



The UK's F-35 Lightning II Joint Strike Fighter

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The F-35 Lightning II Joint Strike Fighter is the new combat aircraft for the Royal Air Force and the Royal Navy. It is a fifth generation multi-role fighter with stealth capabilities.

Lightning II will partner Typhoon to provide the RAF's future fast-jet fleet from 2019 and provide the carrier strike capability for the new Queen Elizabeth-class Aircraft Carriers from 2020 onwards.

The programme is forecast to cost just over £5 billion so far. The bulk order not expected to be placed until 2017. The total fleet size is not expected to be confirmed until the next Strategic and Defence Review at the earliest.

The UK is buying the Short Take-Off and Vertical Landing (STOVL) variant, one of three variants produced by Lockheed Martin. This variant was selected in 2002 but in 2010 the new Government controversially switched to the Carrier variant. This had a knock-on effect of delaying into service the new aircraft carriers currently under construction. In 2012 the Government reversed its position and recommitted to the STOVL variant.

This note provides a short history of the programme for the United Kingdom.

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Contents

1	Introduction	3
2	Key Facts	4
3	Background: short history of the programme	5
	3.1 The Origins of the Joint Strike Fighter	5
	3.2 Selecting the F-35 Joint Strike Fighter	6
	3.3 Switching to the Carrier variant	7
	3.4 Back to STOVL	8
4	What can Lightning II do?	10
	4.1 Weapons	13
5	How many aircraft?	13
6	In service dates	14
7	Cost of the Lightning II programme	15
	7.1 Orders placed	16
	Chronology of main gate orders	16
	Main Gate 4	17
8	The first squadrons	18
	8.1 Training in the United States of America	18
	Videos of F-35B	19
9	Interoperability	20
10	Concerns about the F-35	21
11	Industry and partner countries	22
	Appendix: Comparison of the F-35B and F-35C variants	24

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 Minister.¹ 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. Lightning II will form part of the future fast jet fleet for the RAF alongside the Typhoon, after Tornado retires. 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.

Lightning II is a multirole ‘fifth’ generation fighter aircraft with stealth capabilities.² The programme is led and principally funded by the American Department of Defence (DOD) and is under development in the US. It is the Pentagon’s most expensive programme and has been beset by delays, spiralling costs and developmental problems.

Lockheed Martin is the F-35 prime contractor and was awarded the contract by the DOD in 2001. UK companies have contracts worth “15% by value of the work on each aircraft.”³

Three variants of the aircraft are in production. The UK will operate the Short Take-Off and Vertical Landing (STOVL) variant of the F-35, the same as the US Marine Corps. Upon taking office in 2010 the Government opted against this variant, selected by its predecessor in 2002, and switched to the Carrier variant. It then controversially reverted back to the STOVL variant in 2012.

The total number of aircraft the UK will order has yet to be decided by the Government but the original 150 aircraft is not expected to be realised. So far the Government has approved the purchase of 14 aircraft to provide the first operational squadron, plus four aircraft for testing and training purposes. The total fleet size may not be announced until the fifth and final main gate in 2017, although the next Strategic Defence and Security Review, due after the 2015 election, may provide clarity on this.

The expected cost of the programme so far is just over £5 billion.

Lightning II has an in-service date of 31 December 2018 from land and 2020 from sea. The aircraft will be based at RAF Marham in Norfolk and the fleet is expected to remain in service until 2048.⁴

A note on terminology: The Government and Armed Forces now refer to the aircraft as Lightning II. However historically it has also been referred to as the Joint Strike Fighter, the F-35 and the Joint Combat Aircraft programme. The F-35 is more commonly used in the United States and international media. This note predominantly uses Lightning II.

¹ HC Deb 19 October 2010 c800

² More information about the JSF can be found on the JSF website: <http://www.jsf.mil>

³ 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

⁴ HC Deb 30 June 2014 c356W

2 Key Facts

- A fifth generation multirole stealth combat aircraft
- Known as Lightning II in UK service
- UK to operate the Short Take-Off and Vertical Landing (STOVL) variant
- Will partner Typhoon to provide the RAF's future fast-jet combat fleet
- Will provide Carrier Strike for the Royal Navy from the new aircraft carriers
- To be operated jointly by the Royal Air Force and Royal Navy

- UK taken delivery of three aircraft with five more on order
- Bulk buy to be in fifth and final Main Gate in 2017
- Total number of aircraft to be procured and total cost not expected until 2017
- Expected cost of the programme so far is just over £5 billion

- Initial operating capability from land in December 2018
- Initial operating capability from sea (Carrier Strike) in 2020

- Aircraft to be based at RAF Marham
- UK personnel and aircraft currently based in the United States
- First two squadrons named: 617 squadron and 809 squadron
- 617 'Dambusters' squadron to stand up in 2016

3 Background: short history of the programme

Developing and delivering into service combat aircraft takes decades. The current fast-jet fleet of Tornado and Typhoon were first conceived in the late 1960s and 1980s respectively. The Harrier, the most recent combat aircraft to leave service, can trace its lineage back to the 1960s when the first Harrier variant flew for the RAF.

The selection of the F-35 Lightning II Joint Strike Fighter in 2001 was the culmination of originally separate programmes by the Royal Navy and RAF to replace the Harrier and Tornado fleets.

The UK now operates two fast-jet combat aircraft types. At present these are the Typhoon and Tornado GR4. The latter will be run down broadly in line with the build-up of the Typhoon force and the introduction of Lightning II at the end of decade.⁵ From 2020 onwards RAF's fast-jet combat fleet will consist of Typhoon and Lightning II.

Lightning II will also provide the carrier strike capability from the Royal Navy's two new aircraft carriers. The UK currently does not have a carrier strike capability. The Government announced a ten year gap in carrier strike in the 2010 Strategic Defence and Security Review when it decided to retire the Harrier fleet, retire HMS Ark Royal and convert HMS Illustrious from a fixed-wing to a rotary-wing carrier. Lightning II is expected to be operational from land from December 2018 and from sea in 2020.

