The Auditor-General
Audit Report No.6 2012–13
Performance Audit

Management of Australia's Air Combat Capability—F-35A Joint Strike Fighter Acquisition

Department of Defence
Defence Materiel Organisation

Australian National Audit Office

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Canberra ACT
27 September 2012

Dear Mr President
Dear Mr Speaker

The Australian National Audit Office has undertaken an independent performance audit in the Department of Defence and Defence Materiel Organisation in accordance with the authority contained in the Auditor-General Act 1997. Pursuant to Senate Standing Order 166 relating to the presentation of documents when the Senate is not sitting, I present the report of this audit, and the accompanying brochure, to the Parliament. The report is titled *Management of Australia's Air Combat Capability–F-35A Joint Strike Fighter Acquisition.*

Following its presentation and receipt, the report will be placed on the Australian National Audit Office's Homepage—http://www.anao.gov.au.

Yours sincerely

Ian McPhee
Auditor-General

The Honourable the President of the Senate
The Honourable the Speaker of the House of Representatives
Parliament House
Canberra ACT

AUDITING FOR AUSTRALIA

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Abbreviations

ADF	Australian Defence Force
AFB	Air Force Base
AMTC	Australian Military Type Certificate
CDG	Capability Development Group (Department of Defence)
CTOL	Conventional Take-off and Landing variant of the F-35 (F-35A)
CV	Carrier Variant of the F-35 (F-35C)
DCMA	Defense Contract Management Agency (US)
Defence	Australian Defence Organisation
DGTA	Director General Technical Airworthiness
DMO	Defence Materiel Organisation
DSTO	Defence Science and Technology Organisation
EVMS	Earned Value Management System
FMS	Foreign Military Sales
FRP	Full-Rate Production
IOC	Initial Operational Capability
IPT	Integrated Project Team
JORD	Joint Operational Requirements Document
JSF	Joint Strike Fighter (also known as F-35 Lightning II)

JSF SDD MoU	Joint Strike Fighter System Development and Demonstration Memorandum of Understanding, 2001
JSF PSFD MoU	Joint Strike Fighter Production, Sustainment and Follow-on Development Memorandum of Understanding, 2006
LRIP	Low-Rate Initial Production
NACC	New Air Combat Capability
RAAF	Royal Australian Air Force
SDD	System Development and Demonstration. In more recent US acquisition terminology, the System Development and Demonstration phase is known as the Engineering and Manufacturing Development (EMD) phase.
STOVL	Short Take-off and Vertical Landing variant of the F-35 (F-35B)
T&E	Test and Evaluation
TBR	Technical Baseline Review
TEMP	*Test and Evaluation Master Plan*

Summary

Summary

Background and context

1. In successive Defence White Papers since 1976, Australia has outlined its defence strategy, which includes the control of the air and sea approaches to Australia. In this context, the Defence White Paper 2009 stated:

> Our military strategy is crucially dependent on our ability to conduct joint operations in the approaches to Australia—especially those necessary to achieve and maintain air superiority and sea control in places of our choosing. Our military strategic aim in establishing and maintaining sea and air control is to enable the manoeuvre and employment of joint ADF [Australian Defence Force] elements in our primary operational environment, and particularly in the maritime and littoral approaches to the continent.[1]

2. This audit provides an Australian perspective on the Australian Government's participation in the United States of America's Joint Strike Fighter (JSF) Program. This program is producing the F-35A Lightning II multi-role combat aircraft selected by the Government to replace the Royal Australian Air Force's (RAAF's) 71 F/A-18A/B Hornet aircraft, which at the time of the preparation of this report were planned for withdrawal from service after 2020.[2] F-35A aircraft are also planned to replace the RAAF's 24 F/A-18F Super Hornet aircraft in 2025. The Australian Defence Organisation's (Defence's) management of the current Hornet and Super Hornet fleets is the subject of a companion audit, ANAO Audit Report No.5 2012–13, *Management*

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1 *Defending Australia in the Asia Pacific Century: Force 2030. Defence White Paper 2009*, Canberra, 2009, paragraph 7.3, p. 53.

2 In May 2012, the need for a possible further extension to the F/A-18A/B fleet's Planned Withdrawal Date arose because of the Government's decision to better align the delivery of Australia's F-35A aircraft with the US Department of Defense's F-35 production and acquisition schedule. Consequently, the precise timing of the F/A-18A/B withdrawal from service is dependent upon the delivery of the F-35A aircraft under schedules that are yet to be finalised.

of Australia's Air Combat Capability—F/A-18 Hornet and Super Hornet Fleet Upgrades and Sustainment, 27 September 2012.[3]

3. The New Air Combat Capability project (also known as the AIR 6000 project) was established within Defence in 1999. The Defence White Paper 2000 announced that provision had been made for the eventual acquisition of up to 100 new combat aircraft to replace both the F/A-18A/B and F-111 fleets then being operated by the RAAF. A traditional competitive process was not used to select a new combat aircraft. Rather, in October 2002, the then Government approved Australia becoming a partner in the System Development and Demonstration (SDD) phase of the JSF Program at a cost of US$150 million.

4. The F-35 is a single-seat, single-engine aircraft incorporating low-observable (stealth) technologies, advanced avionics, advanced sensor fusion,[4] internal and external weapons, and advanced prognostic maintenance capability. Advanced design and construction features result in the F-35 being a 'fifth generation' combat aircraft with a 30-year planned service life and an upgrade path capable of maintaining specified air superiority. There are three F-35 variants, the F-35A conventional take-off and landing (CTOL) variant, the F-35B short take-off and landing (STOVL) variant and the F-35C carrier-suitable (CV) variant.

5. Australia's decision to join the SDD phase of the JSF Program raised the expectation that Australia, along with the eight other partner nations that contributed to the SDD phase, would later acquire the JSF Program's F-35 Lightning II aircraft. Australian participation in the JSF Program was planned to provide opportunities for the expansion of Australia's innovative and technologically leading aerospace industry,[5] and, to date, has delivered some A$300 million in contracts to Australian suppliers.

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3 The Defence Portfolio consists of a number of component organisations that together are responsible for supporting the defence of Australia and its national interests. The three most significant bodies are: the Department of Defence, the Australian Defence Force (ADF) and the Defence Materiel Organisation. In practice, these three bodies have to work together closely and are broadly regarded as one organisation known as Defence (or the Australian Defence Organisation). All three of these component organisations are involved in the F-35A acquisition.

4 Sensor fusion is the ability to integrate information from both on-board sensors and off-board sources and present the information to the pilot in an easy-to-use format, thereby greatly enhancing the pilot's situational awareness.

5 Senator the Hon. Robert Hill, Minister for Defence, and the Hon. Ian MacFarlane, Minister for Industry, *Australia's future air combat capability*, transcript of joint press conference, 27 June 2002, p. 2.

6. In November 2006, the Australian Government formally selected the F-35 to provide the basis for Australia's new air combat capability.[6] In December 2006, Australia became a partner in the JSF Program's Production, Sustainment and Follow-on Development (PSFD) Memorandum of Understanding, which established the production, acquisition, support, information access and upgrade arrangements for the F-35 aircraft and its support systems.

7. In 2009, the Australian Government approved the acquisition of the first 14 F-35A aircraft at a then-estimated cost of A$3.2 billion. At that time, the Government indicated it would make a decision on the acquisition of an additional 58 aircraft during 2012. The acquisition of these 72 aircraft, in two tranches, was to enable the formation of three RAAF F-35A operational squadrons and a training squadron.

8. The Defence Capability Plan 2012 indicated that a decision about the potential acquisition of a further 28 F-35As, to bring the total to 100, and so enable formation of a fourth F-35A squadron, was not expected before 2015.[7]

9. In May 2012, the Australian Government announced a two-year delay in acquiring 12 of the first 14 F-35A aircraft.[8] The acquisition of the first two aircraft is proceeding as planned, and by June 2012 Defence had signed contracts for the production of long-lead items for these two aircraft that it intends to order when price and availability data are known. The first two aircraft are scheduled for delivery in 2014 and are to remain in the US for testing and training purposes.

10. As at September 2012, and contingent on further government approvals, Australia's total projected commitment for the acquisition of 100

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6 The Hon Dr Brendan Nelson MP, Minister for Defence, *The Joint Strike Fighter*, media release, 10 November 2006.

7 Department of Defence, *Defence Capability Plan 2012*, Public Version, p. 54. However, this timetable may be affected by the May 2012 Budget decision outlined in paragraph 9.

8 *Prime Minister, Minister for Defence, Minister for Defence Materiel—joint press conference—Canberra*, media transcript, 3 May 2012; *Portfolio Budget Statements 2012–13: Defence portfolio*, p. 166; The Hon Stephen Smith MP, Minister for Defence, *Address to the Air Power Conference*, Canberra, 10 May 2012.

F-35A aircraft, and for other shared costs under the F-35 SDD and production phases, amounted to US$13.211 billion (then-year dollars).[9]

11. The US JSF Program Office manages the development, production and sustainment of the F-35 Lightning II aircraft for the US Government, and on behalf of the other eight JSF Program partner nations, including Australia.[10] The JSF Program Office, a unit of the US Department of Defense, has personnel from all partner nations located within the program office and employed in various management and technical roles. The JSF Program Office relies on the US Defense Contract Management Agency to manage the acquisition contracts with the JSF Program's prime contractors, Lockheed Martin and Pratt & Whitney, and on the US Defense Contract Audit Agency to audit JSF contract performance.

Audit objective and scope

12. Given the strategic significance of Defence's air combat capability, the ANAO considered it timely to examine both the effectiveness of Defence's arrangements for the sustainment of the F/A-18 Hornet and Super Hornet fleets that comprise the RAAF's current capability, and Defence's progress in securing new combat aircraft to replace the F/A-18 fleets at the end of their lives. Accordingly, as noted in paragraph 2, the ANAO has undertaken two companion performance audits on these subjects. This audit focuses on Defence's management of the procurement of F-35A aircraft by Defence's AIR 6000 project through the US JSF Program.

