



The F-35 Lightning II Joint Strike Fighter

Standard Note: SN06278

Last updated: 12 April 2013

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Section: International Affairs and Defence Section

The F-35 Lightning II Joint Strike Fighter is the new multirole fast jet for the Royal Navy and Royal Air Force. It will serve as the strike capability for the new Queen Elizabeth Aircraft Carrier and will partner the Typhoon to form the future fast jet fleet for the RAF. It is a multinational acquisition programme led by the United States in partnership with eight other nations, including the UK.

There are three variants of the F-35:

- F-35A Conventional Takeoff and Landing (CTOL)
- F-35B Short Takeoff/Vertical Landing (STOVL)
- F-35C Carrier Variant (CV)

The UK selected the Joint Strike Fighter (JSF) in 2001 to fulfil the requirements of its Joint Combat Aircraft programme and later selected the F-35B variant. In 2010, the Government announced in its Strategic Defence and Security Review it was switching to the F-35C Carrier variant. The decision was questioned because of the potential cost implications of adapting the Carrier flight deck and for causing a delay to the Carrier in-service date from 2016 to 2020. The Government announced in May 2012 that after reviewing the costs, risks and technical feasibility of adapting the Carriers to the F-35C, it was reverting to the F-35B STOVL variant.

The number of aircraft to be ordered will be made at the Strategic Defence and Security Review in 2015. They will be based at RAF Marham in Norfolk. The F-35 is currently in development and its in-service date has not yet been confirmed, although it is expected to commence test flights from the Queen Elizabeth Carrier and be operational from land-based airfields in 2018. Operational military capability from the Queen Elizabeth is expected in 2020.

The US-led programme has had several problems in development and there are concerns about its life-cycle costs. International orders are being affected by both cutbacks in defence budgets by partner countries and concerns about increasing unit and life-time costs.

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1 Introduction

The F-35 Lightning II Joint Strike Fighter (JSF) will be “the world’s most advanced multi-role combat jet” according to the Prime Minister¹. It was chosen by the Government in 2001 to fulfil the requirements of the Joint Combat Aircraft programme, replacing the Royal Navy’s Sea Harriers and the Royal Air Force’s Ground Attack Harriers.² The JSF will form part of the future fast jet fleet for the RAF, alongside the Typhoon.³ It will also provide the strike capability for the new Queen Elizabeth class aircraft carrier. The fleet will be operated jointly by the Royal Navy and Royal Air Force. It will be the UK’s first stealth aircraft.

The Lockheed Martin F-35 Lightning II Joint Strike Fighter (JSF), to give it its full name, is a multirole ‘fifth’ generation fighter aircraft with stealth capabilities.⁴ It is principally funded and led by the American Department of Defence (DOD) who are seeking to replace their ageing fighter inventories for the US Air Force, Navy and Marine Corps. Lockheed Martin is the F-35 prime contractor and was awarded the contract by the DOD in 2001. It is currently in development in the United States and somewhat unusually it is being produced concurrently to testing. UK companies have contracts worth “15% by value of the work on each aircraft.”⁵

Nine nations are partnering in the JSF’s System Development and Demonstration (SDS) phase. The UK is the only level one partner of the non-US nations. This means the UK’s requirements are formally incorporated into the Joint Operational Requirements Document and it has relatively significant influence in its development.

There are three versions of the F-35, all of which are single-engine, single-pilot aircraft:

- F-35A Conventional Takeoff and Landing (CTOL)
- F-35B Short Takeoff/Vertical Landing (STOVL)
- F-35C Carrier Variant (CV)

The US, as the lead developer of the F-35, is purchasing all three variants: the F-35A for the Air Force, the F-35B for the Marine Corps and the F-35C for the Navy.

The UK selected the Joint Strike Fighter (JSF) in 2001 to fulfil the requirements of its Joint Combat Aircraft programme. The following year it decided on the B variant, the Short Takeoff-Vertical Landing (STOVL). However the Coalition Government switched to the Carrier Variant (C) in the 2010 Strategic Defence and Security Review. At the time the Government argued the carrier variant was more capable, had a longer range and higher payload and would be cheaper overall than the F-35B variant. The decision was much criticised for the potential cost implications of adapting the Carrier flight deck and for delaying the Carrier in-service date from 2016 to 2020. The Government announced in May 2012 that after reviewing the costs, risks and technical feasibility of adapting the Carriers to the F-35C, it was reverting to the F-35B STOVL variant.

¹ HC Deb 19 October 2010 c800

² More information about the Joint Combat Aircraft programme can be found on the MOD [website](#)

³ The assumed out of service date for the Tornado aircraft is 2019 but the Ministry of Defence has said no firm decision needs to be made until the 2015 SDSR, HC Deb 25 June 2012 c4W

⁴ More information about the JSF can be found on the JSF website: <http://www.jsf.mil>

⁵ HC Deb 5 September 2011 c87W; A list of UK companies involved in the F-35 programme is available in the following article: S Mitchell, “F-35 – getting the UK’s largest defence export opportunity on track”, *RUSI Defence Systems*, Summer 2012

The aircraft will be based at RAF Marham in Norfolk.⁶

The aircraft will be known in UK service as the Lightning II, but it is commonly referred to as the F-35 or the Joint Strike Fighter.