3.1 The Origins of the Joint Strike Fighter

In the late 1990s the Ministry of Defence turned its attention to the need to replace both the Carrier-borne aircraft, then provided for by the Sea Harriers and, slightly further ahead, the offensive capabilities of the Tornado GR3 fleet. At the time, the MOD was in the midst of procuring the Eurofighter Typhoon aircraft in an air defence and offensive air support role. The MOD was also debating whether to replace the Invincible-class aircraft carriers, expected to go out of service around 2010, and what aircraft would fly off them. These thoughts crystallised around two programmes, which were fleshed out in the 1998 *Strategic Defence Review: The Future Carrier Borne Aircraft/Future Joint Combat Aircraft* and the *Future Offensive Air System*.

The Future Carrier Borne Aircraft/Future Joint Combat Aircraft

The Future Carrier Borne Aircraft programme was originally conceived in 1996 to replace the capabilities provided by the Royal Navy Sea Harrier on the Invincible-class carriers.⁶ The Joint Strike Fighter under development in the United States was identified by the Government in 1995 as a strong contender for this programme.⁷

The 1998 *Strategic Defence Review* concluded in favour of procuring two new aircraft carriers, arguing that there is a "continuing need for Britain to have the capability offered by aircraft carriers."⁸ This, therefore, required new carrier-borne aircraft to operate from them.

The SDR also established a Joint Force Harrier (JFH) force combining the different Royal Navy and RAF Harrier aircraft fleets. This was created in 2000.⁹ This set the tone for current plans for the Lightning II to be operated jointly by the RN and RAF.

⁵ HC Deb 25 June 2012 c5W

⁶ [HC Deb 1 December 2005 c678W](#)

⁷ HC Deb 20 December 1995 c1175w; The MOD was already a junior partner in the Joint Strike Fighter project which was then in the concept demonstration phase.

⁸ *Strategic Defence Review: supporting essays*, July 1998, 6.7-6.8

The Future Carrier Borne Aircraft Programme was renamed as the Future Joint Combat Aircraft in the aftermath of the 1998 SDR and the decision to create Joint Force Harrier, to reflect the fact the programme was now seeking to replace both the Sea Harrier and the RAF Harrier GR7/9 with a common aircraft type that could be operated from land and sea.¹⁰

The Future Offensive Air System: Replacing Tornado GR4

The 1998 SDR also discussed what might replace the RAF's Tornado GR fleet in the offensive support role when it left service in the mid-2020s. The 'Future Offensive Air System' programme was to examine manned and unmanned systems with a view to selecting an aircraft to enter service in 2018.¹¹ The project never reached initial gate and was closed down in 2005.¹² The capabilities required by the RAF for offensive support was rolled into the Joint Combat Aircraft programme.

The Tornado GR4 is the only Tornado type still in service and is expected to leave service in 2019. Lightning II is not a like-for-like replacement for the Tornado GR4, but the capabilities it currently provides will be provided by the combined fleet of Typhoon and Lightning II.¹³

3.2 Selecting the F-35 Joint Strike Fighter

In 2001 the MOD formally selected the Joint Strike Fighter aircraft to meet its Future Joint Combat Aircraft requirement to replace the Harrier Fleet.

At the time the planning assumption was for 150 aircraft and in service date of 2012. The cost was estimated to be up to £10 billion, although this estimated was dependent on the numbers of aircraft required, variant selected and life support costs.¹⁴

In January 2001 the UK signed a Memorandum of Understanding with the United States to cover the UK's entry into the engineering and manufacturing development (EMD) phase of the joint strike fighter programme. This committed the UK to \$2 billion in development costs.¹⁵

The Government had not then decided on which of the three variants being developed by Lockheed Martin to buy. All three are single engine, single pilot aircraft:

- F-35A Conventional Take-off and Landing (CTOL)
- F-35B Short Take-off/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.

⁹ In 2002 this consisted of two aircraft types: Sea Harrier FA2, an air defence aircraft flown by RN personnel, and Harrier GR7, a ground attack/reconnaissance aircraft flown by RAF personnel. The Government announced plans to retire the Sea Harrier in 2006 and upgrade the GR7 to GR9 standard. HC Deb 28 February 2002, c1451-2w.

¹⁰ HC Deb 3 July 2001 c96W

¹¹ Tom Dodd, *The Strategic Defence Review White Paper*, House of Commons Library Research Paper RP98/91, 15 October 1998; HC Deb 4 February 1999 c735W

¹² "Paris air show: UK MOD scraps FOAS in favour of SUAVE approach", *Jane's Defence Weekly*, 15 June 2005; & "Future Offensive Air System (FOAS)", *Global Security*, accessed 4 July 2014

¹³ HC Deb 10 June 2013 c17W

¹⁴ HC Deb 18 December 2001 c172W; HC Deb 18 April 2012 c1074W; HC Deb 29 April 2002 c530W

¹⁵ *ibid*

At the time opinion within the Ministry of Defence and the services was split between the conventional and the short take-off variants. RAF Wing Cdr Mark Green, JCA integrated project team requirements manager, said in June 2002:

The decision to be made between the STOVL and CTOL variants will be a difficult one. They are being viewed as equal competitors. Our final decision will be informed by the results of the current concept demonstration phase, study work to examine the UK's future offensive air capability, and a range of 'softer' issues such as our concept of operations.¹⁶

The F-35B Short Take-off and Vertical Landing (STOVL) variant was chosen in September 2002 because it would mean any aircraft from the Future Joint Combat Aircraft fleet would be capable of operating from land and sea, unlike the F-35A, and also reflect the services' long experience with Harrier aircraft.¹⁷ A comparison of the STOVL (B) and CTOL (C) variants is provided in the appendix.

The Government said the decision "builds on our unique and valuable knowledge of STOVL aircraft acquired during nearly four decades of operations with Harrier on land and at sea."¹⁸ Chief of the Air Staff Air Chief Marshal Sir Peter Squire said of the choice between the STOVL and Carrier Variant: "both types of aircraft [STOVL and CV] meet our requirements in terms of range and weapons on target, but the flexibility of the STOVL variant is a significant factor."¹⁹

3.3 Switching to the Carrier variant

One of the headline announcements of the Strategic Defence and Security Review of 2010 was the decision to switch to the conventional carrier variant (CV) rather than the Short Take-Off and Vertical Landing variant (STOVL) chosen by the previous Government. Doing so would also require adapting the flight deck of one of the aircraft carriers then under construction which would delay the carrier's in-service date. The Government also opted to retire the entire Harrier fleet, retire HMS Ark Royal and use HMS Illustrious as a helicopter carrier. These decisions would leave the UK without a carrier strike capability for a decade.