13. Figure S 1 shows the planned withdrawal from service of the RAAF's F/A-18 fleets and the scheduled acquisition of the replacement F-35A fleet.

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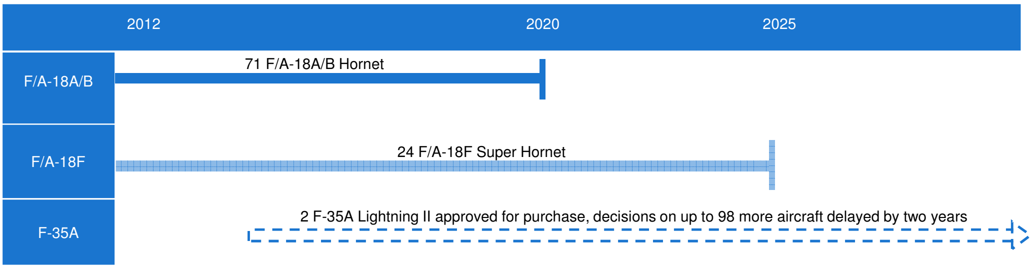
9 Then-year cost estimates are based on the estimated cost of labour and materials and currency exchange rates, at the time expenditure is to occur.

10 The JSF Program partner nations are the USA, United Kingdom, Denmark, Norway, the Netherlands, Canada, Italy, Turkey and Australia.

Figure S 1

Air combat fleet schedule for withdrawal from service and acquisition, as at July 2012



Source: ANAO analysis.

14. The audit objective was to assess the progress of the AIR 6000—New Air Combat Capability project in delivering the required combat aircraft within approved cost, schedule and performance parameters. In particular, the audit assessed Defence's arrangements to ensure that it has adequate insight into the development and production of the F-35A, and information about the status of the JSF Program, to:

- inform progressive acquisition decisions by Government; and
- underpin appropriate contingency planning to avoid any capability gap opening up between the withdrawal from service of the RAAF's F/A-18 fleets, particularly the F/A-18A/B fleet, and the entry into service of the F-35A-based air combat capability.

15. The audit scope included examining:

- the definition of the F-35A JSF New Air Combat Capability requirements, carried out under AIR 6000;
- the progress achieved by the JSF Program's System Development and Demonstration (SDD) phase;
- the progress achieved by the JSF Program's production and sustainment phases; and
- reviews of the JSF Program, and its progress in terms of cost and schedule.

16. As the JSF Program is a US Government undertaking, the ANAO did not intend to, nor was it in a position to, conduct a detailed analysis of the full range of engineering issues being managed within the program's SDD and production phases. Rather, the audit focused on examining the current status of the F-35 SDD and production phases to underpin an assessment of the progress of Australia's AIR 6000—New Air Combat Capability project in delivering the required combat aircraft within approved cost, schedule and performance parameters. The audit did not examine total whole-of-life costs of the F-35A aircraft Australia intends to acquire.

17. The audit scope did not include the JSF partner nations' industrial participation program.[11] The Australian Defence Force's (ADF's) air combat fleet is supported by Airborne Early Warning and Control aircraft, air-to-air refuelling aircraft, lead-in fighter training aircraft, air bases, and command, control and surveillance capabilities.[12] These support systems are also not included in the audit's scope.

18. The audit scope also did not include detailed examination of possible issues arising from the likely extension of the F/A-18A/B fleet's Planned Withdrawal Date beyond 2020 as a result of the postponement until 2019 of the US F-35 Full-Rate Production decision and the Australian Government's consequent May 2012 Budget decision to also delay acquisition of the F-35 for two years. The Government was yet to consider these issues at the completion of the audit, but the ANAO did review the planning underway in Defence to advise the Government on options to address them.

19. To gather appropriate evidence to underpin this audit, the ANAO conducted audit fieldwork in both Australia and the US. The Australian audit fieldwork was conducted from October 2011 to June 2012 at the Canberra offices of the New Air Combat Capability Integrated Project Team. The US fieldwork was conducted in March 2012. It included visiting and collecting evidence from the JSF prime contractor, Lockheed Martin; the Defense Contract Management Agency office in Fort Worth, Texas; the JSF Program Office in Arlington, Virginia; the US Department of Defense in Washington DC; and the Defense Contract Audit Agency in Fort Belvoir, Virginia. In

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[11] Under the international agreements for the JSF Program, the industries of partner nations gained the right to tender for JSF development and production work. The industrial participation program was excluded from audit coverage in order to allow an increased focus on the F-35 development and production phases. However, for convenience, a diagram of the Global Supply Team for the JSF is included at Figure 3.2, and a diagram of Australian industry involvement at Figure 3.3.

[12] *Defending Australia in the Asia Pacific Century: Force 2030. Defence White Paper 2009*, Canberra, 2009, paragraph 8.22, p. 61.

addition, the ANAO visited the US Government Accountability Office (GAO), given its role in auditing and providing independent evidence on the JSF Program to the US Government and the Congress.

20. The ANAO's examination of the current status of the F-35 SDD and production phases included collecting and analysing key project management documents obtained from the Australian New Air Combat Capability Integrated Project Team and from the US Department of Defense's JSF Program Office. In addition, the ANAO considered evidence provided by a number of US Department of Defense agencies which operate outside the line-of-control of the program office and provide independent advice on the JSF Program to the US Government.[13] The ANAO also analysed the GAO's reports on this program, and other official reports and sworn testimony provided to the US Congress.[14] As noted in paragraph 19, the ANAO visited Lockheed Martin and was provided with documents and access to key Lockheed Martin F-35 program executives and managers. Overall, the ANAO was able to interview key personnel responsible for managing the JSF Program or for providing oversight on it.

Overall conclusion

21. Under the JSF Program the US, with its industry partners (in particular Lockheed Martin),[15] is developing the F-35 Lightning II aircraft to replace legacy fighters and strike aircraft in its own Air Force, Navy and Marine Corps air combat fleets.[16] The cost to the US of F-35 development and production is currently estimated at US$395.7 billion, which makes the JSF Program the most costly and ambitious US Department of Defense acquisition program by a wide margin. Australia and seven other nations have entered into partnership

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[13] The US Department of Defense's Director, Operational Test and Evaluation, the US Defense Contract Audit Agency, and the US Department of Defense's Office of Cost Assessment and Program Evaluation.

[14] Since 2001, the GAO has delivered eight reports specifically on the JSF Program, with the latest delivered in June 2012. As a 'congressional watchdog', its focus in undertaking this work has necessarily been on determining whether US Federal funds are being spent efficiently and effectively. In contrast, this audit provides an Australian perspective, which has regard to GAO and other reports, but our conclusions may not always align with the US perspective.

[15] Northrop Grumman, Pratt & Whitney and BAE Systems are also major contractors on the JSF Program.

[16] Planned production of the three variants of the F-35 for the US Services is as follows: 1763 F-35A (CTOL) for the US Air Force, 340 F-35B (STOVL) and 80 F-35C (CV) for the US Marine Corps, and 260 F-35C (CV) for the US Navy.

arrangements with the US to satisfy their own combat aircraft needs via the JSF Program.[17]

AIR 6000–New Air Combat Capability project

22. In 2006, the Australian Government approved the F-35 as the aircraft to provide the basis for Australia's new air combat capability. This decision was reaffirmed in the Defence White Paper 2009, and late in 2009 the Government approved the purchase of the F-35A Conventional Take-off and Landing (CTOL) variant of the F-35. The F-35A aircraft are to be acquired in a number of tranches, with the Government to progressively approve each tranche.

23. Defence's AIR 6000–New Air Combat Capability project is undertaking the procurement of F-35A aircraft for the RAAF through the US JSF Program. As the JSF Program is to develop and produce this key component of Australia's planned new air combat capability, the effectiveness of Defence's arrangements to monitor and assess its progress in terms of cost, schedule and performance is fundamental to Defence acquiring adequate insight into the development and production of the F-35A. Defence requires appropriate evidence about the status of the JSF Program to inform both progressive F-35A acquisition decisions by the Government and to underpin appropriate contingency planning to avoid any capability gap opening up between the withdrawal from service of the RAAF's F/A-18 fleets, particularly the F/A-18A/B fleet, and the entry into service of the F-35A-based air combat capability. Accordingly, establishing the Australian perspective on the JSF Program's progress and the implications of this was a key focus of this audit.

Risks in advanced defence technology development and production programs

24. This audit report draws attention to the wide-ranging cost, schedule and performance risks inherent in advanced defence technology development and production programs, such as the JSF Program. These risks arise from the need to:

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[17] There are three levels of partnership in the SDD phase, dependent on the financial contribution involved, which give each partner nation varying rights, from influencing the design requirements to accessing program information and having personnel within the JSF Program Office (see paragraph 3.7). In the production and later phases, partnership contributions depend on the number of aircraft purchased by a country, the number of partners, and the total cost of the program (see footnote 182 on page 115).

- specify products, in function and performance terms, that continue to satisfy requirements at delivery and are capable of being upgraded in line with changing military requirements;
- pay for work on products years ahead of opportunities to verify their compliance with specifications; and
- ensure continuous collaboration across wide-ranging contractual, organisational, geographic and national boundaries, that is capable of completing highly technical work extending over many years, and of coping with unforeseen technical advances or changes in user requirements.

25. The F-35 aircraft are designed for high-threat multi-role operations, requiring advanced stealth technology and fully integrated internal radar and electro-optical sensor systems. The intent is that the F-35 will sense, track and identify targets, and together with target data provided by sources external to the aircraft, fuse this data and present it to the pilot using an advanced Helmet Mounted Display system. As a consequence, the extent of air combat technology development and systems integration being undertaken by the JSF Program is unprecedented. One result is that the US Department of Defense and its contractors have encountered persistent difficulties in accurately estimating the time and cost of developing and operating F-35 aircraft and their support systems.