2 The UK option: From B to C to B again

The 1998 Strategic Defence Review committed to procuring a “future carrier-borne aircraft to replace the Harrier” for two new aircraft carriers. In 2001 the JSF was selected as the aircraft best able to fulfil the requirements of the Joint Combat Aircraft and the Government signed a Memorandum of Understanding with the US to begin the System Development and Demonstration Phase. This committed the UK to \$2 billion in development costs.⁷

The F-35B Short Take-off and Vertical Landing (STOVL) variant of the JSF was chosen in 2002. This is the version being developed for the US Marine Corps.

The current Government switched to the F-35C Carrier Variant of the JSF in the 2010 Strategic Defence and Security Review (SDSR). In announcing the change, David Cameron blamed the previous government for ordering the “more expensive, less capable version of the Joint Strike Fighter to fly off the carriers.” He argued the carrier version is “more capable, less expensive, has a longer range and carries more weapons.”⁸ The SDSR said: “overall, the carrier-variant of the JSF will be cheaper, reducing through-life costs by around 25%.”

The SDSR proposed converting one carrier (two are under construction) with catapults and arrester gear to operate the F-35C carrier variant. The future use or disposal of the second carrier will not be decided until the 2015 SDSR.

The SDSR stated that the Government’s intention is “to operate a single model of JSF, instead of different land and naval variants.”

Following the SDSR, the Ministry of Defence commissioned a detailed programme of work to look at the costs, risks and technical feasibility of the decision to switch to the Carrier variant. In particular, this looked at the implications of adapting the two Queen Elizabeth class carriers with the catapult and arrestor gear (‘cats and traps’) required to launch and land the aircraft.

The Secretary of State for Defence, Philip Hammond, announced his decision to revert to the STOVL variant in a statement on 10 May 2012.⁹ He said “a number of the underlying facts on which the SDSR decision on carriers was based were changing.” He gave the following reasons:

- Operational carrier strike capability could not be delivered until late 2023 at the earliest, three years later than the SDSR envisaged date of around 2020
- The cost of fitting the Electromagnetic Aircraft Launch System (EMALS) to HMS Prince of Wales has more than doubled from an estimated £950 million to about £2 billion

⁶ HC Deb 25 March 2013, c65WS

⁷ *ibid*

⁸ HC Deb 19 October 2010 c800

⁹ [HC Deb 10 May 2012 c140](#)

- The cost of retro-fitting HMS Queen Elizabeth – the first carrier out of build – would likely cost between £2.5 billion to £3 billion
- It would be unlikely HMS Queen Elizabeth would ever, in practice, be converted
- The STOVL configuration gives the Government optionality, in that both carriers could be used to provide continuous carrier availability at a net additional operating cost averaging about £60 million per year¹⁰
- The balance of risk concerning the STOVL variant has changed from a very significant technical risk at the time of the SDSR to no greater risk than the other variants
- Carrier availability, rather than cross-deck operations, is the more appropriate route to optimising alliance capabilities
- The decision will not delay delivery of the aircraft

Mr Hammond said he was not prepared to accept a delay in regenerating the carrier strike capability beyond that envisaged by the SDSR – i.e. 2020. He also said he was not prepared to put the MoD’s overall equipment plan at risk of a billion-pound plus increase in the carrier programme.

The Chief of the Defence Staff, General Sir David Richards, said the likely delay to having a carrier strike capability to 2023 as “neither desirable nor necessary.”¹¹

Defence Minister Philip Dunne, when asked how the capabilities of the F-35 will differ from those of the Harrier, said:

The F-35 Joint Strike Fighter is a fifth-generation aircraft that represents a step change in capability compared to the third generation Harrier. Unlike the Harrier, it is an all-weather stealth aircraft with an autonomous intelligence-gathering capability, and it has significantly greater range and speed. It can also carry a larger payload of more advanced weapons than the Harrier.¹²

Rear Admiral Chris Parry, former director of doctrine at the Ministry of Defence, criticised the decision to revert to the F-35B rather than what he considers the more capable C variant and suggested the decision was based on short-term cost-saving considerations rather than “a desire to provide value for money and strategic utility over the long term.” He also questioned the lack of air-to-air refuelling capability onboard and the resultant reliance on land-based aircraft.¹³

In response to the latter point, First Sea Lord Admiral Sir Mark Stanhope wrote in a letter to the *Sunday Times*:

Jet-to-jet mid-air refuelling is not a requirement for our operations and is not necessary [to 'attack targets at long range or carry heavier bomb loads']. The carriers will be able to operate within strike range of the vast majority of nations and, in extremis, in

¹⁰ The decision on the future of the second carrier will not be made until the 2015 SDSR but Mr Hammond said if the Government in 2015 take the decision to operate two carriers, the net additional cost will be about £60 million per year

¹¹ “[This change of course on aircraft carriers is essential](#)”, *Daily Telegraph*, 10 May 2012

¹² HC Deb 19 November 2012 c234W

¹³ C Parry, “The United Kingdom’s Future Carriers”, *RUSI Journal*, 19 December 2012 157:6, 4-9

conjunction with both UK and coalition air-to-air refuelling aircraft, would be able to support longer range strike missions as required.