Prime Minister 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."²⁰ The SDSR said: "overall, the carrier-variant of the JSF will be cheaper, reducing through-life costs by around 25%." The SDSR also reaffirmed the position of the MOD to operate a single model of the Joint Strike Fighter rather than operate different land and naval variants – thus ruling out the option of ordering the F-35A for the Air Force and the F-35B or C for the Navy.

The costs of adapting the flight deck become clear

The STOVL and Carrier variants require different flight decks. The F-35C requires catapults and arrestor gear to launch the aircraft off the aircraft and trap it when it lands. This is formally known as the aircraft launch and recovery system or informally as 'cats and traps'. The F-35B will take advantage of an angled flight deck (ski jump) on the new carriers and will land vertically.

¹⁶ "Renamed aircraft project reflects joint RN/RAF role", *Jane's Defence Weekly*, 1 June 2002

¹⁷ [HC Deb 24 October 2002 c429W](#)

¹⁸ [HC Deb 7 November 2002 c470W](#)

¹⁹ "UK commits to STOVL future", *Jane's Defence Weekly*, 4 October 2002

²⁰ HC Deb 19 October 2010 c800

The SDSR proposed converting one of the two carrier's under construction²¹ with the required catapults and arrestor gear and the MOD commissioned a detailed programme of work to look at the costs, risks and technical feasibility of this. At the time the Government was particularly interested in the new US Electro-Magnetic Aircraft Launch System (EMALS) catapult and the US Advanced Arrestor Gear (AAG) recovery system.²²

However concerns about the cost of adapting the flight deck soon became apparent. The Public Accounts Committee (PAC) noted in late 2011 that the "technology proposed has yet to be tested and the version the UK intends to buy will be unique to Britain." The Committee 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."²³

By spring 2012 there were reports the cost had spiralled from £500 million to £1.8 billion.²⁴ 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 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.²⁵ On the latter point, Pete Symonds of the 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."²⁶

Shadow Defence Secretary Jim Murphy wrote to the Secretary of State for Defence in March 2012 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."²⁷

3.4 Back to STOVL

In May 2012 the Government announced it would not proceed with plans to change the carrier flight deck and was reverting back to the F-35B variant.

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.

Mr Hammond said "a number of the underlying facts on which the SDSR decision on carriers was based were changing."²⁸ Fitting the EMALS "to a UK carrier has presented greater design challenges than were anticipated". The costs of fitting the equipment to HMS Prince of Wales had doubled from an estimated £950 million to £2 billion. While retrofitting 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".

²¹ The SDSR left open the future use of the second aircraft carrier. The Prime Minister announced in September 2014 the second carrier will enter service.

²² HC Deb 23 March 2011 c398W; More information about EMALS is available on [Defence Industry Daily](#), 21 December 2011

²³ Public Accounts Committee, [Providing the UK's Carrier Strike Capability](#), 29 November 2011, HC 1427 2010-12, summary

²⁴ "Costs of refitting aircraft carrier trebles", *Daily Telegraph*, 12 March 2012

²⁵ [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

²⁶ "All hands on deck", *Desider magazine*, January 2012, p18

²⁷ [Letter from Jim Murphy to Philip Hammond](#), Defence Management, 2 March 2012

²⁸ [HC Deb 10 May 2012 c140](#)

Mr Hammond argued the problems that had dogged the F-35B variant at the time of the 2010 SDSR had largely been resolved. The F-35B variant was at one stage under threat of cancellation and the programme was put on probation in January 2011.²⁹ With the probation period lifted in January 2012, Mr Hammond said “the balance of risk has changed, and there is now judged to be no greater risk in STOVL than in other variants of JSF.”

In summary, the reasons given by the MOD for switching back to the F-35B were:

- 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 – the catapult system) to HMS Prince of Wales had more than doubled from an estimated £950 million to about £2 billion
- 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 year³⁰
- 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
- Risk to the MOD’s overall equipment plan because of the increased costs of the Carrier programme.³¹

The Shadow Defence Secretary was scathing in his response to the announcement, describing the carrier programme as “chaotic” and a waste of two years and an estimated £250 million.³²

The decision was and continues to be much debated.³³

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

²⁹ “Gates reveals budget efficiencies, reinvestment opportunities”, *American Forces Press Service*, 6 January 2012 “Panetta lifts F-35 probation”, *Aviation Week*, 23 January 2012; “Panetta lifts F-35 Fighter Variant probation”, *American Forces Press Service*, 20 January 2012

³⁰ At the time the decision on the future of the second carrier was not expected to be made until the 2015 SDSR. However in September 2014 the Prime Minister announced at the NATO summit the second carrier will enter service.

³¹ HC Deb 10 May 2012 c140

³² HC Deb 10 May 2012 c143

³³ See Nick Childs, *Britain’s Future Navy*, 2014, chapter 6 for a detailed history of the evolution of the carrier programme and tensions between the RAF and Royal Navy over the choice of aircraft.

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 2010.³⁴

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 battle space of the 21st century. They can both carry the full range of weapons we intend to buy.³⁵

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 on-board the carriers and the resultant reliance on land-based aircraft.³⁶

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 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.³⁷

4 What can Lightning II do?

Lightning II is a multi-role stealth combat aircraft. It will provide a “step-change in the UK’s combat air capability”³⁸ according to one Defence Minister, while manufacturer Lockheed Martin describe it as the “most flexible, technologically sophisticated multirole fighter ever built.”³⁹

³⁴ [“This change of course on aircraft carriers is essential”](#), *Daily Telegraph*, 10 May 2012

³⁵ Ibid

³⁶ C Parry, “The United Kingdom’s Future Carriers”, *RUSI Journal*, 19 December 2012 157:6, 4-9

³⁷ [“Defence in the media: 7 January 2013”](#), *Ministry of Defence*

³⁸ PQ 207652, 8 September 2014

³⁹ [F-35 website](#), accessed 30 January 2015

Specifically, it will be able to conduct a full range of missions traditionally performed by specialised aircraft. This includes air-to-air combat, air-to-ground strikes, electronic attack, intelligence, surveillance and reconnaissance. It is expected to be a first strike aircraft using its stealthy characteristics to avoid enemy radar.

