success in achieving its aims, with Part One reporting on the capabilities of the aircraft delivered. Analysis by the Ministry of Defence and the Department for Business, Innovation and Skills estimates that the project directly supports 8,600 jobs at companies such as BAE Systems, Rolls-Royce and Selex Galileo (who provide key equipment such as the radar). However, the diverse spread of design, manufacturing and support expertise has increased costs of the aircraft overall and poses risks to the timeliness and affordability of support and upgrade activities. We explored the collaborative arrangements for development in detail in an earlier report.¹⁴ Our analysis in this current report focuses on the risks that the collaborative arrangements pose to the timely and cost-effective upgrade and support of the aircraft.

¹³ Two other nations have also purchased Typhoons to date: Saudi Arabia (72) and Austria (15).

¹⁴ Comptroller and Auditor General, *Ministry of Defence: Eurofighter 2000*, Session 1994-95, HC 724, National Audit Office, August 1995.

Collaborative decision-making is inefficient

3.4 The NATO Eurofighter and Tornado Management Agency coordinates the project on behalf of the partner nations and manages the contractual relationship with industry (**Figure 9**), but decision-making remains with the partner nations. Such decisions, for example, to proceed with upgrades, must be made with the consensus of all nations. Although there is a suggested timescale for decisions to be made of 40 working days, it can be difficult for nations to adhere to this. In some instances, key upgrades to the aircraft's capability have taken up to seven years to agree and deliver (**Figure 10** overleaf).

3.5 One of the reasons for the long timescales is that the partner nations do not use the aircraft in the same way as the United Kingdom, as demonstrated by the significantly higher level of flying achieved by the RAF compared to other nations. For example, in 2008-09, RAF Typhoons flew 10,000 hours compared to fewer than 4,000 hours flown by each of the other three partner nations. The United Kingdom also has a more pressing operational need for early enhancements to the ground attack capability of the aircraft. The differences in use mean partners' priorities do not always coincide and this lack of alignment increases the risks to the timely delivery of the upgrades necessary if the Department is to grow the capability of its Typhoons as planned.

3.6 The economic crisis and the consequent limitations placed on the defence budgets of all four partner nations also pose risks to both the level and timing of funding each can commit to the Typhoon project and to how that funding will be prioritised. Given the poor track record of timely decision-making and delivery on the project these additional economic pressures are likely to exacerbate the existing tensions and place the delivery of the United Kingdom's priority upgrades at risk.