[...] The idea of adding further expense with a jet-to-jet refuelling variant of the Lightning for such a limited payload advantage at this stage of the project is misguided and would simply reduce the number of strike jets available.¹⁴

3 Number of aircraft and basing

The decision on the overall number of aircraft will not be made until the next Strategic Defence and Security Review (SDSR) in 2015.¹⁵ The original planning assumption for up to 140 aircraft is not expected to be realised. Defence Secretary Philip Hammond confirmed in July 2012 the UK will order 48 aircraft (including the four test aircraft) with further numbers to be confirmed in the 2015 SDSR.¹⁶

The decision taken in May 2012 to use the STOVL variant rather than the Carrier variant will not affect the number of aircraft to be deployed on the Carrier. Twelve aircraft will be routinely on board the carriers with a potential surge to 36 aircraft if required.¹⁷

The F-35 force will be operated by both Royal Navy and RAF pilots.

The Government has bought four STOVL variant aircraft as test aircraft and received two in 2012.¹⁸ They remain in the US, operating from Eglin air force base in Florida.¹⁹ The third aircraft is due in the second quarter of 2013. Initial Operational Test and Evaluation will take place at Edwards Air Force Base in California from 2014 onwards.

The main operating base will be RAF Marham in Norfolk. RAF Lossiemouth in Scotland had been expected to be its home but Armed Forces Minister Andrew Robathan argued that given RAF Lossiemouth will host three squadrons of Typhoon, combined with plans to drawdown Tornado aircraft (which are based at RAF Marham), RAF Marham is the “most appropriate station” for the F-35 aircraft.²⁰

4 Timetable

The Government expects to have operational military capability of the Carrier strike in 2020. Mr Hammond laid out the timetable on 10 May 2012²¹ which has subsequently been slightly refined by Armed Forces Minister Andrew Robathan in March 2013²²:

July 2012	Delivery of first test aircraft
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¹⁴ “Defence in the media: 7 January 2013”, *Ministry of Defence*

¹⁵ HC Deb 17 January 2012 c792W

¹⁶ “UK slashes F-35B numbers but might look to split buy with F-35As”, *Jane’s Defence Security Report*, 27 July 2012

¹⁷ HC Deb 10 May 2012 c145

¹⁸ “The first of the UK’s next generation stealth combat aircraft has today been handed over to the MOD”, *Ministry of Defence*, 19 July 2012

¹⁹ HC Deb 26 November 2012 c5

²⁰ HC Deb 25 March 2013 c65WS

²¹ HC Deb 10 May 2012 c142

²² HC Deb 25 March 2013 c66WS

2015 onwards	Delivery of 'front-line' aircraft
2017	Queen Elizabeth begins sea trials
2018	Initial operating capability from land ²³ Aircraft begin test flights from Queen Elizabeth
2020	Carrier strike capability

The aircraft are produced in Lots. Then Defence Minister Peter Luff confirmed in July 2012:

Aircraft ordered within Lot 7 are scheduled to be delivered in financial year (FY) 2015-16, Lot 8 are scheduled to be delivered in FY 2016-17, and Lot 9 in FY 2017-18. The number of aircraft to be ordered within these lots is still to be formally approved. The cost of each Joint Strike Fighter will be determined at the next Main Gate decision currently planned for 2013.²⁴

5 Cost of the Joint Strike Fighter

In terms of cost, the Government [stated](#) in April 2011:

The cost of each aircraft will depend on when in the overall production programme it is bought and will vary according to a number of factors, such as other partner nations' procurement plans. We do not routinely reveal the forecast cost of future programmes in order to protect the Department's position in commercial negotiations.

In reply to a question by the Shadow Secretary of State for Defence for the estimated unit cost of the Carrier Variant at the time of the SDSR, the Minister for Defence Equipment, Support and Technology, Peter Luff, replied "I am withholding the information as publication at this time would prejudice the commercial interests of Ministry of Defence."²⁵

Mr Hammond said in his May 2012 statement that the Government chose the F-35 Carrier variant over the STOVL in 2010 because of its lower purchase cost and lower through-life maintenance cost. However in deciding to revert to the STOVL, he said that, taking into account the cost of installing the necessary catapult and arrestor gears, the STOVL variant will be cheaper.²⁶

The Government committed to \$2 billion when it signed the Memorandum of Understanding in 2001. The Government confirmed in September 2011 it had spent £1.8 million to date.²⁷

When asked how much had been spent on analysing the costs of converting the Carriers to accept the F-35C variant, the Ministry of Defence said:

We have committed up to £39 million to the end of April 2012 with both the US Department of Defense (DOD) and UK Aircraft Carrier Alliance, and £1 million on an

²³ HC Deb 25 March 2013, c65WS

²⁴ HC Deb 12 July 2012 c381W

²⁵ HC Deb 16 April 2012 c64W

²⁶ HC Deb 10 May 2012 c140

²⁷ HC Deb 5 September 2011 c86W

air-to-air refueling study. There will be some additional costs as we close down this activity but I cannot release our estimate of these costs now as this would prejudice our negotiations.

We did not order any equipment as part of these investigations into the conversion of the operational aircraft carrier. The decision to revert to purchase of the STOVL F-35B variant of Joint Strike Fighter was made before it was necessary to commit to long lead items for the catapults and arrestor gear.²⁸

Lord Astor of Hever was asked what agreements the Government has made with the US for future upgrades to the programme:

The UK and the US have an agreement in place known as the Production Sustainment and Follow-on Development (PSFD) Memorandum of Understanding (MoU). This document governs how follow-on development (future upgrades) will work, including scope and cost-sharing arrangements across the international partnership.