617 Squadron will be expected to initially conduct air interdiction, close air support, offensive counter air, defensive counter air and suppression/destruction of enemy air defences. Lightning II will also be able to provide strategic attack, counter surface operations, electronic attack and ISR (intelligence, surveillance, reconnaissance).⁴⁰

Lightning II is described as a fifth generation fighter.⁴¹ Lockheed Martin says “a 5th Generation fighter has advanced stealth, exceptional agility and manoeuvrability, sensor and information fusion, network-enabled operations and advanced sustainment.”⁴²

To illustrate the range the F-35 offers, it might be helpful to compare it to some of the RAF’s current and past fast-jet fleets.

Defence Minister Philip Dunne directly compared Lightning II to the Harrier, which was retired by the 2010 SDSR:

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.⁴³

The now mostly retired Tornado family of aircraft were designed to perform different functions, with the GR1 and GR1B primarily offensive aircraft, F3/E-3D defensive aircraft and the GR1A as a reconnaissance aircraft. The Tornado GR4 is the RAF’s current primary ground attack and reconnaissance aircraft and is slated to retire in 2019.

Lightning II will partner Typhoon. Typhoon was originally built as an air-to-air combat fighter though it is now undergoing a major upgrade to enable it to provide a ground attack capability, which some aircraft did in Libya in 2011. It is expected to continue its air defence role known as Quick Reaction Alert after Lightning II enters service.

Justin Brock has explored how the RAF could get the best out of the F-35 and Typhoon:

Given its stealth, electronic warfare capabilities and unparalleled sensor suite, the F-35 could perform excellently as an ‘information sponge’ at medium altitude, providing awareness of ground- and air-based threats to the larger Typhoon force in contested air environments and co-ordinating, for example, the suppression of enemy air-defence networks from a position of relative invulnerability. In effect, a handful of F-35s could provide the RAF with ISTAR and situational awareness capabilities within defended airspace where traditional surveillance platforms such as E-3 AWACS and E-8 Joint-STARS would be unable to operate.

[...]

⁴⁰ “F-35 Lightning II: an air warfare revolution”, *Air International F-35 Special 2014*, p138

⁴¹ [Airforce-technology](#) provides a useful comparison of the F-35 with other advanced fighter aircraft on its website.

⁴² “[The Multi-variant, Multirole 5th Generation Fighter](#)”, *F-35 Lightning II website*, accessed 16 July 2014

⁴³ HC Deb 19 November 2012 c234W

The Typhoon force, by operating at very high altitudes or with standoff munitions such as the Storm Shadow missile, could allow the RAF to fully use the potential of both aircraft. F-35s could find and designate priority targets within defended airspace for the Typhoon force to attack from a relatively safe distance with their greater ordnance capacity. If the airspace in question were too dangerous for Typhoon to enter, the F-35 could be used to provide precision ISTAR and targeting for cruise missiles, as well as delivering its own precision strikes against high-threat air defence assets, thereby providing a window for the Typhoon force to deliver the main strike weight. In other words, the F-35 force should allow British airpower to perform a 'day one' suppression of enemy air defences (SEAD) against a near-peer opponent *in extremis*, if properly co-ordinated with the more numerous and heavily armed, but non-stealthy Typhoons.⁴⁴

Capabilities:

- Advanced electronic warfare: to locate and track enemy forces, jam radars and disrupt attacks; immediate data links with commanders at sea, in the air or on the ground.
- Air-to-surface: low observable stealth, active electronically scanned array radar technology; internal weapons bay. Designed to enter the battlespace first.
- Air-to-Air: integrated sensors, information and weapons systems. Greater ability to detect other aircraft first.
- Intelligence, Surveillance and Reconnaissance (ISR): pilots have real-time, 360-degree access to battlefield information captured from its advanced sensor suite. Data can be shared securely with commanders at sea, in the air and on the ground, providing a comprehensive view of operations. Electro-Optical Targeting System (EOTS) recommends to the pilot which target to attack.
- Stealth: integrated airframe design, advanced materials and other features make the F-35 virtually undetectable to enemy radar.
- Interoperability: F-35 shares data with other aircraft to expand situational aircraft across the entire network of aircraft.
- Helmet Mounted Display: information is projected on the helmet's visor rather than on a traditional Heads-up Display. Six infrared cameras mounted around the aircraft allow pilots to "look through" the airframe.⁴⁵

ALIS, or the Automatic Logistics Information System, is the operational and management system for the F-35. It will serve both the pilots, in terms of mission data and track pilot training, and the aircraft, by tracking maintenance data.

The software that underpins the F-35 is being released in six blocks. The software enables flight controls, radar functionality, communications, navigation and identification, electronic attack, sensor fusion and weapons deployment.⁴⁶

⁴⁴ J Brock, "Integrating Typhoon and F-35: the key to future British airpower", *RUSI Defence Systems*, 9 September 2014

⁴⁵ "Multi-Mission Capability for Emerging Global Threats", www.f-35.com, accessed 30 January 2015

⁴⁶ "A Digital Jet for the Modern Battlespace", *F-35 website*, accessed 16 July 2014

Of the three aircraft the MOD has taken delivery of, the two ordered in LRIP 3 are at Block 1A software standard and the third, ordered in LRIP 4, is at Block 2A standard.⁴⁷ Block 2B provides initial warfighting capabilities. The U.S. Marines will declare IOC with Block 2B. The final block is Block 3F provides 100% of the software.⁴⁸

4.1 Weapons

The Lightning II will be able to carry weapons internally, in weapon bays, and externally, on pylons.

