



National Audit Office

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## **Report**

by the Comptroller  
and Auditor General

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## **Ministry of Defence**

# Delivering Carrier Strike

## Appendices Three to Five

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Ministry of Defence

# Delivering Carrier Strike

## Appendices Three to Five

Report by the Comptroller and Auditor General

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Sir Amyas Morse KCB  
Comptroller and Auditor General  
National Audit Office

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## Appendix Three



### Queen Elizabeth Class carriers

#### Programme description

**1** The UK is buying two new aircraft carriers, HMS Queen Elizabeth and HMS Prince of Wales, the largest warships ever built for the Royal Navy. The carriers will displace 66,600 tonnes and measure 280 metres by 70 metres. They are designed to operate with up to 40 aircraft (fixed and rotary wing). The Ministry of Defence (the Department) plans to deliver the Carrier Strike capability using Lightning II (F-35B) fast-jets. The carriers will (after modification) also provide a base for other types of aircraft. The Department believes that this will offer greater flexibility.

**2** Promoting and maintaining a national shipbuilding industry has been central to the carrier programme. The Aircraft Carrier Alliance (ACA), an alliance between the Department, BAE Systems, Thales UK and Babcock, is building the carriers in Rosyth dockyard. Construction of the blocks that form the hulls of both ships took place at six shipyards around the UK.

**3** The Department originally planned to procure the short take-off and vertical landing (STOVL) variant of the Lightning II jets. These can take off and land on the aircraft carriers unaided. In 2010, the Department decided to procure the carrier variant of the jets, which required the ship to be fitted with launching equipment (catapults) and landing recovery equipment (arrestor gear). On 10 May 2012, the Secretary of State for Defence announced that the Department was reverting to procuring the STOVL variant. We have previously reported on how that decision was made.<sup>1</sup>

#### Performance

**4** The Department renegotiated the commercial terms of the ACA contract, signing a revised contract in May 2014. This contract includes a new schedule for completing the carriers, with the Department expected to formally accept HMS Queen Elizabeth by December 2017 and HMS Prince of Wales by August 2019. However, to reduce the risk of any delays that could affect the Carrier Enabled Power Projection (CEPP) schedule, it agreed a target delivery date of May 2017 for HMS Queen Elizabeth, to achieve better performance.

<sup>1</sup> Comptroller and Auditor General, *Carrier Strike: The 2012 reversion decision*, Session 2013-14, HC 63, National Audit Office, May 2013.

**5** In late 2016, the ACA decided to revise the planned first sailing of HMS Queen Elizabeth by approximately three months to summer 2017. It is managing several technical issues related to the commissioning of the ship's systems. The Department is forecasting that it will accept HMS Queen Elizabeth in late 2017, after the target date and in line with the contractual deadline. At the time of our report, the Department had not yet assessed the impact of this delay on the schedule to 2020, although it believes that the current target of accepting the carrier from the ACA by the end of 2017 is achievable. Experience gained from building HMS Queen Elizabeth has resulted in good progress on the build of HMS Prince of Wales.

**6** In 2014, the Prime Minister announced that both carriers ordered from the ACA would be brought into operational use. This would allow one carrier to be available 100% of the time, either at sea or in port at very high readiness to deploy.

## **Cost**

**7** The renegotiated contract set a target price for ACA to build both carriers. Any costs that ACA incurs above the target price will be shared equally between the Department and industry.<sup>2</sup> In addition, there are other costs such as those resulting from the 2012 decision on the variant of the Lightning II jet to fly from the carriers, bringing the total approved cost to £6.212 billion.<sup>3</sup> **Figure 1** overleaf provides an overview of previous approvals.

**8** Forecast costs for the carrier build have remained close to the approved re-baselined cost of £6.212 billion, reflecting a greater focus on costs by the Department than when we last reported. The Department is dealing with potential cost pressure of some 1% to 2% on the approved cost. This pressure arises from:

- the ACA forecasting the cost of the build will exceed the target price agreed in the re-baselined contract. Under the carriers contract the Department shares any cost increases above the target price with the ACA. The Department has not accepted this increase and is working with the Alliance to achieve the target contract cost and thus minimise any cost increase;
- higher than expected costs associated with the application of thermal metal coating on the landing areas of the carriers to protect them from the intense heat of the Lightning II engines; and
- the financial impact of risks that the Department must manage, which are not included within the provision for risk in the target price. These include provision for unexpected events, crewing for the second carrier and provision of Department-owned resources and equipment, such as spares, radar, helicopters and warehousing.