The upgrade strategy for the aircraft is to field capability and sustainability improvements every two years. The scope of capability upgrades is agreed jointly by the international partnership. The PSFD MoU provides for full UK visibility of costs, and to this effect the UK has personnel embedded within the JSF programme office to analyse the associated information.²⁹

6 The aircraft: STOVL versus Carrier variant

A comparison of the two variants of the F-35 Joint Strike Fighter can be found in the appendix.

At the time of the SDSR, in October 2010, the Government argued the carrier version was more capable, less expensive, has a longer range and carries more weapons.³⁰

In January 2011, shortly after the SDSR was published, the STOVL variant was put on 'probation' by the US Government because of significant problems in testing. Then US Secretary of Defence Robert Gates warned "if we cannot fix this variant during this time frame and get it back on track in terms of performance, cost and schedule, then I believe it should be cancelled."³¹ The probationary period was lifted in January 2012.^{32 33}

In explaining the reason why the Government switched back to the STOVL variant, having previously argued against it in the SDSR, Mr Hammond said it was the right decision at the time, based on the information available. However he said since the SDSR a number of the underlying facts had changed:

At the time of the SDSR there was judged to be a very significant technical risk around the STOVL—short take-off, vertical landing—version of the joint strike fighter, and some commentators were speculating that it could even be cancelled. Indeed, the STOVL programme was subsequently placed on probation by the Pentagon However,

²⁸ HC Deb 13 June 2012 c504W

²⁹ HL Deb 11 February 2013 cWA91

³⁰ HC Deb 19 October 2010 c800

³¹ "[Gates reveals budget efficiencies, reinvestment opportunities](#)", *American Forces Press Service*, 6 January 2012

³² "[Panetta lifts F-35 probation](#)", *Aviation Week*, 23 January 2012

³³ "[Panetta lifts F-35 Fighter Variant probation](#)", *American Forces Press Service*, 20 January 2012

over the past year, the STOVL programme has made excellent progress and in the past few months has been removed from probation. The aircraft has now completed more than 900 hours of flying, including flights from the USS Wasp, and the US Marine Corps has a high degree of confidence in the in-service date for the aircraft. The balance of risk has changed, and there is now judged to be no greater risk in STOVL than in other variants of JSF.³⁴

The Chief of the Defence Staff, General Sir David Richards, wrote in *the Daily Telegraph* on the same day as the Philip Hammond announcement:

The improvements to the STOVL aircraft since the SDSR are impressive. Once a troubled project on probation, it has now demonstrated its capabilities, flying more than 900 hours. This reduces the danger of complications and cost increases that we feared in 2010.³⁵

He also addressed the factors the Prime Minister had originally citing when opting for the Carrier variant in 2010:

While it is true that the Carrier Variant offered greater range, this is not a crucial advantage – given our major investment in air-to-air refuelling – when weighed against the greater time to bring it into service, and the increasing cost. The balance has tipped back in favour of STOVL, which has distinct advantages of its own, such as versatility and agility....

Both the Carrier Variant and the STOVL aircraft represent a generational shift from the jets that we use today. Through their computer technology, stealth and communications they are more capable than their ship- or land-based predecessors. They are cutting-edge, multi-role platforms fit for the battlespace of the 21st century. They can both carry the full range of weapons we intend to buy.³⁶

The F-35B variant is being developed for the US Marine Corps, the UK and for the Italian Navy and Air Force (Italy is also purchasing the F-35A for its Air Force). The F-35A variant is expected to make up the bulk of international orders.

7 Interoperability

One of the arguments laid out in the 2010 Strategic Defence and Security Review in favour of the C variant was that it would enable greater cooperation with allies. Specifically, it said that fitting the catapult and arrestor gear “will allow our carrier to operate in tandem with the US and French navies, and for American and French aircraft to operate from our carrier and vice versa.”³⁷ The Government has since argued that it is carrier availability, rather than being able to land each other’s aircraft, that is more important.

Under a UK/US Statement of Intent on Carrier Co-operation and Maritime Power Projection, signed on 5 January 2012, the U.S. Navy will assist the Royal Navy in developing its next generation of aircraft carriers. The UK/France defence and security declaration, signed in February 2012, sets out plans to have, by the early 2020s, the ability to deploy a joint UK-France carrier strike group.³⁸

³⁴ HC Deb 10 May 2012 p141

³⁵ [“This change of course on aircraft carriers is essential”](#), *Daily Telegraph*, 10 May 2012

³⁶ Ibid

³⁷ [Strategic Defence and Security Review](#), 19 October 2010

³⁸ [UK-France declaration on security and defence](#), *Number 10 website*, 17 February 2012

A National Audit Office July 2011 report on Carrier Strike questioned the feasibility of the flying UK planes from the French carrier and French aircraft from the Queen Elizabeth.³⁹ The Secretary of State for Defence told the Commons in March 2012 that the collaboration with the French is more about carrier deployment and “not about interoperability of aircraft as such.”⁴⁰

Mr Hammond told the Commons, in his May 2012 statement:

Further work with our allies on the best approach to collaborative operation has satisfied us that joint maritime task groups involving our carriers, with co-ordinated scheduling of maintenance and refit periods, and an emphasis on carrier availability, rather than cross-deck operations, is the more appropriate route to optimising alliance capabilities.⁴¹

He added the French and American governments supported the UK decision to revert back to the STOVL variant.⁴² Lord Astor of Hever likewise stated that the US “made it clear that carrier availability, rather than cross-decking or the capability of aircraft, is the key issue for it.”⁴³

The Chief of the Defence Staff, General Sir David Richards, wrote in *the Daily Telegraph*:

This fifth-generation aircraft is a weapons system unmatched by our rivals, and will be an integral part of the package we offer our friends and allies – not least the French, with whom we have developed such a close relationship, and the Americans, who have been and will continue to be essential partners in developing our new capability.⁴⁴

8 Weapons

The Lightning II will be able to carry weapons both internally, in weapon bays, and externally, on pylons. According to the RAF⁴⁵ this will allow a maximum weapon payload of: 6 Paveway IV (short-range air-to-surface missile), 2 AIM-120C AMRAAM (air-to-air missile), 2 AIM-132 ASRAAM (air-to-air missile) and a missionised 25mm gun pod.