26. However, the intense, high-level attention given to the JSF Program in recent years, including by the US Congress, has identified a range of issues that were previously impacting on cost, schedule and performance, and key initiatives to improve performance are starting to show results.[18] Significant resources have now been focused on these issues, and a delay of the F-35 Full-Rate Production decision until 2019 has been accepted by the US, to allow time for the initiatives to take full effect. Nonetheless, the overall outcome, in terms of cost, schedule and capability delivery, remains dependent on the effectiveness of a range of initiatives being pursued to address the technical challenges identified in recent technical reviews.

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[18] These are discussed in paragraph 44, and include software development and flight test targets.

27. From Australia's perspective, although the recent US actions to reduce risk in the JSF Program are positive, there are implications arising from the three-year delay to the schedule for the F-35 Full-Rate Production decision (now not scheduled until 2019) that require close management. As indicated in ANAO Audit Report No.5 2012–13, *Management of Australia's Air Combat Capability—F/A-18 Hornet and Super Hornet Fleet Upgrades and Sustainment*, 27 September 2012, Australia has for over a decade been actively upgrading its air combat fleet capability and addressing its sustainment. At the end of that audit, the Planned Withdrawal Date for the RAAF's F/A-18A/Bs was 2020. The audit noted that the task for Defence of successfully sustaining the ageing F/A-18A/B fleet to that date, so that no capability gap arises before the introduction into service of the F-35As, was already challenging. Given the age and expected condition of these aircraft at that point, each additional year in service will involve significant costs.

28. At the completion of these two linked audits, the Government was yet to consider the need for a further extension, beyond 2020, of the Planned Withdrawal Date of the RAAF's F/A-18A/Bs. However, in response to ANAO inquiries about contingency plans, Defence indicated that planning was underway to advise the Government on options in relation to this matter, including a limited extension beyond 2020. Nonetheless, should further delays occur in the JSF Program, Defence's capacity to absorb any more delays in the entry into service of the replacement air combat capability to be provided by the F-35A has limits, is likely to be costly,[19] and has implications for capability.

Australia's partnership in the JSF Program

29. For comparatively modest investments of US$205 million and an estimated US$643 million respectively, Australia has secured Level 3 partner status in the SDD phase and in the production and later phases of the JSF Program.[20] This status has enabled Defence to access a comprehensive range of data to inform the acquisition recommendations it has progressively presented

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[19] See Chapters 2 to 4 in ANAO Audit Report No.5 2012–13, *Management of Australia's Air Combat Capability—F/A-18 Hornet and Super Hornet Fleet Upgrades and Sustainment*, 27 September 2012.

[20] The other partner nations' contributions to the SDD phase range from US$2 billion for Level 1 partners to US$125 million for Level 3 partners (see Table 3.1 for details). For the production and later phases, the total contribution by partner nations is estimated at US$21.876 billion, with the US bearing US$16.843 billion of that amount (see paragraph 4.5). Partner contributions are made bi-annually, with amounts determined through agreed cost-share arrangements.

to Government; to influence the decision-making within the JSF Program to suit Australia's operational requirements, through membership of the JSF Executive Steering Board; and to facilitate Australian industry participation in the broader JSF Program. While the partner nation contributions to the SDD and production phases are separate from the costs of Australia's acquisition of its own F-35 aircraft, in due course Australia will also benefit by acquiring F-35 aircraft at JSF partner nation prices.[21]

30. Subject to further government decisions, Australia intends to acquire up to 100 F-35 aircraft. In September 2012, the total development and production cost of 100 F-35As, and other costs shared with JSF partner nations, was estimated to be US$13.211 billion (then-year dollars).[22] At the time of the audit, US Department of Defense agencies were conducting a coordinated, in-depth cost analysis of the production program with the aim of achieving increased efficiencies so as to reduce production contract prices.

F-35 concurrent development and production

31. The JSF development and production program's size and engineering complexity, and its defence and industry importance, are reflected in the multinational partner arrangements between the United States, the United Kingdom, Denmark, Norway, the Netherlands, Canada, Italy, Turkey and Australia.[23] The JSF Program partner nations have established a global supply network focused on F-35 airframe assembly production, with the majority of F-35 Mission Systems development and production occurring in the US.

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[21] An alternative to Australia's joining the SDD and production phases was the acquisition of F-35 aircraft and their associated systems and logistics support through the US Government's Foreign Military Sales (FMS) program. The US FMS program manages the sale of US defense articles and services authorised by the US Arms Export Control Act. It is operated on a no-profit/no-loss basis, and FMS purchases must be funded in advance by the FMS customer. An FMS Administrative Surcharge is applicable to all purchases made through the US FMS program, and from 1 August 2006 this surcharge rose from 2.5 per cent to 3.8 per cent. Other additional FMS fees include a Contract Administration Services Surcharge of 1.5 per cent, and a Nonrecurring Cost fee for pro rata recovery of development costs. The amount of cost recovery is decided during negotiation of an FMS case, although it may be waived. As a partner in the Production, Sustainment and Follow-on Development (PSFD) phases, Australia will not be acquiring the JSF via the US FMS program, and therefore will not incur any FMS fees for its aircraft.

[22] See Table 4.1 on page 118.

[23] The partnership is based on two Memoranda of Understanding (MoU): the JSF System Development and Demonstration (SDD) MoU signed in 2001–02, and the Production, Sustainment and Follow-on Development (PSFD) MoU, signed in 2006–07. Australia's contribution to the SDD MoU arrangement was US$150 million, with a further US$50 million to be paid by 2014. As at December 2011, Australia's commitment to the PSFD MoU amounted to an estimated US$643 million.

Aircraft assembly, final system checkout, and contractual acceptance by the US Government from Lockheed Martin occur at Fort Worth, Texas. By July 2012, 13 F-35 flight test aircraft, six ground test articles and two pole-model radar signature test articles, produced as part of the SDD phase had been delivered, with an additional 28 F-35 Low-Rate Initial Production (LRIP) phase aircraft having completed their maiden flights. At full maturity, the global supply network is expected to support annual production of more than 200 F-35 aircraft.

32. For technologically advanced systems such as the F-35, there needs to be an overlap between the system development phase and the production phase. This risk management strategy involves the production of fully integrated systems needed for test and evaluation purposes, and the development of production facilities and processes that are themselves tested and evaluated with respect to their ability to produce, within cost and schedule budgets, products verified to comply with function and performance specifications.

33. This 'concurrent' development and production strategy as applied in the JSF Program has been reviewed annually by the US Congress, and significant concerns arose about the costs that this strategy was generating. This was because, until recently, the US Government has been bearing nearly all of the costs of concurrency (such as re-work needed after additional testing).

34. From the Australian perspective, concurrency risks in the JSF Program are not as significant because the US, as the principal developer of the F-35, is bearing the bulk of the costs and risks involved. By the time Australia acquires its first F-35 aircraft, the concurrency issues currently being experienced are expected to have been largely dealt with.[24] Rather, Australia has benefited from the concurrency strategy of enabling F-35 production processes and facilities to be tested and refined ahead of the F-35 Full-Rate Production decision, and in the face of the pending retirement of our existing air combat fleets.

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[24] As long as the discovery of defects continues to diminish and the correction of defects by the contractor remains timely and effective.

F-35 test and evaluation program

35. Although current estimates of the F-35's performance are close to those required, performance will not be fully demonstrated until the completion of Initial Operational Test and Evaluation, presently expected in February 2019.[25] F-35 aircraft development and production risks are being managed through a large-scale and sophisticated F-35 ground and flight test program. Prior to conducting flight tests, each incremental advance in F-35 development is subjected to extensive laboratory testing. Once each incremental increase in F-35 capability has been cleared for entry into the flight test and evaluation program, testing commences in an extensively modified Boeing 737 which is used by Lockheed Martin to conduct F-35 system development and software integration testing. In addition, each F-35 sensor supplier continues to use surrogate aircraft to test their particular sensors; for example, Northrop Grumman conducts radar and Distributed Aperture System testing in its BAC 1-11 aircraft. The next stage of flight tests involves a fleet of 13 F-35 engineering development aircraft, and five F-35 LRIP aircraft assigned to the F-35 flight test program.[26] There are also six F-35 airframes undergoing structural strength and durability (fatigue) testing, and two pole-model airframes used for radar signature testing. By June 2012, the F-35 mission systems had completed nearly 345 000 hours of laboratory testing and 18 500 hours of flight testing—of which 3700 hours were completed in F-35 aircraft.

36. In relation to the F-35A variant to be purchased by Australia, the test and evaluation program requires the achievement of 24 951 test points covering all F-35A war-fighting requirements needed to achieve the Initial Operational Capability milestone. By March 2012, F-35A capability testing was ongoing, and a total of 5282 test points had been achieved. This represents some 21 per cent of the overall testing required to validate Initial Operational Capability achievement.

37. By June 2012, the F-35A static test article had successfully completed its structural strength test program, and the F-35A durability test (fatigue test) article was about halfway through its two lifetimes test program of 16 000 hours. The durability test program aims to certify that the F-35A airframe can

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25 *Selected acquisition report (SAR): F-35, as of December 31, 2011*, Washington DC, pp. 9, 11–15.

26 At the time of the audit, the 14th and final SDD aircraft was to be delivered later in 2012.

achieve its design safe life of 8000 hours under specified flight profiles.[27] In addition, contract negotiations to extend the durability test to three lifetimes (24 000 hours) were underway as part of the US JSF Program's F-35 high-risk mitigation management.

Software development

38. Software is critical to the success of the JSF Program, as it provides the means by which all safety-of-flight and mission-critical systems operate, and are monitored, controlled and integrated. F-35 software is being released in three capability blocks. Block 1 software provides an initial training capability, and in the second quarter of 2012 its test phase was completed and it was released into the F-35 pilot training program. Block 2 software is to provide initial war-fighting capability, including weapons employment, electronic attack, and interoperability between forces. At the time of the audit, the initial release of Block 2—known as Block 2A—was undergoing flight testing and was scheduled for release to the F-35 flight test program in September 2012, and for release to the F-35 pilot training program in the second quarter of 2013. The final release of Block 2 capability—known as Block 2B—is scheduled for 2015. Block 3 software provides full F-35 war-fighting capability, including full sensor fusion and additional weapons. At the time of the audit, 61 per cent of initial Block 3 capability had been developed against a target of 81 per cent, and its integration into F-35 flight test aircraft is planned to commence from November 2012. Block 3 release into the F-35 fleet is scheduled for mid-2017. At the time of the audit, F-35 software development was undergoing high-risk mitigation management.