The aircraft has 11 weapon stations which can carry air-to-air missiles, bombs and additional fuel tanks. The F-35B has a smaller internal weapons bay than the F-35A or F-35C – up to 1,000lb-class munitions rather than 2,000lb-class munitions.⁴⁹

According to the RAF a maximum weapon payload will consist of: 6 Paveway IV (precision-guided bomb), 2 AIM-120C AMRAAM (advanced medium-range air-to-air missile), 2 AIM-132 ASRAAM (advanced short-range air-to-air missile) and a missionised 25mm gun pod.⁵⁰

Initial Operational Capability is expected to comprise two air-to-air missiles (ASRAAM and AMRAAM) and Paveway IV.⁵¹

Future armaments include: Storm Shadow (long-range air to surface), SPEAR 1 (air-to-surface), and METEOR (beyond visual range air-to-air missile). In the longer term it is also expected to carry the MDBA SPEAR 3, a munition capable of striking a moving target from long-range and of swarming enemy defences with multiple munitions.⁵²

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.⁵³

5 How many aircraft?

The original planning assumption of 150 aircraft is not expected to be realised.⁵⁴ In July 2012 the Government has committed to 48 aircraft but has refused to be drawn on the total number of aircraft it expects to order.⁵⁵

Until early 2014 the Government had signalled the fleet size will be decided in the 2015 Strategic Defence and Security Review. However the Government has since suggested the final numbers to be ordered will not be confirmed until the fifth and final Main Gate in 2017.⁵⁶

⁴⁷ HC Deb 1 July 2014 c554W

⁴⁸ "A Digital Jet for the Modern Battlespace", www.f35.com, accessed 16 January 2015

⁴⁹ A full list of potential weapons and how they are mounted on the aircraft can be found in "F-35 Lightning II", *Air International F-35 Special 2014*, p45

⁵⁰ [F-35 Lightning II](#), accessed 12 April 2013

⁵¹ "F-35 Lightning II", *Air International F-35 Special 2014*, p139

⁵² "F-35 Lightning II", *Air International F-35 Special 2014*, p139

⁵³ "Lockheed completes fit check of Norwegian JSM missile on F-35", *Airforce-technology.com*, 15 March 2013

⁵⁴ This was stated clearly to the Defence Committee as late as September 2005: Defence Committee, *Future Carrier and Joint Combat Aircraft Programmes*, 21 December 2005, HC 554 2005-06, Ev 42, para 14. By 2007, the number had dropped to 138: "Details emerge of UK JSF deliveries", *Jane's Defence Weekly*, 5 November 2007

⁵⁵ "UK slashes F-35B numbers but might look to split buy with F-35As", *Jane's Defence Security Report*, 27 July 2012

⁵⁶ HC Deb 5 February 2014 c242W

It remains to be seen whether the 2015 SDSR explicitly states the final number of aircraft the UK expects to order.

Lightning II will be operated jointly by the Royal Navy and Royal Air Force and be deployable from sea - from the Queen Elizabeth-class aircraft carriers - and from land. Financial considerations will undoubtedly heavily influence the final fleet size.

The Royal Air Force will partner Lightning II with Typhoon as its future fast-jet fleet. By 2020 the RAF expects to have six Typhoon squadrons and one Lightning II squadron.⁵⁷ The RAF is also considering the future mix of manned and unmanned combat aircraft for the post-Typhoon period, i.e. 2030 onwards, and one option is to buy more Lightning II's.⁵⁸

In terms of estimating the number of aircraft the Royal Navy might need to provide a carrier strike capability, the 2010 SDSR envisaged regularly embarking 12 Lightning II aircraft for operations. The First Sea Lord, Admiral Sir George Zambellas has baldly said "there is no point in having the carriers without jets."

However the carriers may not always be deployed with fast jets. Under what the MOD calls Carrier Enabled Power Projection (CEPP), the Carrier is also expected to perform Littoral Manoeuvre operations, with rotary-wing aircraft. The Carrier can carry up to 36 Lightning II and four helicopters in a carrier strike role, or 40-45 helicopters in a Littoral manoeuvre role (acting in a manner of a landing platform helicopter⁵⁹), or a hybrid of the two. During evidence to the Defence Committee, Air Chief Marshal Sir Andrew Pulford noted the current requirement is to provide "100% capability of an aircraft carrier, either at sea or at readiness. Not 100% carrier strike at sea or at readiness." Although Admiral Zambellas added "fundamentally we will need enough jets to make those carriers credible as strategic assets."⁶⁰

6 In service dates

- Initial Operating Capability (land): 31 December 2018
- Initial Operating Capability (sea): 2020
- Out of Service date: 2048

A minimum of nine F-35B aircraft will equip the first front line squadron at Initial Operating Capability in 2020. This could be supplemented from other assets from across the fleet if required, the MOD said.⁶¹ Interestingly the MOD had previously resisted explicitly stating how many aircraft are required to provide Initial Operating Capability.⁶²

⁵⁷ Defence Committee, *Oral evidence: Future Force 2020*, 17 December 2014, HC 512, q296

⁵⁸ The other options are a Typhoon life extension, an unmanned combat aircraft or a new-build manned aircraft. Defence Committee, *Remote Control: Remotely Piloted Airy Systems – current and future UK use: Government Response*, 29 July 2014, HC 611

⁵⁹ HMS Ocean, the Navy's landing platform helicopter, is expected to leave service towards the end of this decade and there are currently no plans to provide a like-for-like replacement.

⁶⁰ Defence Committee, *Oral evidence Future Force 2020*, 5 November 2014, HC 512, q173-181

⁶¹ [PQ HL4167](#), 26 January 2015

⁶² See for example Michael Fallon and Air Chief Marshall Sir Stephen Hillier's response to Defence Committee Members questions during *Oral evidence: Future Force 2020*, 17 December 2014, HC 512 2014-15, q272-277. The number of aircraft in a squadron varies between ten and 16 aircraft.