<sup>2</sup> Industry's liability is capped at £600 million.

<sup>3</sup> See footnote 1.

**Figure 1**  
History of the Queen Elizabeth Class carrier programme

Phase	Dates	Cost (£m)	Description
Assessment	December 1998	118	Original approval for assessment phase
	November 2010	288	Final cost of assessment phase
Demonstration	December 2005	297	Original approval for demonstration phase
	March 2011	266	Final cost of demonstration phase
Manufacture	July 2007	3,900	Original manufacture phase announced, not to exceed cost of £3,900 million, including capitalised assessment and demonstration phase costs
	March 2009	4,574	Revised approved cost
	January 2011	5,242	Revised approved cost
	May 2014	6,212	Revised approved cost

Source: National Audit Office analysis

**9** Facing constraints on resources and personnel shortages, the Department has prioritised the carriers over other ships. It has decided not to extend HMS Ocean in service beyond 2018 to provide crew for the second carrier. HMS Ocean underwent maintenance and refit work between 2012 and 2014 to ensure that it could provide a helicopter carrier capability until at least 2019. But it would require significant capital investment in a major refit to keep running beyond that. The Department now plans for the carriers to provide some capacity to support battlefield helicopter operations. However, the changes to the carriers necessary to achieve this are yet to be fully funded and will add further work to the CEPP schedule. Also, the Royal Navy's capability to undertake certain 'ship to shore amphibious operations' from 2018 onwards will be reduced.

## Risks and issues

**10** There remain many uncertainties until the initial sea trials have finished:

- The ACA is managing several technical issues with the commissioning of ship's systems on HMS Queen Elizabeth.
- Staff shortages in the Department's commercial teams mean the Navy may not have received all the spares for the first carrier when it sails from Rosyth. The Department may need to take spares from the second carrier, delaying overall progress.



**11** The carrier programme is part of the government's Major Projects Portfolio and undergoes regular reviews by the Infrastructure and Projects Authority. The last review was in September 2016. This noted progress on the carrier build, but also warned that significant issues remain. It assessed delivery confidence in the programme as amber, in line with the previous review. This is consistent with the assessment by the Navy's senior responsible owner for the carriers, who highlighted the following risks:

- Forecast support costs may exceed funding because they do not yet reflect the 2014 decision to provide 100% carrier availability. There is also uncertainty about the carriers' maintenance needs until they have completed sea trials.
- Delays in setting up contracts for support may limit the support available at Portsmouth. The Department is changing the way it contracts for warship support as part of a 'common support model'. It must set up new contracts and align existing ones before the Navy accepts the first carrier by the end of 2017.
- Time and cost constraints may delay achieving the necessary testing and approvals for the equipment to be used before 2021. This would result in a reduced Carrier Strike capability.
- Personnel shortages across the Navy may result in insufficient personnel to operate and support the carriers and the wider task group. This may restrict the Department's ability to provide carrier availability for deployment 100% of the time.

# Appendix Four



## Lightning II

### Programme description

1 The UK is buying the Lightning II, or F-35, a fifth-generation stealth aircraft, which will provide the UK with a multi-role combat aircraft able to fly in contested airspace. Lightning II jets include advanced sensors and integrated mission systems and can be equipped with air-to-air and air-to-ground weaponry (**Figure 2**).

2 The Lightning II programme is an international partnership consisting of nine countries (United States, UK, Italy, Australia, the Netherlands, Canada, Turkey, Denmark and Norway). The US contracted with Lockheed Martin and Pratt & Whitney for building the jets and the engines, respectively. The eight other partner nations purchase jets under a memorandum of understanding with the US. Lightning II is the largest defence project in history, with a total expected value of more than \$1.5 trillion and an expected total production run of 3,100 aircraft.<sup>4</sup> There are three variants of the F-35 and the UK is buying the 'B' variant, which is capable of short take-off and vertical landing.