Figure 9
Collaborative arrangements

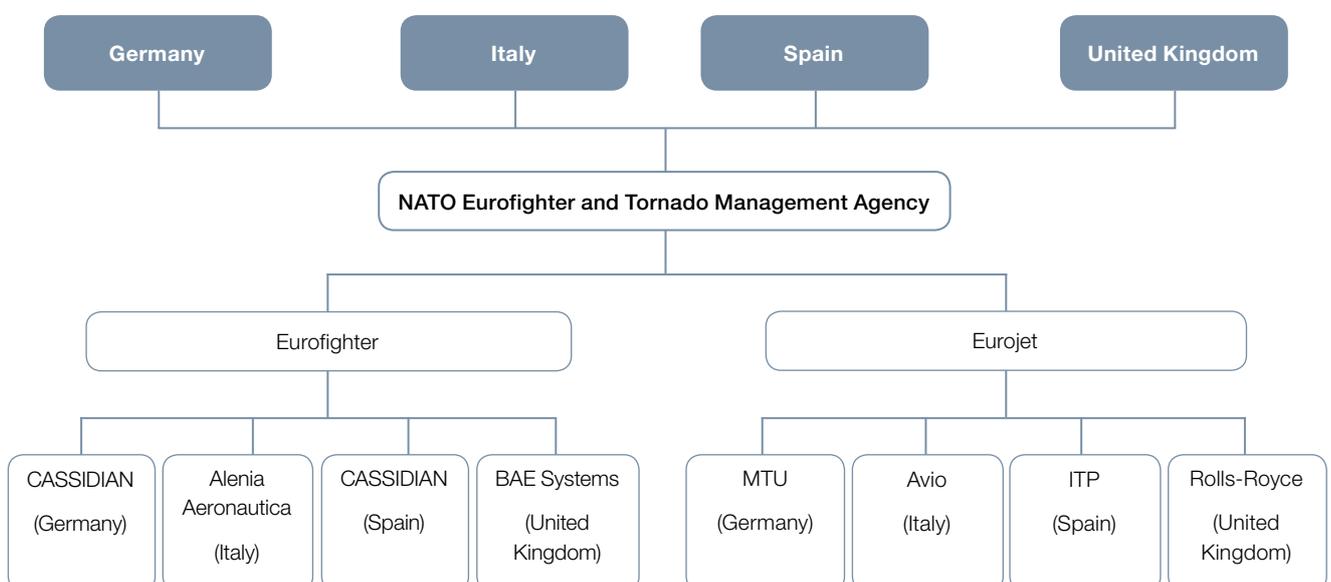


Figure 10

The time taken to agree key ground attack upgrades

Upgrade	Details	First request to industry	Delivery	Forecast cost (£m)
Ground attack capability for Tranche 1 aircraft	United Kingdom-only change All nations had to agree use of test aircraft and equipment	June 2004	Solution declared combat ready by RAF in July 2008	119
Ground attack capability for Tranche 2 aircraft (stage one)	One year for industry to provide acceptable proposal Stage one will be delivered in two phases, with capability of first phase still to be fully defined	April 2005	Forecasted delivery from June 2012	445

NOTE

- 1 The Tranche 1 upgrade cost of £119 million comprises £85 million for integration and £34 million for hardware that can be reused on other aircraft.

Source: National Audit Office analysis of Ministry of Defence data

3.7 The government management arrangements are replicated by industry with the prime contractors from each nation (BAE Systems for the United Kingdom) forming a consortium called Eurofighter Jagdflugzeug GmbH to deliver and support the aircraft (Figure 9). There are similar arrangements for the engine with Rolls-Royce taking the role of United Kingdom prime contractor in the Eurojet Turbo GmbH consortium. The four nations share aircraft production and support work in proportion to the number of aircraft each nation is buying. As a result, the design and production of individual components is spread widely across the four nations and each nation has its own final assembly line for the aircraft.

Evolution of the collaborative arrangements

3.8 The Department is aware of the shortcomings with the existing collaborative structures and is working with partner nations to streamline decision-making and improve the efficiency of industry arrangements to make upgrades and support of the aircraft more cost-effective and agile. The Department's aim is to achieve a 50 per cent reduction in cost and time for future upgrades. There have been some recent improvements in the arrangements:

- Nations have agreed to consolidate the existing international support and upgrade contracts from 12 (of which 11 are for support) to four.
- Planning for future upgrades is also being revised with nations' requirements being developed in smaller increments and to a standard format making it easier for industry to understand the requirement and generate solutions more quickly as part of a rolling upgrade programme.

3.9 In November 2010, NATO announced that it intended to rationalise its agency structure, including the NATO Eurofighter and Tornado Management Agency, to achieve greater synergy between similar functions and maximise efficiency and effectiveness. Until a detailed plan is announced in June 2011 it is unclear whether the changes will help improve the collaborative management of the Typhoon project.

The Department's management of the project

Governance follows the Department's standard approach but is complex

3.10 Governance on the Typhoon project follows the Department's standard approach and is based around the coordinated progression of eight components which together deliver the Typhoon capability: training, equipment, personnel, infrastructure, doctrine and concepts, organisation, information and logistics. Representatives of the component owners sit on a Programme Board, chaired by a Senior Responsible Owner. The Programme Board has now been in place for two years in its current form, although a similar construct has been in place on Typhoon for several years, and there are indications that it is facilitating better debate. For example, component owners identified the risk that late development of the required infrastructure at RAF Leuchars could have adversely impacted on training and acted quickly to install temporary simulators to help mitigate the risk.

3.11 While the introduction of a Programme Board is a step forward, governance arrangements for the delivery of Typhoon capability remain complex. A key issue is that there is no individual who is accountable and clearly in charge of the whole project. As **Figure 11** shows, budgetary and managerial responsibility for the eight components of capability is split between different parts of the Department and the RAF. The Senior Responsible Owner can influence the owners of each of the components of capability but cannot compel them to take action or make cost or performance trade-offs between components.