The National Audit Office described IOC as “declaration of the ability of the UK Lightning Force to be able to undertake contingent operations.”⁶³ A senior RAF officer described IOC as the F-35 being able to contribute to warfighting operations, equipped with Advanced Short-Range and Advanced Medium-Range Air-to-Air missiles and Paveway IV bombs.⁶⁴

Full Operating Capability is expected to be declared in 2023.⁶⁵

July 2012	Delivery of first test aircraft
2016	First unit – 617 Squadron – to stand up
2017	Queen Elizabeth begins sea trials
2018	Aircraft begin test flights from Queen Elizabeth 31 December: Initial operating capability from land
2020	Carrier strike capability
2048	Scheduled out of service date

For comparison, the US Marine Corps, which is the US service which will also operate the F-35B STOVL, has an Initial Operational Capability date of mid-2015. This is for the first operational squadron equipped with 10 to 16 aircraft.⁶⁶

7 Cost of the Lightning II programme

The programme is forecast to cost just over £5 billion so far. This covers the demonstration and manufacture phase and the procurement of the first squadron of aircraft in Main Gate Four. This does not represent the expected total cost of the programme as this does not yet include the bulk purchase expected at Main Gate Five. Main Gate Four has an approved cost of £2.75 billion.⁶⁷

The Government has refused to be drawn on the likely overall total cost, citing concerns about protecting the department’s commercial negotiations. Defence Equipment Minister Philip Dunne has said that while the MOD has a detailed through-life cost estimate for the programme which forecasts all Main Gates, it is withholding that information because disclosure would prejudice commercial interests.⁶⁸ In 2003 the Government estimated Government estimated the procurement cost of the JSF programme to be up to £10 billion, dependent on the number of aircraft acquired and support costs.⁶⁹

⁶³ National Audit Office, *Major Projects Report 2014 and the Equipment Plan 2014 to 2014: Appendices and project summary sheets*, 13 January 2015, HC 941-II 2013-14, p110, table C.3.1

⁶⁴ “Learning to fly”, *Jane’s Defence Weekly*, 17 December 2014

⁶⁵ “UK orders first operational F-35 combat aircraft”, *Jane’s Defence Weekly*, 24 November 2014

⁶⁶ “F-35 Joint Strike Fighter (JSF) program”, *Congressional Research Service*, 29 April 2014, RL30563, p11

⁶⁷ National Audit Office, *Major Projects Report 2014 and the Equipment Plan 2014 to 2024*, 13 January 2015, HC 941-I and 941-II 2014-15. The NAO states that the project team estimate the actual cost of the first squadron will be less than this, at £2.42 billion.

⁶⁸ PQ 201934, 30 June 2014; see also HC Deb 28 April 2011 c570W for a similar statement

⁶⁹ HC Deb 20 June 2003 c517W

The unit cost of each aircraft will vary depending on when it is ordered.⁷⁰ This is because unit costs are being progressively driven down in the United States, and costs should reduce once full-rate production begins and firm international orders are made. The eventual buy at the full-production rate is expected to be “significantly cheaper” than aircraft ordered in low-rate initial production lots, according to the RAF.⁷¹

The MOD expects to spend around £17.9 billion over the next ten years in the combat air sector, according to its *Defence Equipment Plan 2014*. This includes spending not just on Lightning II but also Typhoon upgrades, unmanned aerial systems and support costs. The plan does not give a total estimate of the Lightning II programme.⁷²

7.1 Orders placed

Lightning is following an incremental acquisition approach unlike other procurement programmes which have just one main investment point. As such, the Lightning II has five main investment points (Main Gates) spread from 2001 to 2017. Main Gate Four was approved in January 2014. These are illustrated in the table below.

The aircraft are produced in Lots. Currently these are at what is known as Low Rate Initial Production (LRIP). Full rate production is slated for 2019. The production rate is set by the United States Department of Defense as the primary customer.

UK aircraft orders have been placed in four different LRIP lots so far: LRIP’s 3, 4, 7 and 8. These have spanned two Main Gates – Main Gate three and Main Gate four.

Main Gate three approved the purchase of four aircraft for training and Operational Test and Evaluation (OT&E) purposes.

Main Gate four approved 14 operational aircraft, of which four were ordered in November 2014. Further contracts are yet to be signed. See below for more detail on Main Gate Four.

The bulk buy is expected to be placed in 2017 in Main Gate Five.⁷³

Chronology of main gate orders⁷⁴

Main Gate 1	January 2001: Approved the UK’s entry into the US System Design and Development phase of the JSF Programme, equivalent to Initial Gate
Main Gate 2	December 2006: Approval of business case to participate in Production, Sustainment & Follow on Development phase
Main Gate 3	March 2009: Approval for the procurement of aircraft for Joint Operational

⁷⁰ For example, the unit cost of an F-35B has fallen from \$113 million in LRIP lot 5 to \$104 million in LRIP lot 7, excluding the cost of the engine, according to “[F-35 Joint Strike Fighter Program](#)”, *Congressional Research Service*, RL20563, 29 April 2014, table 1.
⁷¹ “Learning to fly”, *Jane’s Defence Weekly*, 17 December 2014
⁷² Ministry of Defence, *The Defence Equipment Plan 2014*, 13 January 2015
⁷³ HC Deb 5 February 2014 c242W
⁷⁴ Data in this table is sourced from: NAO, *Major Projects Report 2013*, vol II, page 106; [PQ 216426](#), 5 December 2014; “UK orders first operational F-35 combat aircraft”, *Jane’s Defence Weekly*, 24 November 2014; HC Deb 24 June 2014 c164W; entry on Scramble website entitled: [Lockheed Martin F-35 Lightning II](#), accessed 12 December 2014

	Test and Evaluation	
	LRIP lot 3 (2009)	Two operational test and evaluation aircraft ordered: BK-1 and BK-2. Delivered 2012.
	LRIP lot 4 (2010)	One training aircraft ordered: BK-3. Delivered 2013.
	LRIP lot 7 (September 2013)	One operational test and evaluation aircraft ordered: BK-4. In production, to be delivered in 2016.
Main Gate 4	2014: Approval for procurement of aircraft and support required to deliver Initial Operating Capability which is currently scheduled for 2018. Total expected: 14 aircraft.	
	LRIP lot 8 (2014)	Four production aircraft ordered
Main Gate 5	Bulk purchase of aircraft. Expected in 2017.	

Main Gate 4

- Agreement for 14 aircraft to deliver Initial Operating Capability
- Four aircraft ordered under LRIP lot 8
- Contract announced on 24 November 2014
- Approved budget of £2.75 billion
- Actual cost forecast to be £2.42 billion

The Treasury approved Main Gate 4 in January 2014. This covers procurement of aircraft for the first operational squadron (14 aircraft), associated support equipment and capital spares, and all associated support contracts up to 2020. The in-service date (initial operating capability) is set for 31 December 2018.