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### Figure 2

#### Selected features of Lightning II

Low observability	The stealth capabilities mean that enemy radar cannot easily detect the aircraft; this allows it to fly with greater freedom. It gives those nations operating Lightning II a significant tactical advantage.
Fifth-generation avionics	Fifth-generation capability refers to the aircraft's advanced sensor suite, which can give the pilot a comprehensive range of information, enhancing the pilot's situational awareness so that they can act more rapidly and effectively than their adversary.
Short take-off and vertical landing (B variant)	Ability to take off and land on the aircraft carriers unaided. Further development is ongoing of the shipborne rolling vertical landing technique to increase flexibility in hot, humid or low-pressure climatic conditions.

Source: National Audit Office

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4 The forecast cost up to 2070, including an assumption on inflation.

## Performance

**3** The Ministry of Defence (the Department) has taken an incremental approach to approving the purchase of Lightning II jets and associated infrastructure (**Figure 3** overleaf). In 2014, the Department and HM Treasury approved the purchase of a squadron of 14 front-line aircraft, equipment, support, infrastructure and sustainment contracts to achieve an initial operating capability from a land base by December 2018 and an initial operating capability from a carrier by December 2020.<sup>5</sup> This decision built on earlier approvals to invest in a test and evaluation squadron of three aircraft to be based in the US and the first training aircraft.

**4** As part of the 2015 Strategic Defence and Security Review (SDSR), the Department decided to bring forward the expected buy profile of a further 30 jets, so that 24 jets, split across two squadrons, will be available from 2023. The SDSR also re-affirmed the Department's commitment to purchasing 138 jets over the life of the Lightning II programme.

**5** To date, the UK has taken delivery of three testing aircraft and five front-line aircraft currently used for training. These are based in the US with UK personnel in preparation for the establishment of the first Lightning II squadron.

**6** The Department expects the UK to take delivery of the remaining jets in line with its planning assumptions. Figure 9 in our report sets out how numbers in the UK fleet are expected to grow. The squadron will travel to the UK in August 2018. The test aircraft will be based in the US permanently. Some training aircraft will remain in the US, as part of the UK/US pooling arrangement, for a period to be agreed.

## Cost

**7** The Department has so far approved spending £9.1 billion on the Lightning programme. This includes the UK's contribution to early development costs, infrastructure, purchase and initial support of 48 aircraft, and administration costs. The Department is purchasing the aircraft in stages. The latest approval to purchase 30 jets, initial support and administration was in January 2017 for around £3 billion. **Figure 4** on page 11 describes how the Department forecasts and approves costs.

<sup>5</sup> Initial operating capability is where the capability can be deployed on operations, but with limitations. This is based on military judgement and varies according to the type of capability. Further testing, modifications and increased numbers are required before full operating capability is achieved.

**Figure 3**  
History of the Lightning II programme

Phase	Dates	Approved cost (£m)	Description
System development and demonstration	January 2001		UK contribution as a tier 1 partner for development and demonstration of the aircraft. Tier 1 status allowed the UK to decide and agree aircraft specification.
	Total system development and demonstration phase	1,874	
Production sustainment and follow-on development	December 2006		Long lead items for first two aircraft, UK contribution (2007 to 2009) to the Lightning II programme and development of UK Freedom of Action solutions and implementation.
	March 2009		Purchase and initial support of first three aircraft, two of which are operational test aircraft and will remain in the United States, and UK contribution (2010) to the Lightning II programme.
	March 2012		Long lead items for the fourth aircraft, plus UK contribution (2011 to 2012) to the Lightning II programme.
	November 2012 – March 2014 (three approval periods)		Full production of the fourth aircraft, plus long lead items for a further four UK aircraft. UK contribution (2013 to 2015) to the Lightning II programme.
	January 2014		Purchase of 14 front-line aircraft to Block 3f capability, along with training, initial support and software development costs.
	September 2015		UK contribution (2016) to the Lightning II programme.
	October 2016		Procurement of the UK F-35 strategic facility including operating costs for the first five years.
	October 2016		UK contribution to the Lightning II programme (2017 to 2021), plus UK contribution for pre-engineering manufacture and development activities for further modernisation of the aircraft for 2017.
	January 2017		Approval for the procurement, spares and support equipment for the remaining 30 F-35B aircraft in the tranche 1 fleet, enabling the second front-line squadron and full operational capability.
	Total production sustainment and follow-on development phase approvals to date	7,258	
<b>Total approvals to date</b>		<b>9,132</b>	