Future armaments include: Storm Shadow (long-range air to surface), SPEAR (air-to-surface), and METEOR (beyond visual range air-to-air missile).

These weapons relate to the UK Lightning II aircraft. Other nations may choose different weapons, for example Norway has developed a new long-range anti-surface missile (joint strike missile) for its F-35As.⁴⁶

³⁹ “Carrier Strike”, National Audit Office, HC1092, 2010-2012, 7 July 2011

⁴⁰ HC Deb 26 March 2012 c1143

⁴¹ HC Deb 10 May 2012 c141

⁴² HC Deb 10 May 2012 c142

⁴³ HL Deb 10 May 2012 c81

⁴⁴ “This change of course on aircraft carriers is essential”, *Daily Telegraph*, 10 May 2012

⁴⁵ F-35 Lightning II, accessed 12 April 2013

⁴⁶ “Lockheed completes fit check of Norwegian JSM missile on F-35”, *Airforce-technology.com*, 15 March 2013

9 Concerns about the F-35

The biggest concerns about the programme centre on are its effectiveness, affordability and control (of software source codes) according to a detailed study of the programme by *Defense Industry Daily*.⁴⁷

As the prime developer and lead nation, much of the detailed analysis of the programme has taken place in America.

The US Government Accountability Office (GAO) has repeatedly expressed concern about the costs and long-term affordability of the F-35 programme. The GAO estimates the total US investment in the JSF to developing and procure the aircraft through to 2037 is \$397 billion, as opposed to the £233 billion estimated at the start of the programme in 2001. The GAO has also repeated its concerns about affordability over the programmes life-time in its most recent report, of March 2013. It estimates acquisition funding requirements to average \$12.6 billion annually to 2037.⁴⁸ It estimates the unit cost has increased from \$81 million in 2001 to \$161 million in 2012.⁴⁹ This is the estimated cost to the US Government and should not be interpreted as reflecting the unit costs for international partners.

According to a *Defense News* article in May 2012:

Using 2012 dollar values, the Pentagon projects the Air Force version of the F-35, the aircraft being purchased by most international customers, to cost \$78.7 million. The carrier version's is projected to cost \$87 million, and the Marine Corps' short-takeoff, vertical-landing version, \$106 million.⁵⁰

The GAO blames much of the cost growth on concurrency – testing and producing the aircraft nearly simultaneously – and the Pentagon has admitted that putting the F-35 into production before the first test flight “was acquisition malpractice, it should not have been done.”⁵¹ An additional financial danger is the potential need for costly retrofits in production aircraft if significant problems are found in future tests.⁵²

The GAO also points out delays to the programme (both production delays and procurement deferrals) means the US Government is extending the life of existing aircraft and buying new ones to mitigate shortfalls. Australia is currently looking at the option of extending its Boeing F/A-18F Super Hornet fleet to avoid any gap in air combat capability.⁵³

The GAO's March 2013 report does provide a few rays of light. It notes that “the F-35 program has been extensively restructured over the last 3 years to address prior cost, schedule, and performance problems” and that “overall, the F-35 Joint Strike Fighter program is now moving in the right direction after a long, expensive, and arduous learning process.” However it does still warn the programme “still has tremendous challenges ahead” and calls on the US Department of Defence and Lockheed Martin to “demonstrate that the F-35

⁴⁷ “F-35 Lightning: the Joint Strike Fighter Program, 2012-13”, *Defense Industry Daily*, 14 January 2013.

Available via subscription or a copy is available on the following [weblink](#).

⁴⁸ “F-35 Joint Strike Fighter: Current Outlook Is Improved, but Long-Term Affordability Is a Major Concern”, *US Government Accountability Office*, March 2013

⁴⁹ “F-35 Joint Strike Fighter: Current Outlook Is Improved, but Long-Term Affordability Is a Major Concern”, *US Government Accountability Office*, March 2013

⁵⁰ “Proposal directs Pentagon to give battle-ready dates for F-35”, *Defense news*, 9 May 2012

⁵¹ “US admits producing F-35 before flight tests was a mistake”, *Jane's Defence Weekly*, 8 February 2012

⁵² “F-35 Lightning: the Joint Strike Fighter Program, 2012-13”, *Defense Industry Daily*, 14 January 2013.

Available via subscription or a copy is available on the following [weblink](#).