Contracts for the first four aircraft were signed in November 2014 as part of Low Rate Initial Production lot 8. Further contracts will be placed for the remaining ten aircraft on an annual basis through to 2014.⁷⁵ The Ministry of Defence said:

The contract for the F-35B aircraft forms part of the MOD's investment in Lightning II over the next 5 years to procure an initial 14 of these multi-role fifth generation aircraft, as well as putting in place the necessary support arrangements and infrastructure.⁷⁶

Main Gate four has an approved budgeted cost of £2.75 billion. The National Audit Office notes in its *Major Projects 2014* report that the project team currently forecast the actual cost will eventually be £326 million less than this, at £2.42 billion.⁷⁷

⁷⁵ "F-35 Lightning II", *Air International F-35 Special 2014*, p137

⁷⁶ "Contract signed for first production batch of F-35B aircraft", *Ministry of Defence*, 24 November 2014

It is not possible to estimate the unit cost of the aircraft from this figure because the budget includes the cost of support and spares. However based on the 43 aircraft ordered in total in LRIP 8 for the US and other international customers, Jane's Defence Weekly estimates the unit cost of the F35B procured in LRIP 8 is US\$102 million, excluding the engine.⁷⁸

The contract had been expected to be signed earlier in 2014, to coincide with the international debut of the F-35 at two air shows in the UK in July. However a fire on board an F-35A in June temporarily grounded the entire fleet and caused a temporary suspension in negotiations on LRIP lot 8 between the Pentagon and Lockheed Martin.

8 The first squadrons

The Lightning II force will be operated by both Royal Navy and RAF pilots. Aircraft deployed to provide the Carrier strike capability will be flown by pilots from both services.

The RAF's 617 'Dambusters' squadron⁷⁹ will stand up as the UK's first operational Lightning II squadron in 2016 in the United States. The squadron has a long and distinguished history. It was disbanded as a Tornado GR4 squadron in April 2014. It will move to RAF Marham in 2018.

809 'Immortals' Naval Air Squadron will be the second Lightning II squadron.⁸⁰

Lightning II will be based at RAF Marham in Norfolk from 2018. Three heat resistant landing pads are being built at Marham to enable Lightning II to land vertically. It will land in the conventional manner at other suitable RAF bases.

RAF Marham is currently home to three frontline Tornado squadrons. The planned out of service date for the Tornado GR4 fleet is 2019. The Tornado's assumed out of service date is 2019.

Separately, the UK will also be home to the first American F-35 squadrons in Europe. The US Department of Defense announced on 8 January 2015 it will deploy two squadrons of F-35As to Lakenheath from 2020 onwards.⁸¹

8.1 Training in the United States of America

The UK has developed an extremely close relationship with the US Marine Corps during the development and testing of the F-35B.

All aircraft evaluation and testing and pilot training is currently taking place in the United States. Pilot training will switch from the US to the UK in 2019 when the operational conversion unit stands up at RAF Marham.

The two operational test and evaluation aircraft are based at Edwards Air Force Base in California, having moved from Eglin Air Force base in Florida in 2014. These are BK-1 and BK-2 aircraft. They come under the RAF's No.17(R) Test and Evaluation Squadron and

⁷⁷ National Audit Office, *Major Projects Report 2014 and the Equipment Plan 2014 to 2024*, 13 January 2015, HC 941-I 2014-15, p18 and p42

⁷⁸ The unit cost of the F-35A is US\$94.8 million and US\$115.7 million for the F-35C. The engine is developed by Pratt and Whitney. In 2012 the US Government separated out the cost of the aircraft from the engine.

⁷⁹ The squadron was disbanded as a Tornado GR4 squadron on 1 April 2014

⁸⁰ "Royal Navy air squadron reformed to fly new jets", *Ministry of Defence*, 9 September 2013

⁸¹ "US announces first F-35 in Europe to be based in the UK", *Ministry of Defence*, 8 January 2015

represent the UK component in the Joint Operational Test Team, led by the United States. It is expected BK-4, ordered in September 2013 and to be delivered by 2016, will join these aircraft.

RAF and Royal Navy pilots have been training with the Marine Corps under a partnering agreement between the UK and the US. Previously based at Eglin Air Force Base in Florida, they have now moved to the Marine Corps Air Station Beaufort in South Carolina, alongside US Marine Fighter Attack Training Squadron 501 (VMFAT-501). BK-3 is the training aircraft operated by the UK in a pooled arrangement with the US Marine Corps. 617 Squadron will form in 2016 from UK personnel based at MCAS Beaufort and will remain there until 2018 it will move to RAF Marham.⁸²

Flight trails off the deck of the Queen Elizabeth aircraft carrier will be carried out between the end of 2018 and May 2019 by No.17 Test and Evaluation Squadron. They will take place in US waters.

The first aircraft to take off from the carrier will be a British Lightning II, the Secretary of Defence confirmed in evidence to the Defence Committee.⁸³ This was in response to media reports suggesting US Marine Corps F-35B aircraft might be flown from the carriers first. However the MOD is “exploring areas of cooperation”, seeing as they will also operate the F-35B aircraft.⁸⁴

In addition, personnel are working alongside their US counterparts as the UK regenerates a carrier strike capability. The UK and US signed a Statement of Intent on 5 January 2012. This provides a high level framework for US/UK co-operation.⁸⁵

Videos of F-35B

The MOD, Lockheed Martin and the individual services have posted a number of videos about the F-35 on Youtube, including:

- [RAF pilot performs first UK takeoff of F-35B Lightning at sea](#): Squadron Leader Jim Schofield and Lieutenant Commander Robin Trewinnard-Boyle of the Royal Navy discuss the F-35B's performance during ship suitability testing onboard the USS Wasp in August 2013. It includes footage of day and night take-offs and landings and the first UK take-off of the F-35 at sea.
- [First F-35B hover](#)
- [Interview with Royal Air Force Squadron Leader Hugh Nichols](#)
- [F-35C Sea Trials](#): for a comparison to the F-35B, see how the carrier variant takes-off and lands
- [A Pilot's Perspective: The F-35 Helmet and F-35 Lightning II Helmet Mounted Display System & Simulator](#)
- [F-35B first vertical landing](#)