#### Notes

- 1 Totals have been rounded to the nearest whole number.
- 2 January 2001 UK contribution as a tier 1 partner is UK sterling value of \$2 billion contribution at time of payment.
- 3 Individual approval amounts are not shown because they are commercially sensitive. The latest approval was in January 2017 for around £3 billion, included in total above.
- 4 This does not include a £150 million approval in November 1996 to enter into the concept and demonstration phase for a new stealth aircraft (later to become the Lightning II). Boeing and Lockheed Martin both submitted designs for the aircraft. Lockheed Martin was selected as the preferred design.

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## Figure 4

### How the Department forecasts costs

The Department forecasts the future cost of different components and activities required to build and support equipment. These forecasts are based on assumptions, such as about the future price of steel or inflation rates. The Department uses these forecasts to assess whether future costs will be affordable within its budget. These forecasts are not fixed and may fluctuate as future costs become more certain, such as when a contract is signed. The Department reports on these forecast costs in its 10-year Equipment Plan and we assess the robustness of its assumptions on costs and the level of risk to overall affordability.<sup>1</sup>

Once programme teams have a clearer idea of expected costs, they must seek approval to spend the money and undertake work. These requests for approval undergo scrutiny, which provides assurance that the proposal offers value for money and is affordable within the Department's financial resources. Approval is provided by each Command; however, approval requests for high-value or high-risk programmes are discussed by the Department's Investment Approvals Committee, chaired by the Department's Director General Finance. Programmes are held to account against this approved amount as part of the regular quarterly review of costs. They cannot exceed it without requesting further approval. Approvals may cover an entire programme, or discrete elements within a larger programme. The Department's forecasts in its Equipment Plan include forecast costs for programmes both approved and not yet approved.

#### Note

1 Comptroller and Auditor General, *The Equipment Plan 2016 to 2026*, Session 2016-17, HC 914, National Audit Office, January 2017.

Source: National Audit Office

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## Risks and issues

- 8 There remain a number of risks and issues in the programme. In particular:
- Lightning II is the most technologically advanced aircraft ever created. Design and testing are happening concurrently.<sup>6</sup> While this approach enables the capability to be ready sooner, it increases the risk that the delivered jets require modification if design or mechanical issues are identified.
    - a US auditors (the Government Accountability Office) have reported significant technical issues that must be resolved before the aircraft can be used in combat, such as dealing with engine fires, software malfunction and cracks in the airframe.
    - b The US Director of Operational Testing and Evaluation for the Lightning II programme in his 2016 annual report highlighted a number of technical and software issues that could result in delays to the aircraft being ready for use in combat.<sup>7</sup>
  - Shortages in staff in the UK Lightning II programme team will affect the ability to complete UK activities needed before the jets can be used in combat. The SDSR 2015 decision to buy jets sooner enabled more flying hours, supporting the planned pipeline of training to deliver the required capability. However, the number of trained pilots is expected to be just sufficient up to 2026.

<sup>6</sup> The design phase is expected to complete in late 2019, when full production is expected to begin.

<sup>7</sup> Director, Operational Test and Evaluation, *FY 2016 Annual Report*, December 2016, available at: [www.dote.osd.mil/pub/reports/FY2016](http://www.dote.osd.mil/pub/reports/FY2016)

- A collaborative British, Australian and Canadian project to provide data for use on jets does not have sufficient staff to complete work before initial operating capability is achieved. Software programming is running late and may not be ready in time, delaying integration of UK weapons onto the jets until after 2018, limiting how the jets can be used.
  - Infrastructure work at RAF Marham, the main operating base for the jets, is well under way. Some UK infrastructure facilities require certification by US authorities that they have been built according to security stipulations. Delays may result in these not being signed off in time for the jets' arrival in 2018. Other RAF Marham upgrades are running with just three weeks' contingency in advance of the arrival of the squadron in 2018.
  - The UK will need to align the US-led global support solution for the jets with UK arrangements, including supporting the squadron at sea. These arrangements are being developed, but must be put in place before initial operating capability is achieved.
- 9** The UK's Lightning II programme is part of the government's Major Projects Portfolio and undergoes regular reviews by the Infrastructure and Projects Authority. The last review was in October 2016. The review observed that the schedule is tight. The programme plan is ambitious given the number of milestones within the schedule and the number of significant issues and risks that could derail progress.