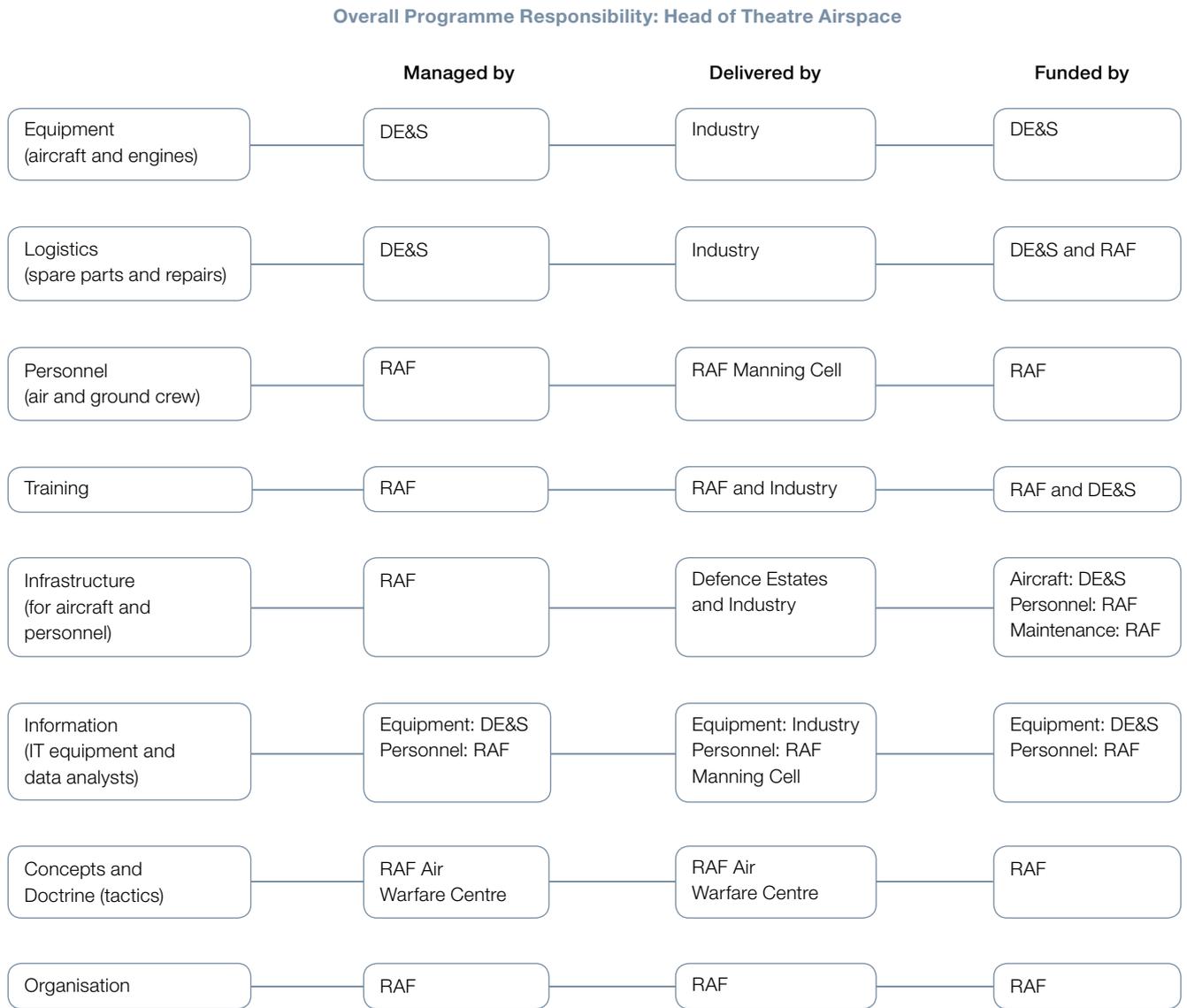
Strategic decisions involving Typhoon can impact on the delivery of capability

3.12 Decisions which have significant influence on the delivery of Typhoon capability, such as agreements with export customers, are taken beyond the Programme Board structure. There have been some examples of tensions between the operational capability decisions taken by the Programme Board and such broader strategic decisions which require a wider perspective not just within the Department but also across other government departments and industry.

3.13 Typhoon has already been successfully exported to Saudi Arabia and Austria and further opportunities are being pursued. The Department is actively seeking to maximise export potential recognising the cost, operational, diplomatic and industrial benefits which they can bring.¹⁵ The Senior Responsible Owner does not attend key meetings of the most senior group of officials within the Department making Typhoon export related decisions, yet export decisions can impact on the project. For example, funding for the Typhoon project was not adjusted to reflect the strategic decision about providing support for pilot training to export customers. The hours diverted to training export customers could keep two RAF pilots fully trained in all roles in 2010-11 and four in 2011-12. Similarly, support for export campaigns, such as flying demonstrations, has to be managed by the Programme Board from existing resources, diverting them from the RAF.