⁵³ “Australia considers Super Hornet fleet expansion”, *Jane's Defence Weekly*, 13 December 2012

program can effectively perform against cost and schedule targets in the new baseline and deliver on promises.”⁵⁴

A 2011 internal Pentagon technical report identified 13 current or potential structural problems and recommended a procurement slowdown, according to *Jane's Defence Weekly*. US Defence Secretary Leon Panetta said in early January 2012: “we've got a long way to go with the JSF testing, and it's obviously not out of the woods yet.”⁵⁵

The F-35 B STOVL variant was grounded on 18 January 2013 following a problem with a fuelhydraulic system on a UK-owned aircraft. They were cleared for flight on 12 February 2013.⁵⁶ Later that month, the entire F-35 fleet were briefly grounded in February 2013 after the discovery of a crack in a turbine blade.⁵⁷

A Pentagon report from February 2013, publicised in March, cited performance deficiencies in radar, the helmet-mounted display and the touch screen interfaces.⁵⁸

Relations between Lockheed Martin and the partner Governments have at times appeared fraught. In September 2012 the head of the Pentagon's F-35 programme office, Lieutenant General Chris Bogdan, described his office's relationship with Lockheed Martin as “the worst I've ever seen.”

The eight international partners had what was described as a “lively meeting” in Australia in March 2012 amid concerns at delays, cost increases and the potential consequences of the US slowing its procurement for partner nations.⁵⁹

The retiring general manager of programme integration at Lockheed Martin admitted running the F-35 programme was more complicated than running some companies. He said the company had learnt some hard lessons, including not fully appreciating the need to have everyone involved using the same information technology systems from the start to enable a seamless share of data.⁶⁰

Trevor Taylor, in exploring the financial risks of the F-35 programme to the UK, has suggested that the UK has little choice but to stay with the programme as any withdrawal by the British would be a “massive vote of no confidence in the programme” and could precipitate a “significant crisis in US-UK relations in general.” Not installing catapults on the Carriers has also locked the UK in to the F-35B as it is the only combat aircraft type in the world that “can be operated from such ships.” Mr Taylor points out that the UK does not know the precise capabilities of the F-35s it will eventually possess, when they will be delivered and how much they will cost. He raises the possibility the US could, under financial pressure, cancel the F-35B, leaving the UK in “a very difficult position.”⁶¹

⁵⁴ “F-35 Joint Strike Fighter: Current Outlook Is Improved, but Long-Term Affordability Is a Major Concern”, *US Government Accountability Office*, March 2013

⁵⁵ “Panetta lifts F-35 Fighter Variant probation”, *American Forces Press Service*, 20 January 2012

⁵⁶ “F-35B cleared for flight testing”, *Jane's Defence Weekly*, 14 February 2013

⁵⁷ “Safety inspection clears F-35 fleet to resume flight operations”, *Jane's Defence Weekly*, 1 March 2013

⁵⁸ “GAO raises F-35 life-cycle cost fears”, *Jane's Defence Weekly*, 12 March 2013

⁵⁹ “JSF partner nations endorse US plans for crackdown on costs, delays”, *Jane's Defence Weekly*, 15 March 2012

⁶⁰ “Outgoing Lockheed F-35 chief reflects on program”, *Defence News*, 29 March 2013

⁶¹ T Taylor, “Que Sera, Sera: the UK and the F-35”, *RUSI Newsbrief*, March 2013, Vol 33, no 2

10 Partner countries

The Joint Strike Fighter is a multinational programme involving eight countries. The US is the lead developer and will be, by far, the largest purchaser of the F-35: it intends to buy 2,457 aircraft in total: the F-35A for the Air Force, the F-35B STOVL for the Marine Corps and the F-35C for the Navy. The F-35 JSF programme is the Pentagon's largest procurement programme.⁶²

Eight other countries are involved with the UK being the only tier one partner. Italy and the Netherlands are level 2 partners and the remaining level 3 partners are Australia, Canada, Denmark, Norway and Turkey.⁶³ Israel and Singapore are Security Cooperative Participants. Tier one status gives the UK significant influence through the System Development and Demonstration phase and means its requirements are formally incorporated into the Joint Operational Requirements Document.

Exact figures on numbers of JSF to be procured by each partner nation, and other countries who have selected the F35, are not finalised. Individual countries have stated the overall numbers they wish to purchase but, like the UK, have yet to fully commit. Pressures on defence budgets, and the rising costs associated with the programme, may lead to further reductions in orders. Italy, for example, has cut its order by 41 aircraft as part of a wider effort to reduce its defence budget.

The F-35B variant is being developed for the US Marine Corps, the UK and for the Italian Navy and Air Force (Italy is also purchasing the F-35A for its Air Force). The F-35A variant is expected to make up the bulk of international orders.

- Australia intends to eventually buy up to 100 F-35A and has ordered 14 but is only contractually obliged to take delivery of two for testing and evaluation in 2014.⁶⁴
- Turkey is expected to buy about 100 F-35A aircraft. It committed to purchasing two aircraft in January 2012.⁶⁵
- Norway is expected to order up to 52 F-35s, four less than originally envisaged. It placed an order for four in June 2011, to be delivered in 2015 and 2016, with the main batch to start deliveries in 2017.⁶⁶
- The Netherlands signed a contract for a second F-35 in June 2011.⁶⁷ However the Ministry of Defence has invited alternative bids to replace the Air Force's F-16s and in April 2013 grounded its two test aircraft. A decision on whether to continue purchasing the F-35 will be made at the end of the year.⁶⁸
- Israel ordered 20 F-35s in October 2011 and is expected to buy 10 altogether.⁶⁹

⁶² "F-35 Joint Strike Fighter (JSF) Program: Background and Issues for Congress", *Congressional Research Service*, 16 February 2012 RL30563