⁸² PQ 218358, 18 December 2014

⁸³ Defence Committee, *Oral evidence: Future Force 2020*, 17 December 2014, HC 512 2014-15, q285

⁸⁴ PQ 218014, 17 December 2014

⁸⁵ A copy of the statement was laid in the library of the House as [DEP2012-0189](#)

9 Interoperability

When the Government switched to the carrier variant in the 2010 SDSR, one advantage given was that it would allow greater cooperation with allies. 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.”⁸⁶

Since switching back to the STOVL variant, 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 Statement says that from a political-military perspective:

Cooperation on carrier operations and maritime power projection is critical to ensure long-term interoperability between the United States and the United Kingdom across the full spectrum of capabilities. The goal of such cooperation is to ensure that, should the need arise, both nations can operate jointly and seamlessly in contingencies well into the future, much as the Participants have done in the past.⁸⁷

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.⁸⁸

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.⁸⁹ 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.”⁹⁰

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.⁹¹

He added the French and American governments supported the UK decision to revert back to the STOVL variant.⁹² 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.”⁹³

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

⁸⁶ [Strategic Defence and Security Review](#), 19 October 2010

⁸⁷ A copy of the statement was laid in the library of the House as [DEP2012-0189](#)

⁸⁸ [UK-France declaration on security and defence](#), *Number 10 website*, 17 February 2012

⁸⁹ “[Carrier Strike](#)”, National Audit Office, HC1092, 2010-2012, 7 July 2011

⁹⁰ HC Deb 26 March 2012 c1143

⁹¹ HC Deb 10 May 2012 c141

⁹² HC Deb 10 May 2012 c142

⁹³ HL Deb 10 May 2012 c81

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.⁹⁴

US Marine Corps F-35B aircraft *will* be able to fly off the carriers and the Deputy Chief of the Defence Staff discussed the UK's extremely close relationship with the US Marine Corps in evidence to the Defence Committee. Air Marshal Sir Stephen Hillier said “that we can embark other nations' aircraft shows the strength of the capability that we can deploy. It is a strength in strategic terms of being a full part of an alliance with the US.”⁹⁵

Having said that, not installing catapults on the carriers locks the UK into the F-35 programme because the F-35B is the only combat aircraft type in the world that can be operated from such ships.⁹⁶

10 Concerns about the F-35

The early life F-35 programme has undeniably been a troubled one.

The US-led programme is the Pentagon's most expensive weapons system and has experienced ballooning costs, software glitches and repeated delays, caused by production delays and procurement deferrals. Through life costs for the US is now estimated to be \$397 billion, up from the £233 billion estimated at the start of the programme in 2001.⁹⁷

This has an impact on the eventual cost to the UK and other international partners. Delays to in service dates are also having a knock-on effect for some international partners who may be unexpectedly extending their current fleets to avoid a gap in air combat capability. Canada, for example, is extending the life of its CF-18 fleet while it decides whether to go ahead with its planned F-35 purchase.⁹⁸

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 has kept a close eye on the programme and repeatedly published witheringly critical reports. 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.”⁹⁹ An additional financial danger is the potential need for costly retrofits in production aircraft if significant problems are found in future tests.¹⁰⁰

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

⁹⁴ “This change of course on aircraft carriers is essential”, *Daily Telegraph*, 10 May 2012

⁹⁵ Defence Committee, *Oral evidence: Future Force 2020*, 17 December 2014, HC 512 2014-15, q290-291

⁹⁶ T Taylor, “‘Que Sera, Sera’: the UK and the F-35”, *RUSI Newsbrief*, March 2013, Vol 33, no 2

⁹⁷ “F-35 Joint Strike Fighter: Current Outlook Is Improved, but Long-Term Affordability Is a Major Concern”, *US Government Accountability Office*, March 2013

⁹⁸ “Canada extends life of fighter jet fleet as it mulls replacements”, *Reuters*, 30 January 2015

⁹⁹ “US admits producing F-35 before flight tests was a mistake”, *Jane's Defence Weekly*, 8 February 2012

¹⁰⁰ “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](#).

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.”¹⁰¹

11 Industry and 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.¹⁰²

Lockheed Martin is the F-35 prime contractor, while Northrop Grumman and BAE Systems are principal partners in the project. Pratt and Whitney are producing the engine – the F135. Rolls Royce is a subcontractor for Pratt and Whitney and has built the vertical lift system for the F-35B.

The UK is the only tier one partner. This gives the UK significant influence through the System Development and Demonstration phase and meant its requirements were formally incorporated into the Joint Operational Requirements Document. 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.¹⁰³ Israel and Singapore are Security Cooperative Participants.

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.”¹⁰⁴

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.”¹⁰⁵

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.¹⁰⁶ Approximately 120 UK companies are in the supply chain.¹⁰⁷

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

¹⁰¹ T Taylor, “‘Que Sera, Sera’: the UK and the F-35”, *RUSI Newsbrief*, March 2013, Vol 33, no 2

¹⁰² “F-35 Joint Strike Fighter (JSF) Program: Background and Issues for Congress”, *Congressional Research Service*, 16 February 2012 RL30563

¹⁰³ The financial contribution of each nation is available on the [JSF website](#)

¹⁰⁴ HC Deb 26 November 2012 c6

¹⁰⁵ HC Deb, 18 March 2009, c54WS

¹⁰⁶ More information about the JSF UK Industry team can be found on its website <http://www.jsf.org.uk/home.aspx>

¹⁰⁷ 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

reductions in orders.¹⁰⁸ The F-35A variant is expected to make up the bulk of international orders. So far the only other country likely to buy the STOVL variant, apart from the UK and the US, is the Italian Navy.

Italy and Turkey will provide heavy maintenance of the F-35 aircraft and F135 engine respectively in Europe from 2018, the Pentagon announced in January 2015. The UK will provide backup for aircraft maintenance if needed. Further maintenance sites are expected to be established in Norway and the Netherlands.

¹⁰⁸ A list of countries expected to buy the F-35 is available in: "[Factbox: the 11 countries expected to buy the F-35 fighter jet](#)", *Reuters*, 5 June 2014

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]