Cost control

39. In order to reduce the cost of F-35 aircraft and their logistics support for JSF Program partner nations, and for US Foreign Military Sales customers, US Government personnel from procurement, contract administration, contract

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[27] Airframe static strength and durability tests are conducted in laboratories to ensure that a structure, such as an aircraft wing, can withstand the extreme loads likely to be encountered in flight, and to provide assurance that the aircraft will remain airworthy for its designed service life. During static testing, the actual load-bearing strength of an airframe structure is compared to design specifications. During durability (fatigue) tests, airframe assemblies are subjected to smaller repeated loads that can cause cumulative damage over time. These tests are conducted to verify and certify the safe life of airframe structures, to help determine inspection requirements and inspection intervals for the fleet of aircraft, to identify critical areas of the airframe not previously identified by analysis, and to certify that the structure can meet or exceed service life requirements.

audit, and engineering organisations were, at the time of the audit, conducting a coordinated and in-depth cost analysis of the F-35 production phase. The pursuit of efficiencies through this process is intended to achieve reductions in production contract prices. The cost analysis is part of the US Government's Will-Cost/Should-Cost management policy, which is focused on identifying unneeded cost and rewarding its elimination over time.

40. The F-35 cost reduction effort is enabled by the US Truth in Negotiations Act (TINA), passed in 1961, which requires prime contractors and subcontractors to submit cost or pricing data and to certify that such data are current, complete and accurate, prior to the award of any negotiated contract. Cost reduction is also enabled by the US Weapon Systems Acquisition Reform Act of 2009, which requires proactive program management practices that include targeting affordability and controlling cost growth, improving tradecraft in services acquisition, and reducing non-productive processes. The most extensive implementation of those practices was the JSF Program's 2010 Technical Baseline Review, which gave rise to several program changes that have resulted in the JSF Program progressing closer to cost, schedule and the technical progress plans than previously achieved.

41. As at June 2012, the JSF Program Office estimated the Unit Recurring Flyaway (URF) cost of a CTOL F-35A aircraft for Fiscal Year 2012 to be US$131.4 million. That cost includes the baseline aircraft configuration, including airframe, engine and avionics. The URF cost is estimated to reduce to US$127.3 million in 2013, and to US$83.4 million in 2019. These expected price reductions take into account economies of scale resulting from increasing production volumes, as well as the effects of inflation. The estimates indicate that, after 2019, inflation will increase the URF cost of each F-35A by about US$2 million per year. However, these estimates remain dependent upon expected orders from the United States and other nations, as well as the delivery of expected benefits of continuing Will-Cost/Should-Cost management by the US Department of Defense.

Overall summary

42. As indicated in paragraph 14, the audit objective was to assess the progress of the AIR 6000—New Air Combat Capability project in delivering the required combat aircraft within approved cost, schedule and performance parameters. In this context, the ANAO assessed Defence's arrangements to ensure that it has adequate insight into the JSF Program's development and production of the F-35A to inform progressive acquisition decisions by the

Government and underpin appropriate contingency planning to avoid any capability gap opening up between the withdrawal from service of the RAAF's F/A-18 fleets, particularly the F/A-18A/B fleet, and the entry into service of the F-35A-based air combat capability.

43. Australia's partnership with the US in the JSF Program, including in terms of Australian Defence staff working within the JSF Program Office, has provided Defence with considerable insight into the status of the program, its risks, and the actions over time that the US Department of Defense is taking to mitigate these risks. Defence (including the AIR 6000—New Air Combat Capability project office here in Australia, the RAAF and the Capability Development Group) monitors and analyses information and evidence acquired through our partnership with the US, so that it may inform the Government on both F-35 procurement decisions and options for managing the risk of an air combat capability gap arising before the entry into service of the F-35A aircraft.

44. Overall, the achievement of the JSF Program's objectives of developing and producing F-35 aircraft for high-threat multi-role operations has progressed more slowly and at greater cost than first estimated. Nonetheless, recent indications are that initiatives to improve performance are starting to show results, in terms of software development milestones being more closely adhered to, and planned flight test targets being reported as met or exceeded in 2011–12. However, a full assessment as to how effectively that progress can be maintained will be some years off. At the time of the audit, almost 80 per cent of the F-35 test and evaluation program was yet to be completed, so significant F-35 key performance parameters had not been fully validated as being achieved by F-35 aircraft.[28] Although program cost reduction measures are being pursued by the US Department of Defense and its contractors, the cost targets remain challenging, as do wider issues outside the JSF Program

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[28] Validation is the proof, through evaluation of objective evidence, that the specified intended end use of a product or system is accomplished in an intended environment.

Office's control, such as the 'debt sequestration' initiative by the US Government.[29]

45. Accordingly, while the ANAO considers that Defence has gained reasonable assurance that adequate work has been undertaken to identify significant risks in the US JSF Program, and that measures have been progressively developed and implemented to mitigate them, significant risks still remain, including in relation to mission-system data processing, software development schedule adherence, Helmet Mounted Display performance, structural health monitoring and structural durability testing. These will require close management as the final stages of development of the F-35A aircraft unfold.

46. For Australia, the remaining challenges include coordinating all the elements of capability that will make the F-35 fleet into a fully effective military system.[30] This includes actively managing the transition from the F/A-18 fleets to the F-35A-based air combat capability, including containing costs through limiting the period during which the RAAF bears the expense of sustaining both F/A–18A/B and F-35A aircraft. As previously discussed, at the time of preparation of this report, the Planned Withdrawal Date for the F/A-18A/B fleet was 2020. Following US Government and Australian Government decisions that have delayed the intended earlier F-35A delivery, the ANAO asked Defence for advice on its consequent contingency planning. Defence advised that later this year it will be presenting options to the Government on managing the air combat capability, including a limited extension of the Planned Withdrawal Date for the F/A-18A/Bs, as the RAAF transitions from

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29 The Budget Control Act of 2011, signed into law by President Obama on 2 August 2011, committed the US Congress to legislating US$1.2 trillion in savings by 23 December 2011, in the absence of which, automatic cuts would apply to federal spending—including defense spending—over the following ten years, beginning in January 2013. The Joint Select Committee on Deficit Reduction failed to reach agreement by the specified date, and at the time of writing (September 2012) the automatic cuts, known as 'debt sequestration', remain on the United States statute book.

30 See Appendix 6: The Fundamental Inputs to Capability.

the current fleet to a predominantly F-35A fleet.[31] Defence indicated that this would include strategies to reduce the risks associated with the likely extension of the F/A-18A/B fleet's operational life, and to minimise risks associated with progressing to the F-35A's Initial Operational Capability.

47. The ANAO has not made any formal recommendations for administrative improvements in Defence's management of the ADF's air combat capability in this audit report (or in its companion report, Audit Report No.5 2012–13, *Management of Australia's Air Combat Capability—F/A-18 Hornet and Super Hornet Fleet Upgrades and Sustainment*). This is because, in the context of the JSF Program where there are many dependencies not under Australia's control, the approach adopted to-date by Australian Governments and the Defence Organisation has provided appropriate insight into the program, in support of informed decision-making, commensurate with the cost and complexity of the planned acquisition.

48. Nonetheless, the successful coordination of this highly complex and costly procurement with the effective sustainment of the ageing F/A-18A/B fleet and the planned transition to an F-35-based air combat capability in the required timeframe, so that a capability gap does not arise between the withdrawal from service of the F/A-18A/B fleet and the achievement of full operational capability for the F-35, remains challenging. Following US and Australian Government decisions that have delayed earlier F-35A delivery intentions, the F/A-18A/B fleet's operational life is likely to be extended beyond the current Planned Withdrawal Date of 2020. As indicated in paragraph 28, Defence's capacity to accommodate any further delays in the production and/or acquisition of F-35s through a further extension to the life of the F/A-18A/B fleet, beyond the limited extension currently being considered, has limits, is likely to be costly,[32] and has implications for capability. That said, decisions in relation to capability for the ADF, including Australia's acquisition

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[31] Currently, the RAAF's 24 Super Hornets (the F/A-18Fs) have a Planned Withdrawal Date of 2025, and so will form part of Australia's air combat capability even after the planned entry into service of the F-35As and the withdrawal of the F/A-18A/Bs. In August 2012, the Government also announced its decision to acquire the Growler electronic warfare system for 12 of the Super Hornets, with the total capital cost estimate for this acquisition around $1.5 billion. Accordingly, the Planned Withdrawal Date for the Super Hornets may be reviewed.

[32] See Chapters 2 to 4 in ANAO Audit Report No.5 2012–13, *Management of Australia's Air Combat Capability—F/A-18 Hornet and Super Hornet Fleet Upgrades and Sustainment*, 27 September 2012.

of F-35As, properly rest with the Australian Government, informed by advice from Defence.

Key findings by chapter

Chapter 2—JSF Concept Refinement and Technology Development

49. The JSF Program is managed under the multi-phase US defense acquisition process, which steps through concept refinement, technology development, system development and demonstration, early and final production, and sustainment and disposal. The program seeks to satisfy the combat aircraft needs of the United States and its partner nations, and is the culmination of several projects in the US and the United Kingdom, some of which date back to the 1980s. The first phase developed a validated set of combat aircraft requirements, demonstrated key leveraging technologies, and developed operational concepts for subsequent strike weapon systems. Flight testing of the JSF concept demonstrator aircraft (the X-32 and X-35) was completed in August 2001, and the results were reported to have met or exceeded expectations, to an unprecedented degree in many cases. In October 2001, the US Secretary of Defense provided certification to Congressional Defense Committees that the JSF Program demonstrated sufficient technical maturity to enter the SDD phase.