⁶³ The financial contribution of each nation is available on the [JSF website](#)

⁶⁴ "Australia to review F-35 timetable", *Jane's Defence Weekly*, 30 January 2012

⁶⁵ "Turkey approves F-35 purchase", *Jane's Defence Industry*, 6 January 2012

⁶⁶ "Lockheed completes fit check of Norwegian JSM missile on F-35", *airforce-technology.com*, 15 March 2013

⁶⁷ "Dutch buy second F-35", *Jane's Defence Weekly*, 10 June 2011

⁶⁸ "Netherlands halts F-35 test flights", *Jane's Defence Weekly*, 8 April 2013

⁶⁹ "Israel unveils base plans for F-35", *Jane's Defence Weekly*, 24 November 2011

- Canada said in July 2010 it intends to purchase 65 F-35s.⁷⁰ However the Canadian government has since capped its funding for the project and transferred responsibility for it from the Department of National Defence to the Department of Public Works, in response to a critical Auditor General report into the F-35 in April 2012. The Public Works Minister said Canada will not purchase new aircraft until further due diligence, oversight and transparency is applied.⁷¹ Canada is actively seeking alternatives to the F-35.⁷²
- Italy has cut its intended order of 131 aircraft by 41, to 90 aircraft, because of cuts to national defence spending.⁷³
- Denmark is a consortium member but has yet to make a decision on what will replace its F-16s and in late 2012 reopened its fighter procurement competition. A decision is not expected before mid-2015.⁷⁴

Japan is the first international buyer not to be a member of the consortium. It selected the F-35 for its next-generation combat aircraft in December 2011 and intends to buy 42 aircraft. The total cost over a twenty year period is estimated to be \$20.5 billion.⁷⁵ Tom Burbage, the Lockheed Martin general manager of the F-35 program integration, noted in recent comments that the US pivot to the Pacific has had a big effect on the Joint Strike Fighter programme as a whole, leading to two new partners in Japan and potentially South Korea. He said “those countries, by the way, are bigger quantity buyers than almost every one of the European buyers, so as they do come online they can help on this production.”⁷⁶ South Korea will purchase 60 aircraft and is currently running a competition (FX-III) to decide which aircraft to procure (it is between the F-35A, Typhoon and Boeing’s F-15SE Silent Eagle concept) and a decision is expected in 2013.⁷⁷

11 Industry

Lockheed Martin is the F-35 prime contractor, while Northrop Grumman and BAE Systems are principal partners in the project. The JSF UK Industry Team is an informal alliance between BAE Systems, Cobham, GE Aviation, Honeywell, Martin-Baker, MBDA, Qinetiq, Rolls-Royce, SELEX Galileo, Ultra Electronics and EDM Ltd.⁷⁸

The tier-1 partner status of the UK means 15% of the aircraft’s components are manufactured in the UK which the Ministry of Defence says secures “more than 25,000 jobs.”⁷⁹

⁷⁰ “Canada selects F-35 JSF”, *Jane’s Defence Industry*, 19 July 2010

⁷¹ “Canada caps F-35 funding after audit”, *Defence News*, 8 April 2012

⁷² “Canada looks for JSF alternatives”, *Jane’s Defence Weekly*, 30 January 2013

⁷³ “Italian defence ministry announces austerity cuts”, *Jane’s Intelligence Weekly*, 16 February 2012

⁷⁴ “Denmark restarting fighter procurement competition”, *Jane’s Defence Weekly*, 11 December 2012

⁷⁵ “Japan selects F-35 as next generation fighter”, *Jane’s Defence Weekly*, 21 December 2011

⁷⁶ “Outgoing Lockheed F-35 chief reflects on program”, *Defence News*, 29 March 2013

⁷⁷ “Air superiority: South Korea’s FX-III race a contest between proven and potential”, *Jane’s Defence Weekly*, 8 November 2012

⁷⁸ More information about the JSF UK Industry team can be found on its website

<http://www.jsf.org.uk/home.aspx>

⁷⁹ HC Deb 26 November 2012 c6

The previous Labour government said: “over the lifetime of the JSF programme, depending on aircraft costs and numbers ordered, overall expenditure with UK industry is likely to outweigh by far the UK MOD’s investment in the programme.”⁸⁰

Approximately 120 UK companies are in the supply chain.⁸¹

12 The Catapults and arrestor gear debate

The cost of modifying the two aircraft carriers to accept the F-35C variant and the consequent three year delay to operational carrier strike capability were among the reasons cited by the Defence Secretary in the decision to revert back to the F-35B variant. During the period between the 2010 SDSR and the 2012 reversal, the implications of fitting catapults and arrestor gear to the carriers was heavily debated.