¹⁵ Ministry of Defence, *Equipment, Support and Technology for UK Defence and Security: A Consultation Paper* CM 7989, December 2010.

Figure 11
Typhoon governance arrangements



NOTE

1 DE&S refer to Defence Equipment and Support, the Department's procurement and support agency.

Source: National Audit Office analysis

Appendix One

Methodology

The main elements of our fieldwork, which took place between August and November 2010, were:

Selected Method

Purpose

1 Analysis of performance

We analysed the Department's performance information including contracted performance indicators, aircraft and pilot flying hours, personnel numbers and experience, and spares data.

Identify project performance against requirements and the forecast cost for the development and operation of Typhoon.

2 Analysis of cost information

We assembled the through life cost estimates for the project's eight capability components from Departmental information. We validated estimates against our previous reports on Typhoon, contracts and underlying cost models and assessed the key assumptions such as inflation and risks to achieving these estimates.

Identify forecast cost for the development and operation of Typhoon.

3 Document review and interviews

We reviewed key documents for each capability component, such as delivery plans, investment approvals, risk registers and contracts. We also reviewed meeting papers for the United Kingdom and international project governance structures.

Identify requirements, assumptions and risks for the project, and review the effectiveness of governance arrangements.

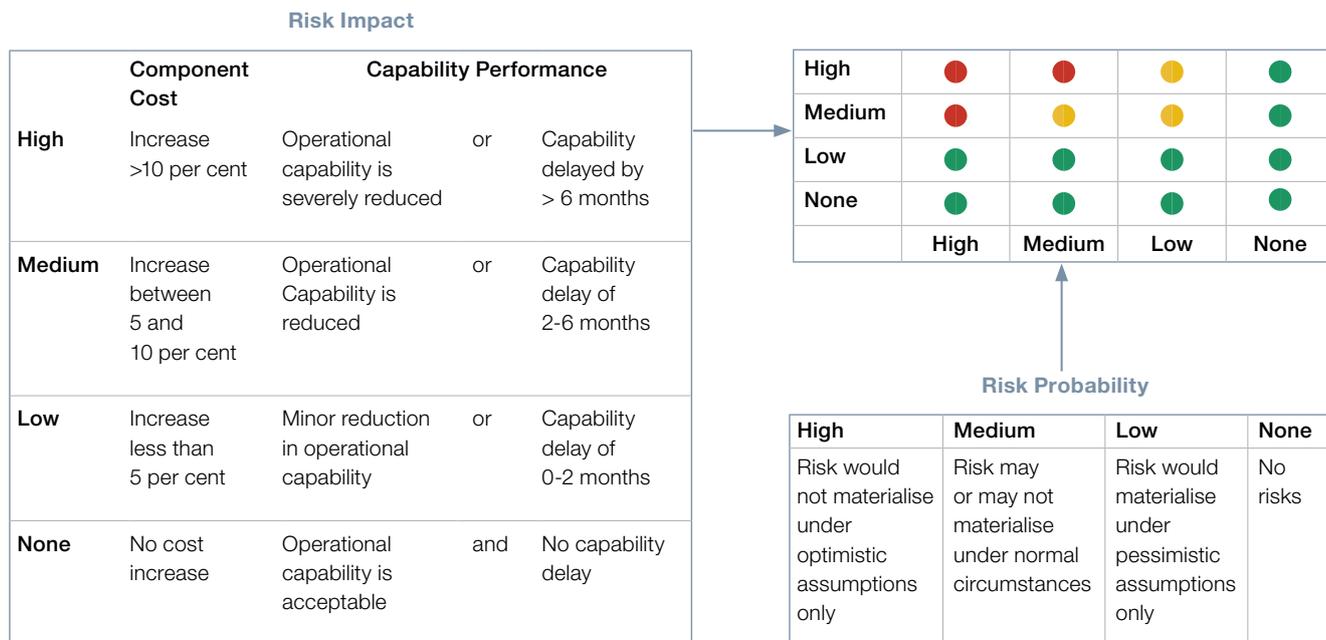
We interviewed project representatives in the Department, its procurement and support agency, the RAF and industry.

4 Evaluation of risks to delivering capability components

We identified the key risks for each capability component and used them to rate the risk of delivery of the component to time and performance and to cost, using the criteria in **Figure 12**.

Evaluate project performance to date and key risks for future delivery.

Figure 12
Criteria for rating risks to the delivery of capability



Source: National Audit Office analysis



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