50. In May 1999, project AIR 6000 was formed within Defence, with a remit to consider the 'whole-of-capability' options for providing Australia's ongoing air combat and strike capability once the F/A-18A/B and F-111 aircraft were withdrawn from service. In mid-October 2002, Australia formally joined the JSF Program's SDD phase via a Memorandum of Understanding (MoU), and with a commitment to contribute US$150 million.[33] Since then, AIR 6000 has had two objectives: to deliver a new air combat capability that is characterised by the attributes of balance, robustness, sustainability and cost-effectiveness; and to maximise the level and quality of Australian industry and science and technology participation in the global JSF Program. AIR 6000 aims to achieve these objectives through Australia's partnership in the JSF Program.

[33] In 2008, Australia committed an additional US$50 million to the SDD phase, to be paid between 2009 and 2014.

51. The Australian Government gave First Pass approval for the purchase of the F-35 Joint Strike Fighter in November 2006, shortly before Australia joined the JSF Production, Sustainment and Follow-on Development MoU.[34] In November 2009, at Second Pass, the Government approved Phase 2A/B Stage 1 funds, at an estimated cost of $3.2 billion, to acquire an initial tranche of 14 F-35A aircraft, establish the initial training capability in the United States, and allow commencement of operational testing in Australia.[35]

52. In May 2012, in the context of the 2012–13 Federal Budget, the Government announced its decision to delay the acquisition of 12 of this initial tranche of 14 aircraft by two years, with the result that the acquisition of these aircraft would be better aligned with the US Initial Operational Release of the F-35A aircraft.[36] At the time of the audit, Australia had no contractual obligation to purchase more than the long-lead items for two F-35A aircraft.[37]

53. Following the May 2012 Budget decision, Defence was replanning the F-35 acquisition schedule under AIR 6000, including the schedule for the remaining 12 aircraft to be acquired under Phase 2A/B Stage 1, and this replan was subject to government approval. The delivery of the remaining 12 aircraft in Stage 1 needs to occur in a manner that facilitates the training of sufficient RAAF pilots, and the conduct of operational test and evaluation that demonstrates the achievement of Initial Operational Capability by the date approved by the Government following its consideration of the advice Defence intends to provide this year on options.

Chapter 3—F-35 System Development and Demonstration

54. The SDD phase involves development of the F-35 aircraft, the establishment of F-35 manufacturing facilities and processes, and the

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[34] The First Pass approval process provides the Government with an opportunity to narrow the alternatives being examined by Defence to meet an agreed capability gap. This includes approval to allocate funds from the Capital Investment Program to enable the options endorsed by Government to be investigated in further detail, with an emphasis on cost and risk analysis.

[35] The Second Pass approval process leads to the final approval milestone, at which the Government endorses a specific capability solution and approves funding for its acquisition.

[36] *Prime Minister, Minister for Defence, Minister for Defence Materiel—joint press conference—Canberra*, media transcript, 3 May 2012; *Portfolio Budget Statements 2012–13: Defence Portfolio*, p. 166.

[37] Defence Materiel Organisation, New Air Combat Capability Integrated Project Team, *Acquisition project management plan*, version 1.0a, July 2011, p. 15.

completion of system development test and evaluation. This phase commenced in October 2001 and is now expected to end in 2019, at an estimated overall cost of US$55.234 billion (then-year dollars).

55. The SDD phase aims to develop and prove the F-35 aircraft and its manufacturing system, particularly through a substantial test and evaluation program. Eight partner nations joined the United States in this phase, contributing US$5.2 billion. In 2010, the United States added US$4.6 billion to the SDD phase, over and above its existing share.

56. Australian participation in the SDD phase has enabled Defence staff to be stationed in the JSF Program Office, and to play a role in promoting capability outcomes for Australia as program decisions are made. It also allows Australian firms to bid for work as part of the F-35 Global Supply Team. As at June 2012, Australian industry had signed JSF SDD and production contracts to a total value of $300 million.

57. As of December 2010, estimates for all F-35 Key Performance Parameters (KPP) were within threshold requirements, with the exception of the F-35A Combat Radius KPP. In February 2012, the US Joint Requirements Oversight Council revised this KPP to reflect the aircraft's optimum airspeed and altitude values, as obtained through testing. Once these values were applied to the mission profile, the performance of the aircraft exceeded the original KPP threshold value. Although current estimates of the F-35's performance are close to those required, performance will not be fully demonstrated until the completion of Initial Operational Test and Evaluation, currently scheduled for February 2019.

58. As at July 2012, 13 of the planned 14 SDD flight test aircraft had been delivered. An additional five production aircraft will be used in the SDD test program, resulting in a total of 19 aircraft in the SDD test fleet. There were also two airborne laboratories and several ground laboratories. Combined, these resources have enabled the conduct of over 18 500 hours of flight testing and 345 000 hours of laboratory testing of F-35 flight and mission system performance.

59. All three F-35 variants are designed and manufactured by Lockheed Martin to a Joint Services specification, which includes a structural-fatigue safe life of 8000 airframe hours for aircraft operating within specified flight profiles.[38] The SDD phase includes full-scale static and durability tests of representative test articles of all three F-35 variants, in order to verify that the F-35 aircraft may safely be operated within expected usage patterns, out to their design lifetimes (or safe life) of 8000 airframe hours, without excessive risk of a catastrophic structural failure.

60. By September 2011, airframe structural strength (static) testing of the three F-35 variants was complete. In August 2012, airframe full-scale durability testing (or fatigue testing) achieved 8000 hours of testing, which is one Equivalent Flight Hours (EFH) or one aircraft lifetime. This is 50 per cent of the two lifetimes of testing required for SDD. Two airframe lifetimes testing to 16 000 hours is scheduled for completion by 2015. Durability tests to three lifetimes (24 000 hours) were decided on as part of the Technical Baseline Review in 2010. This additional testing will provide increased assurance that a structural-fatigue safe life of 8000 hours has been achieved by the F-35 design and production process. At the time of the audit, this additional durability testing was expected to be entered into contract during the latter half of 2012.

61. By August 2012, the F-35 SDD test fleet consisted of 15 aircraft—13 SDD test aircraft and two production aircraft. Of these, ten were used for flight sciences tests and five for mission system tests. The overall F-35 SDD flight test plan calls for the verification of 59 585 test points through developmental test flights by the end of the SDD phase. This testing needs to be done in line with the development of each of the three F-35 capability Blocks, and is therefore being conducted while software development and aircraft production continues. In relation to the F-35A variant to be purchased by Australia, the test and evaluation program requires the achievement of 24 951 flight test points covering all F-35A Block 3 Initial Operational Capability requirements. In March 2012, F-35A capability testing was ongoing, and a total of 5282 test points had been achieved. This represents some 21 per cent of the overall testing required to verify achievement of Initial Operational Capability. Consequently, almost 80 per cent of the F-35 test and evaluation program is yet to be completed, and significant F-35 Key Performance Parameters are yet to be fully validated as being achieved by F-35 aircraft. Completion of Initial

[38] By way of comparison, the F/A-18A/B and F/A-18F aircraft are rated at 6000 hours. See Table 2.1 for additional comparisons.

Operational Test and Evaluation of F-35 Block 3 capability is presently scheduled for February 2019.[39]

Chapter 4—F-35 Production and Sustainment

62. The F-35 production phase commenced in November 2006, and the US Government's December 2011 production cost estimates for the 2457 F-35 aircraft it currently intends to acquire amounted to US$335.7 billion (then-year dollars). This phase is expected to end in 2037.

63. F-35 production is occurring under the Production, Sustainment and Follow-on Development Memorandum of Understanding (JSF PSFD MoU), which establishes the acquisition, support, information access and upgrade arrangements for the JSF Air System over its service life. Australia signed this MoU on 12 December 2006, and has committed an estimated US$643 million as its contribution to the production, sustainment and follow-on development of the F-35 aircraft (this amount is separate from the costs of Australia's acquisition of its own F-35 aircraft). Under this arrangement, the costs of follow-on development (that is, future upgrades) will be shared by the partner nations in proportion to the number of aircraft they purchase. In Australia's case, our PSFD investment represents around 3 per cent of the overall shared non-recurring production cost identified in the JSF PSFD MoU.

64. When the SDD phase began in 2001, the US Department of Defense also approved the production of 465 Low-Rate Initial Production (LRIP) F-35 aircraft in six LRIP contracts, in order to meet the US Armed Services' Initial Operational Capability requirements, prevent a break in production, and ramp-up to Full-Rate Production. Program changes to December 2011 have resulted in the number of LRIP aircraft to be produced for the US Armed Services decreasing from 465 to 365. This is in accordance with the US *Fiscal Year 2012 Budget Request,* which sought to balance development and concurrency risk, while leaving room for procurement by the international partner nations and for procurements by other nations through the US Government's Foreign Military Sales arrangements. As at August 2012, 205 F-35 LRIP aircraft were planned for procurement by these nations, bringing the total LRIP production planning to 570 aircraft. Since 2001, the number of

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[39] *Selected acquisition report (SAR): F-35, as of December 31, 2011*, Washington DC, pp. 9, 11–15.

production lots has increased from six to 11, with each LRIP lot the subject of separate contracts negotiated between the United States Government and Lockheed Martin. The first LRIP contract commenced in 2006, and the final one is expected in 2018.

65. The numbers of aircraft in each LRIP lot have been reduced as a result of program reviews in recent years, as part of a significant slowing of the planned production ramp-up. This is in response to technical difficulties and slower than envisaged production of the SDD phase's engineering development aircraft. The rate of design changes during F-35 system development has also remained higher than expected, and this has resulted in the need to implement design changes in the LRIP aircraft in the production line and those already produced.

66. Producing aircraft before the completion of the SDD phase (known as concurrency) has resulted in increased engineering and budget risks. In response to the budget risks, the US Department of Defense has changed its contracting strategy, sharing some of the costs of concurrency up to a cost ceiling, above which the costs are to be borne by the contractor. Recent testimony from the US Department of Defense to Congress was that concurrency is a transient issue, with risks being progressively reduced as the aircraft design is confirmed or issues requiring changes are identified and incorporated.