The Carrier variant of the Joint Strike Fighter requires the fitting of catapults and arrestor gear to the landing deck, also known as ‘cats and traps’, or more officially the aircraft launch and recovery system. This is required to catapult the aircraft off the flight deck and ‘trap’ it when it lands. The Government was looking particularly at the US Electro-Magnetic Aircraft Launch System (EMALS) catapult and the US Advanced Arrestor Gear (AAG) recovery system.^{82 83}

Philip Hammond cited the cost of adapting the carriers and the subsequent delay to the carrier’s in-service date as the reasons why he decided to not proceed with the Carrier variant (the F-35C) and instead complete both carriers in the STOVL configuration (the F-35B). He argued the decision provides greater optionality as it enables the next government, when it considers the future of the second carrier in its 2015 SDSR, to use both carriers if it wants to. He said the costs of converting the second carrier to cats and traps were so high – likely to be between £3.5 billion and £3 billion – as to make it unlikely ever to occur. He criticised the previous government for ordering two 65,000 tonne carriers “three times the size of a typical STOVL carrier, without cats and traps”.⁸⁴

The reversal to STOVL followed several media reports expressing concerns about the catapults and arrestor gear. *The Daily Telegraph* reported in March the costs of adapting the carrier flight deck have “risen from £500 million to £1.8 billion”⁸⁵. Operational concerns cited in press and official reports include the positioning of the arrestor hook on the aircraft; risks associated with the Electro-Magnetic Aircraft Launch System (the catapult); the potential need for an air-to-air refuelling capability for when aircraft cannot land on the flight deck; and the lack of experience in the UK with operating the carrier variant.^{86 87} Pete Symonds of the

⁸⁰ HC Deb, 18 March 2009, c54WS

⁸¹ A list of UK companies involved in the F-35 programme is available in the following article: S Mitchell, “[F-35 – getting the UK’s largest defence export opportunity on track](#)”, *RUSI Defence Systems*, Summer 2012

⁸² HC Deb 23 March 2011 c398W

⁸³ More information about EMALS is available on [Defence Industry Daily](#), 21 December 2011

⁸⁴ HC Deb 10 May 2012 c144

⁸⁵ “[Costs of refitting aircraft carrier trebles](#)”, *Daily Telegraph*, 12 March 2012

⁸⁶ “[Choosing plan B: Reviewing the UK’s choice of Joint Strike Fighter](#)”, *RUSI analysis*, 23 March 2012

⁸⁷ “[Choosing plan B: Reviewing the UK’s choice of Joint Strike Fighter](#)”, *RUSI analysis*, 23 March 2012 and “[Carrier Strike](#)”, National Audit Office, HC1092, 2010-2012, 7 July 2011

Aircraft Carrier Alliance explained the difference between the F-35B and F-35C for carrier use as “with STOVL landing you stop and land; CV landing is land and stop.”⁸⁸

Shadow Defence Secretary Jim Murphy wrote in early March 2012 to the Secretary of State for Defence asking “whether any consideration is being given to reversing the decision to abandon the Short Take-Off and Vertical Landing variant of the F-35.”⁸⁹

The Public Accounts Committee (PAC) report into the UK’s Carrier Strike Capability expressed concern that the “technology proposed has yet to be tested and the version the UK intends to buy will be unique to Britain.” The PAC warned that not knowing the conversion costs leaves “the project at risk of cost growth and slippage, and there are new technical risks and challenges integrating the new aircraft with the carriers.”⁹⁰

In his May 2012 statement, Mr Hammond said fitting the EMALS “to a UK carrier has presented greater design challenges than were anticipated”. He said the estimated cost of fitting this equipment to HMS Prince of Wales has more than doubled in the past 17 months, from an estimated £950 million to about £2 billion “with no guarantees that it will not rise further”. He also said that the cost of retrofitting ‘cats and traps’ to HMS Queen Elizabeth, the first carrier out of build, would be even higher, making it “unlikely that she would ever, in practice, be converted in the future”.

⁸⁸ “All hands on deck”, *Desider magazine*, January 2012, p18

⁸⁹ [Letter from Jim Murphy to Philip Hammond](#), Defence Management, 2 March 2012

⁹⁰ Public Accounts Committee, *Providing the UK’s Carrier Strike Capability*, HC1427, 2010-12, summary

Appendix: Comparison of the F-35B and F-35C variants

	F-35B	F-35C
Length	51.2 ft / 15.6m	51.5 ft / 15.7m
Height	14.3 ft / 4.36m	14.7 ft / 4.48m
Wingspan	35 ft / 10.7m	43 ft / 13.1m
Wing area	460 sq ft / 42.7 sq m	668 sq ft / 62.1 sq m
Horizontal tail span	21.8 ft / 6.65 m	26.3 ft / 8.02 m
Weight empty	32,300 lb	34,800 lb
Internal fuel capacity	13,500 lb / 6,125 kg	19,750 lb / 8,960kg
Weapons payload	15,000 lb / 6,800 kg	18,000 lb / 8,160 kg
Standard internal weapons load	Two AIM-120C air-to-air missiles Two 1,000-pound GBU-32 JDAM guided bombs	Two AIM-120C air-to-air missiles Two 2,000-pound GBU-31 JDAM guided bombs
Maximum weight	60,000 lb class	70,000 lb class
Propulsion* (uninstalled thrust ratings)	F135-PW-600 38,000 lb Max. 26,000 lb Mil. 40,500 lb Vertical	F135-PW-100 40,000 lb Max. 25,000 lb Mil.
Speed (full internal weapons load)	Mach 1.6 (~1,200 mph)	Mach 1.6 (~1,200 mph)
Combat radius (internal fuel)	>450 nm / 833km	>600 nm / 1,100km
Range (internal fuel)	>900 nm / 1,667 km	>1,200 nm / 2,200 km
Max g-rating	7	7.5

* Maximum Power (Max) = with afterburner; Military Power (Mil) = without afterburner;
Vertical = without afterburner

[Source: Lockheed Martin website, [F-35 Lightning II](#) – undated, viewed 19 March 2012]