# Appendix Five



## Crowsnest

### Programme description

**1** Crowsnest is a helicopter-borne radar system that provides long-range airborne surveillance, control and early warning capability. The Crowsnest radar system will be fitted to 10 of the 30 Merlin helicopters currently in service with the Royal Navy. The remaining 20 Merlin helicopters will also be modified to allow them to be fitted with the Crowsnest radar system in future if required. Crowsnest will replace the current helicopter-borne radar capability provided by the Sea King Mk7.

**2** Lockheed Martin is the Ministry of Defence's (the Department's) prime contractor for the Crowsnest demonstration and manufacture phase, under a single source contract. It works with Leonardo, which is the manufacturer of the Merlin helicopters, and Thales, which is responsible for developing the radar system.

### Performance

**3** The Department began considering options for replacing the Sea King Mk7 helicopters in 2005. In our 2013 report, we noted that, as part of its 2012 exercise to balance its Equipment Plan, the Department had decided to delay introduction of Crowsnest to after the Department first planned to deploy the carriers. This would have limited the operational use of the carriers without mitigating actions to provide airborne surveillance. In 2014, the Department decided to accelerate the programme so that an initial Crowsnest operating capability is achieved in April 2020, in time for initial operating capability of Carrier Strike in December 2020.<sup>8</sup>

<sup>8</sup> Initial operating capability is where the capability can be deployed on operations, but with limitations. This is based on military judgement and varies according to the type of capability. Further testing, modifications and increased numbers are required before full operating capability is achieved.

**4** Approval to proceed to the demonstration and manufacture stage and to sign the contract with Lockheed Martin was given in May 2016 (**Figure 5**). The Department intended to let the contract quickly following approval; however, this was delayed due to technical specification issues, the cost of the chosen system and additional work to fully interpret and apply the single source contracting regulations.

**5** To prevent the overall schedule from being delayed, the Department gave Lockheed Martin an ‘instruction to proceed’ with preparatory work while negotiations on the financial contract concluded. This covered work up to a value of £41.9 million between April 2016 and November 2016, contained within the overall contract value of £269 million. The Department and Lockheed Martin concluded negotiations and signed a contract in November 2016. The Department is not forecasting any delays to the schedule as a result of the delayed signing of the contract.

**Figure 5**  
History of the Crowsnest programme

Phase	Date	Cost (£m)	Description
Assessment phase 1	July 2005	10.3	Approval to examine a range of possible solutions for the airborne surveillance and control requirement.
Assessment phase 2	June 2008	6.5	Approval to examine how to extend the life of the Sea King Mk7 helicopters.
Assessment phase 3	February 2013	43.2	Decision to deliver capability by fit-out of additional equipment to Merlin helicopters, rather than pursuing a separate Crowsnest vehicle.
Demonstration and manufacture phase	November 2016	269	Value of Crowsnest contract.

Source: National Audit Office analysis



## **Cost**

6 The Department is forecasting to spend £60 million on development costs. In November 2016 the Department signed a £269 million contract for Crowsnest.

## **Risks and issues**

7 There remain a number of risks to the Department successfully delivering Crowsnest, particularly:

- All 30 Merlin helicopters will be either fitted with the Crowsnest radar system, or adapted to allow the system to be fitted. This modification will require each aircraft to be removed from service for this period, when it is already involved in several high-priority roles and is in high demand. Failure to release the aircraft from active service to allow modification work could delay the programme.
- There is a risk that the decision to use an existing helicopter (Merlin) could affect the overall performance of the Crowsnest system. The Departmental team responsible for the Merlin aircraft must understand the extent of this risk as it trials the new equipment and take any mitigating actions required.
- There is now limited contingency in the schedule to allow training of aircrew and integration activities with the other equipment which are required to deliver Carrier Strike.

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