67. Australia's exposure to concurrency costs is limited in three ways. Australia presently intends to order its first two F-35A aircraft in 2012, in time for inclusion in the 2014–15 LRIP Lot 6 production program. The purchase of the F-35A variant is likely to contain Australia's exposure to concurrency-related costs to the aircraft variant with the least design and production risk. Since Australia is ordering its first aircraft from LRIP Lot 6, this further contains Australia's exposure to only those design and production defects that were not discovered in the earlier five LRIP production lots. Further, as the bulk of Australia's F-35A orders are scheduled to occur between 2015 and 2020, it is expected that the risk of F-35 design and production defects being discovered for the first time during that period, and their remediation costs, would decrease significantly from present levels.

68. The JSF sustainment concept seeks to maximise affordability through globalised asset pooling, platform-level performance-based logistics with Lockheed Martin, and best-value placement of global support capacity. At the time of the audit, overall sustainment costs were not of tender quality due to the early stage of the program, and high-confidence estimates are not expected until the JSF system achieves maturity in around 2018. However, some actual sustainment costs became available from late 2011, when the first F-35s commenced service at the US Air Force's Eglin Air Force Base, and these figures are now being used to refine and update forward estimates.

69. The objectives of the New Air Combat Capability project include maximising the level and quality of Australian industry participation and science and technology participation in the global JSF sustainment program. Project records indicate that Australia's minimum F-35 sustainment activities that must be performed locally, based on sovereign needs and performance requirements, have been defined. These include an intent to keep the RAAF workforce constant between the F/A-18A/B and F-35 fleets, and to ensure that, once the aircraft have arrived in Australia, all Australian aircraft maintenance and pilot training occurs in Australia.

Chapter 5—JSF Program Reviews and Progress

70. The JSF Program is acknowledged as the Pentagon's most expensive current weapons program. Evaluating the cost of such a large acquisition program is extremely difficult, given the inherently long and expensive task of designing and manufacturing aircraft with leading-edge technology, and maintaining that capability for up to 30 years.

71. The JSF Program Office, other US Department of Defense authorities, and the US Government Accountability Office have conducted regular reviews and audits of the JSF Program. These provide a level of assurance that the JSF Program is progressing with an appropriate level of US Government oversight focused on improving program outcomes. They have resulted in significant revisions of production numbers, costs and schedules. The estimated cost of the F-35 development phase has increased from US$34.4 billion to US$55.234 billion (in then-year dollars), a rise of 61 per cent since system development commenced in October 2001. Further, the estimated total cost to the US of the program as a whole has risen from US$233.0 billion to US$395.712 billion (in then-year dollars), a rise of 70 per cent since 2001. As at December 2011, the development effort was reported by the US Department of Defense to be 80 per cent complete. Part of the increases in development costs can be attributed to US Government decisions to increase the scope of F-35 development and demonstration effort.

72. The most comprehensive systems engineering review of the JSF Program to date was the 2010 Technical Baseline Review (TBR), which in January 2011 led to a budget increase of US$4.6 billion. That increase was needed to fund the program's March 2012 cost and schedule rebaseline, which included the SDD phase being extended by three years to 2019. At the same time, budget considerations and concurrency risks drove a decision to further reduce the numbers of aircraft being produced in LRIP lots. Data from Lockheed Martin's Earned Value Management System indicates that, since the TBR, the program has been achieving its cost and schedule goals in a more sustained manner than previously, indicating the potential for the program to continue progress within its cost and schedule parameters.

73. The US Weapon Systems Acquisition Reform Act of 2009, prompted by the cost overruns in the JSF Program and other programs, has driven a strong focus towards delivering better value to the taxpayer. For the JSF Program in particular, the US Department of Defense has adopted a proactive approach to pricing through a Should-Cost initiative, which requires program managers to justify each element of program cost and show how it is improving. In the first half of 2012, negotiations for the next F-35 production contract were being conducted within a Fixed Price Incentive Firm Target contract arrangement. This is expected to lead to Lockheed Martin and the US Government sharing equally the burden of any cost overruns over a contract Target Price and up to a Ceiling Price, which is set at 6.5 per cent above the Target Price; any costs above the Ceiling Price are to be Lockheed Martin's responsibility.

Summary of agency response

74. Defence provided the following response to this report and the companion report:

> Defence welcomes the ANAO audit reports on the Management of Australia's Air Combat Capability. These extensive reports demonstrate the complex and evolving nature of Australia's air combat systems which are at the forefront of Australia's Defence force structure.
>
> These reports also highlight a number of challenges that Defence faces in transitioning from its current 4th and 4.5th generation fighters into the 5th generation F-35A.
>
> Defence has made significant progress towards increasing efficiencies and maximising combat capability over a decade of continuous air combat upgrades and acquisitions. The experience gained stands Defence in good

stead for the acquisition of future air combat capabilities through a strong collegiate approach across the various areas of Defence, the Defence Materiel Organisation and external service providers. This experience will ease the burden during what will be a carefully balanced transition to the F-35A.

Defence acknowledges that there is scope to realise further improvements through process alignment and business practice innovation, and will continue to build on the work that has already been undertaken. Defence is committed to managing the complexities of its various reform programs whilst continuing to assure Australia's future air combat capability requirements.

75. The formal response from Defence is included at Appendix 1.

76. Extracts from the proposed report were also provided to the US Government's JSF Program Office and to Lockheed Martin for formal comment. The JSF Program Office response is included at Appendix 2, and the Lockheed Martin response at Appendix 3.

Audit Findings

1. Introduction

In the light of its history, Australia places a high priority on its air combat capability. This chapter therefore explains the long lead-times involved in aircraft development and sustainment, and outlines this audit's approach and methodology.

Background

1.1 In successive Defence White Papers since 1976,[40] Australia has outlined its defence strategy, which includes the control of the air and sea approaches to Australia. In this context, the Defence White Paper 2009 stated:

> Our military strategy is crucially dependent on our ability to conduct joint operations in the approaches to Australia—especially those necessary to achieve and maintain air superiority and sea control in places of our choosing. Our military strategic aim in establishing and maintaining sea and air control is to enable the manoeuvre and employment of joint ADF [Australian Defence Force] elements in our primary operational environment, and particularly in the maritime and littoral approaches to the continent.[41]

1.2 At the time the Defence White Paper 2009 was developed, the RAAF's air combat capability consisted of an ageing fleet of 21 F-111C fighter-bomber aircraft and 71 F/A-18A/B Hornet aircraft. However, the acquisition of 24 F/A-18F Super Hornets was in train. Describing the air combat capability needed to implement the strategy set out in paragraph 1.1 above, the White Paper stated:

> The Air Combat Capability Review [2008] assessed that the squadron of F/A-18F Super Hornets being acquired as a bridging air combat capability is a highly capable 4.5 generation aircraft and, as long as it retains commonality with the planned US Navy development path, will remain effective until at least 2020. The F/A-18F Super Hornet will begin to enter service from the end of 2010.
>
> The Review concluded that a fleet of around 100 fifth generation multirole combat aircraft would provide Australia with an effective and flexible air

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[40] Defence White Papers have been published in 1976, 1987, 1994, 2000 and 2009.

[41] *Defending Australia in the Asia Pacific Century: Force 2030. Defence White Paper 2009*, Canberra, 2009, paragraph 7.3, p. 53.

combat capability to 2030. A further judgement of the review was that the F-35 Joint Strike Fighter (JSF) is the preferred solution for that requirement. Other fourth and fifth generation combat aircraft considered by the Review were judged to be less capable of fulfilling Australia's multirole air combat capability requirements.

The Government has decided that it will acquire around 100 F-35 JSF, along with supporting systems and weapons. The first stage of this acquisition will acquire three operational squadrons comprising not fewer than 72 aircraft. The acquisition of the remaining aircraft will be acquired in conjunction with the withdrawal of the F/A-18F Super Hornet fleet, and will be timed to ensure that no gap in our overall air combat capability occurs.

Australia's future air combat capability will therefore be based on four operational air combat squadrons consisting initially of three JSF squadrons and a squadron of Super Hornet aircraft, which will be replaced by a fourth JSF squadron. Defence will continue to progressively upgrade the systems and airframes of the current F/A-18 aircraft to ensure that they remain capable and sustainable until the JSF enters service with the ADF.[42]

1.3 Australia's air combat capability is underpinned by acquisition decisions which typically take several years to achieve final operational capability. Over the last six decades, the RAAF has been equipped with successive fleets of bomber and fighter aircraft, as illustrated in Table 1.1. The 1950s combination of the Canberra and Sabre fleets was followed by the F-111 fleet, which was operated first with the Mirage fleet and then with the Hornet fleet.

1.4 The RAAF fleets are now in a period of transition similar to the transition from the Canberra bomber fleet to the F-111 fleet in the early 1970s, or from the Mirage fighter fleet to the Hornet fleet in the mid-1980s. In 2010 the then remaining fleet of 21 F-111C long-range strike and reconnaissance aircraft

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[42] Lockheed Martin is developing, on behalf of the United States Department of Defense and its partner nations, three F-35 JSF variants: an F-35A multi-role conventional take-off and landing (CTOL) fighter; an F-35B multi-role short take-off and vertical landing (STOVL) fighter; and an F-35C multi-role carrier variant (CV) fighter. The F-35C is similar to the F-35A, but has larger wings for increased fuel capacity, plus slats as well as larger horizontal tails and control surfaces for better low-speed landing performance, strengthened structure and landing gear for carrier landings, and removal of the internal cannon in favour of an optional gun pod on the fuselage centre-line station. *Defending Australia in the Asia Pacific Century: Force 2030. Defence White Paper 2009*, Canberra, 2009, paragraphs 9.58–9.61, pp. 78–9.

was withdrawn from service,[43] while the current fleet of 55 F/A-18A (single-seat) and 16 F/A-18B (dual-seat) Hornets has been in operational use for up to 27 years. However, the F-35A JSF aircraft, which is to replace both F/A-18 types (the F/A-18A/Bs and the F/A-18F Super Hornets), is not expected to achieve Initial Operational Capability until after 2020,[44] by which time the oldest RAAF F/A-18 would have been in service for 35 years. The upgrade and sustainment of the Hornet and Super Hornet fleets are the subject of a companion audit, ANAO Audit Report No.5 2012–13, *Management of Australia's Air Combat Capability—F/A-18 Hornet and Super Hornet Fleet Upgrades and Sustainment*, 27 September 2012.

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43 The four F-111As acquired in 1982 had been converted to F-111C configuration, making a total of 28 F-111Cs. By 2010, this fleet had been reduced by attrition to 21.

44 The achievement of the Initial Operational Capability (IOC) milestone by the RAAF's F-35A variant was originally planned for 2012–14, but by 2011 it had slipped to 2018. Until recently, it was expected that the US Air Force IOC would be achieved in early 2018, and that the RAAF IOC would occur after that. However, the US Services have requested a delay in establishing IOC dates, anticipating that they will identify these dates in 2013, after observing additional test results during 2012. After the May 2012 Budget decisions, and subject to further Defence planning, Australian IOC was initially projected to occur in 2020. *Defence Capability Plan 2004–2014*, p. 45; *Defence Capability Plan 2011*, p. 57; *Selected acquisition report (SAR): F-35, as of December 31, 2011*, Washington DC, pp. 6, 63.

Table 1.1

RAAF acquisitions of combat aircraft since 1953

Aircraft	Type	Purchase approved	Entry into service	Withdrawal from service	Years in service	Number acquired	Assembled in
Canberra	Bomber	1950	1953	1982	29	48	Australia
Sabre	Fighter	1951	1955	1971	16	112	Australia
F-4E Phantom[(a)]	Fighter-bomber	1970	1970	1973	3	24	USA
F-111C F-111A F-111G	Fighter-bomber	1963 1980 1992	1973 1982 1993	2010 2010 2007	37	24 4 15 43	USA
Mirage IIIO/IIID	Interceptor/ ground-attack fighter	1960 1962 1963 1964 1970	1964	1988	24	30 30 40 10 6 116	2 in France, 114 in Australia
F/A-18A/B Hornet	Strike fighter	1981	1985	[2020]	[35]	75	2 in USA, 73 in Australia
F/A-18F Super Hornet[(b)]	Strike fighter	2007	2010	[2025]	[15]	24	USA
F-35 JSF	Strike fighter	2009[(c)]	[2014–21][(d)]			[100][(e)]	USA[(f)]

Notes: (a) The Phantoms were leased as an interim measure, pending the delivery of the F-111s.

(b) The Super Hornets were purchased as an interim measure, pending the acquisition of the F-35s.

(c) Australia became a partner nation for F-35 JSF development in 2002, and for F-35 production in 2006.

(d) Projected date from *Defence Capability Plan 2011*.

(e) The Defence White Paper 2009 outlined Australia's intent to purchase 100 F-35 JSFs. To date, the Government has approved the purchase of 14 F-35 JSFs, with purchase of another 58 originally planned for approval in 2012, and a decision on a final batch not expected before 2015 (*Defence Capability Plan 2011*, p. 57); see paragraphs 2.44 to 2.50 and 2.65 to 2.68 for the impact of May 2012 Budget decisions on these plans.

(f) Although the F-35 is to be assembled in the United States, significant manufacturing work for the aircraft is being undertaken by industry in the international partner nations; for an indication of international and Australian manufacturing involvement in the F-35, see Figure 3.2 and Figure 3.3.

Source: ANAO analysis.[45]

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[45] Sources for the historical dates in this table include: *Australian centenary history of Defence, Volume II: The Royal Australian Air Force*; Susans, MR, *The RAAF Mirage story*, Royal Australian Air Force Museum, Point Cook, 1990; Lax, M, *From controversy to cutting edge: a history of the F-111 in Australian service*, Air Power Development Centre, Department of Defence, Canberra, 2010; Australian Parliament Hansard; Cabinet records, National Archives of Australia; Defence media releases; and the RAAF Museum website, http://www.airforce.gov.au/raafmuseum/.

1.5 At the time of the audit, in order to ensure that Australia continues to have the capability outlined in the Defence White Paper 2009, pending the introduction into service of the replacement capability to be provided by the F-35A JSF aircraft, the service life of the F/A-18A/B fleet had been extended until 2020, and a fleet of 24 F/A-18F Super Hornets had been acquired to replace the F-111s.

Audit objective and scope

1.6 Given the strategic significance of Defence's air combat capability, the ANAO considered it timely to examine both the effectiveness of Defence's arrangements for the sustainment of the F/A-18 Hornet and Super Hornet fleets that comprise the RAAF's current capability, and Defence's progress in securing new combat aircraft to replace the F/A-18 fleets at the end of their lives through the AIR 6000 project. Accordingly, the ANAO has undertaken two companion performance audits on these subjects. This audit focuses on Defence's management of the procurement of F-35A aircraft by Defence's AIR 6000 project through the Joint Strike Fighter Program, which is a United States Government undertaking in partnership with eight other partner nations.

1.7 The audit objective was to assess the progress of the AIR 6000—New Air Combat Capability project in delivering the required combat aircraft within approved cost, schedule and performance parameters. In particular, the audit assessed Defence's arrangements to ensure that it has adequate insight into the development and production of the F-35A and, accordingly, appropriate evidence about the status of the JSF Program to:

- inform progressive acquisition decisions by Government; and
- underpin appropriate contingency planning to avoid any capability gap opening up between the withdrawal from service of the RAAF's F/A-18 fleets, particularly the F/A-18A/B fleet, and the entry into service of the F-35A-based air combat capability.

1.8 Given that the JSF Program is still in its development and initial production phases, the audit scope included examining:

- the definition of the F-35A JSF New Air Combat Capability requirements, carried out under AIR 6000 (Chapter 2);
- the progress achieved by the JSF Program's System Development and Demonstration (SDD) phase (Chapter 3);

- the progress achieved by the JSF Program's Production and Sustainment phases (Chapter 4); and
- reviews of the JSF Program, and its progress in terms of cost and schedule (Chapter 5).

1.9 As the JSF Program is a US Government undertaking, the ANAO did not intend to, nor was it in a position to, conduct a detailed analysis of the full range of engineering issues being managed within the program's SDD and production phases. Rather, the audit focused on examining the current status of the F-35 SDD and production phases to underpin an assessment of the progress of the AIR 6000—New Air Combat Capability project in delivering the required combat aircraft within approved cost, schedule and performance parameters. The audit did not examine total whole-of-life costs of the F-35A aircraft Australia intends to acquire. Whole-of-life costs include costs for research and development, production, personnel to operate and maintain a system, facilities and eventual disposal. They would also include sustainment costs, which cannot yet be fully established for the F-35A, because at the time of the audit, these costs were being refined and updated having regard to actual costs of sustaining Low-Rate Initial Production F-35 aircraft, and were the subject of JSF Program Office targeted affordability initiatives.

1.10 The audit scope did not include the industrial participation program for JSF partner nations.[46] The Australian Defence Force's (ADF's) air combat fleet is supported by Airborne Early Warning and Control aircraft, air-to-air refuelling aircraft, lead-in fighter training aircraft, air bases, and command, control and surveillance capabilities.[47] These support systems are not included in the audit's scope.

1.11 The audit scope also did not include possible issues arising from any extension of the F/A-18A/B fleet's Planned Withdrawal Date beyond 2020 as a result of the Government's May 2012 Budget decision to delay acquisition of

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[46] Under the international agreements for the Joint Strike Fighter Program, the industries of partner nations gained the right to tender for JSF development and production work. The industrial participation program was excluded from audit coverage in order to allow an increased focus on the F-35 development and production phases. However, for convenience, a diagram of the Global Supply Team for the JSF is included at Figure 3.2, and a diagram of Australian industry involvement at Figure 3.3.

[47] *Defending Australia in the Asia Pacific Century: Force 2030. Defence White Paper 2009*, Canberra, 2009, paragraph 8.22, p. 61.

the F-35. The Government was yet to consider this issue at the completion of the audit; however, the ANAO did review the planning underway in Defence to advise the Government on options to address such issues.

1.12 To gather appropriate evidence to underpin this audit, the ANAO conducted audit fieldwork in both Australia and the US. The Australian audit fieldwork was conducted from October 2011 to June 2012 at the Canberra offices of the New Air Combat Capability Integrated Project Team. The US fieldwork was conducted in March 2012. It included visiting and collecting evidence from the JSF prime contractor, Lockheed Martin; the Defense Contract Management Agency office in Fort Worth, Texas; the JSF Program Office in Arlington, Virginia; the US Department of Defense in Washington DC; and the Defense Contract Audit Agency in Fort Belvoir, Virginia. In addition, the ANAO visited the US Government Accountability Office (GAO), given its role in auditing and providing independent evidence on the JSF Program to the US Government and the Congress.

1.13 The ANAO's examination of the current status of the F-35 SDD and production phases included collecting and analysing key project management documents obtained from the Australian New Air Combat Capability Integrated Project Team and from the US Department of Defense's JSF Program Office. In addition, the ANAO considered evidence provided by a number of US Department of Defense agencies, which operate outside the line-of-control of the program office and provide independent advice on the JSF Program to the US Government.[48] The ANAO also analysed the GAO's reports on this program, and other official reports and sworn testimony provided to the US Congress.[49] As noted in paragraph 1.12, the ANAO visited Lockheed Martin and was provided with documents and access to key Lockheed Martin F-35 program executives and managers. Overall, the ANAO was able to interview key personnel responsible for managing the JSF Program or for providing oversight of it.

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48 The US Department of Defense's Director, Operational Test and Evaluation, the US Defense Contract Audit Agency, and the US Department of Defense's Office of Cost Assessment and Program Evaluation.

49 Since 2001, the GAO has delivered eight reports specifically on the JSF Program, with the latest delivered in June 2012. As a 'congressional watchdog', its focus in undertaking this work has necessarily been on determining whether US Federal funds are being spent efficiently and effectively. In contrast, this audit provides an Australian perspective, which has regard to GAO and other reports, but our conclusions may not always align with the US perspective.

1.14 The following high-level audit criteria have been applied in this audit:

- Defence has fully defined the F-35 JSF capability requirements in terms of:
  - Operational Concepts;
  - Function and Performance Specifications; and
  - Test Concepts.
- The Memorandum of Understanding arrangements with the US JSF Program allow for Defence to adequately verify that the F-35A aircraft have achieved their specified cost, schedule and performance requirements.
- Reports and statistics on the development of the F-35 provide assurance that the cost, schedule and performance of Project AIR 6000, as agreed to by the Government, are likely to be achieved.

1.15 The audit was conducted in accordance with the ANAO auditing standards at a cost to the ANAO of $371 800.[50]

Report structure

1.16 The remainder of this audit report is structured into four chapters.

- Chapter 2 examines the JSF Program's Concept Refinement and Technology Development phases, international partnership arrangements for those phases, and the status of the Australian Government's approval for the acquisition of F-35A aircraft under project AIR 6000.
- Chapter 3 examines the JSF Program's SDD phase, which has constructed F-35 engineering development aircraft in the three variants of the F-35 Lightning II. This phase is also developing F-35 manufacturing processes and sustainment arrangements, which are specified to be affordable and executable. The chapter also considers the F-35's design approval and acceptance process, and Australian Military Type Certification.

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[50] As mentioned in paragraph 1.4, this report is a companion to ANAO Audit Report No.5 2012–13. The combined cost of both audits was $676 100.

- Chapter 4 examines the Low-Rate Initial Production (LRIP) phase of the JSF Program, which is taking place concurrently with the project's SDD phase. The chapter also discusses the issues arising in the concurrent development and production of F-35 aircraft, and outlines the planned approach to sustainment of the Australian F-35 fleet.
- Chapter 5 examines program issues that have resulted in delays in the JSF Program, drawing upon recent program reviews conducted in both the United States and Australia. It also examines the performance metrics for the JSF Program in terms of cost and schedule, and provides current Unit Recurring Flyaway (URF) cost estimates for the F-35A aircraft out to 2037.

2. F-35 Concept Refinement and Technology Development

This chapter examines the JSF Program's Concept Refinement and Technology Development phases, international partnership arrangements for those phases, and the status of the Australian Government's approval for the acquisition of F-35A aircraft under project AIR 6000.

The JSF Program

2.1 The Joint Strike Fighter (JSF) Program is developing the F-35 aircraft, which has been selected by the Australian Government to provide a capability to allow Australia to dominate its air and sea approaches out to 2030 and beyond, and to effectively contribute to regional security and future coalition operations.[51]

2.2 The JSF Program is the culmination of several aircraft-development projects in the United States and the United Kingdom, some of which date back to the 1980s.[52] The US Department of Defense's 1993 *Report on the Bottom-up Review*[53] acknowledged the Services' need to affordably replace their ageing strike assets, and this led to the establishment of the Joint Advanced Strike Technology (JAST) Program in 1994. The JAST Program's objectives were to facilitate the Services' development of a validated set of joint requirements,

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51 Senator the Hon. John Faulkner, Minister for Defence, *F-35 Joint Strike Fighter—Australia's next generation air power*, media release, 25 November 2009.

52 These projects included: a US–UK project for an Advanced Short Take-Off and Vertical Landing (ASTOVL) aircraft, 1983–94; the STOVL Strike Fighter (SSF), 1987–94; the Common Affordable Lightweight Fighter (CALF), 1993–94; Multi-Role Fighter (MRF), 1990–93; Advanced Tactical Aircraft (ATA), 1983–91; Naval Advanced Tactical Fighter (NATF), 1990–91; and Advanced-Attack/Advanced/Fighter-Attack (A-X/A/F-X), 1992–93.
For detailed accounts of the pre-history of the F-35, see: F-35 Lightning II Program, *History* [Internet], Arlington, VA, 2009, available from http:/www.jsf.mil/history/; Office of the Parliamentary Budget Officer, *An estimate of the fiscal impact of Canada's proposed acquisition of the F-35 Lightning II Joint Strike Fighter*, Ottawa, 2011, pp. 11–13, available from http://www.parl.gc.ca/PBO-DPB/documents/F-35_Cost_Estimate_EN.pdf; and Martin Baker Aircraft Co. Ltd., *A history of the Joint Strike Fighter Programme: the search for a Harrier replacement*, 2005, available from http://www.martin-baker.co.uk/getdoc/d25952ab-5881-4999-8593-6f7f196c8770/a_history_of_the_joint_strike_fighter_programme.aspx.

53 Les Aspin, Secretary of Defense, *Report on the Bottom-Up Review*, Department of Defense, Washington DC, October 1993.

demonstrate key leveraging technologies, and develop operational concepts for subsequent strike weapon systems.[54]

2.3 US congressional action later combined the Common Affordable Lightweight Fighter (CALF) Program with the JAST Program. The CALF Program's aim was to develop the technologies and concepts to support the next generation Advanced Short Take-off and Vertical Landing (ASTOVL) aircraft for the US Marine Corps and the UK Royal Navy.[55]

2.4 In November 1995, the US Department of Defense completed the initial set of JSF requirement specifications. Known as the Joint Initial Requirements Document (JIRD), these specifications were updated in 1997 and 1998, with each update based on cost and performance trade-offs, with an emphasis on cost as an independent variable (CAIV).[56] In March 2000, the JSF requirements development process culminated in the approval of the Joint Operational Requirements Document (JORD) by the US Air Force, Navy and Marine Corps and the Royal Navy.[57] The JORD was last revised in 2008.[58]

2.5 A key JSF Program strategy is to achieve cost-saving during the aircraft design, manufacture and sustainment phases, through commonality of aircraft parts, international partnerships and mass production. The JSF aircraft requirements call for 70 per cent to 90 per cent commonality between all three variants. This has resulted in high-cost components, such as engines, avionics,

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54 US Department of Defense, *Joint Strike Fighter operational requirements document*, March 2000, p. 1.

55 US Department of Defense, *Joint Strike Fighter operational requirements document*, March 2000, p. 1.

56 The US Department of Defense Directive 5000.01 (which governs the US defense acquisition system) requires US defense planners to recognise the reality of fiscal constraints, and to plan programs based on realistic projections of the dollars and manpower likely to be available in future years. The concept of cost as an independent variable is that cost should be treated on an equal footing with the other variables, namely performance and schedule, and trade-offs of cost, performance and schedule should be made to achieve challenging but realistically achievable goals. Cost in this context refers to the life-cycle cost of a capability. The CAIV concept—the equivalent of sound commercial business practices—has been in place since 1995. US Department of Defense, *Directive 5000.01: The Defense acquisition system*, 12 May 2003, paragraph E1.1.4; Defense Acquisition University, *Defense acquisition guidebook*, as at 29 July 2011, section 3.2.4.

57 *Selected acquisition report (SAR): JSF, as of December 31, 1996*, Washington DC, p. 2; *Selected acquisition report (SAR): F-35 (JSF), as of September 30, 2001*, Washington DC, p. 4.

58 However, the Joint Requirements Oversight Council (JROC) approved changes to the F-35's Key Performance Parameters (KPPs) in March 2012 (see paragraph 3.47). *Selected acquisition report (SAR): F-35, as of December 31, 2011*, Washington DC, pp. 6, 15.

and major airframe structural components, being of a common design.[59] However, the goal of 70 per cent to 90 per cent commonality has proven more difficult than Lockheed Martin and the JSF Program Office envisaged. The exception is avionics, where almost 100 per cent commonality has been achieved.

2.6 The vision of the F-35 Lightning II Joint Strike Fighter (JSF) Program is to:

> 'deliver and sustain the most advanced, affordable strike fighter aircraft to protect future generations worldwide.' The JSF Program will address the needs of the United States (US) and International Partners (Partners) by developing, deploying and sustaining three variants of the Lightning II that maximize affordability by capitalizing on commonality and modularity. This family of strike fighter aircraft consists of the F-35A Conventional Takeoff and Landing (CTOL), F-35B Short Takeoff and Vertical Landing (STOVL), and F-35C aircraft carrier suitable (CV) variants […]. The F-35A will provide the US Air Force (USAF) and Partners with a multirole aircraft to replace the F-16 Falcon, A-10 Thunderbolt II and various Partner legacy aircraft. The F-35B will provide the US Marine Corps (USMC) with a replacement for the AV-8B Harrier and F/A-18A/C/D Hornet. The F-35C variant will provide the US Navy (USN) with a carrier based, advanced technology strike fighter to complement the F/A-18E/F Super Hornet. The F-35B will provide the United Kingdom (UK) with an enhanced capability replacement for the RN F/A-2 Sea Harrier and RAF GR-7/9 Harrier.[60]

2.7 The F-35 is a single-seat, single-engine aircraft incorporating low-observable (stealth) technologies, advanced avionics, advanced sensor fusion,[61] internal and external weapons, and advanced prognostic maintenance capability. These technologies and capabilities, combined with advanced

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59 Jeremiah Gertler, *F-35 Joint Strike Fighter (JSF) Program: Background and issues for Congress*, Congressional Research Service, 26 April 2011, p. 2.

60 F-35 Lightning II Joint Strike Fighter Program Office, *F-35 Lightning II Joint Strike Fighter: Test and evaluation master plan (TEMP)*, Third Revision, January 2009, paragraph E.1. Although the UK Government decided in October 2010 that it would purchase the F-35C variant for its new aircraft carriers, rather than the F-35B, this decision was reversed in May 2012, and the UK will now be acquiring F-35Bs for its fleet. *Securing Britain in an age of uncertainty: the strategic defence and security review*, London, 2010, p. 23; *House of Commons Hansard*, 10 May 2012, columns 140–42.

61 Sensor fusion is the ability to integrate information from both on-board sensors and off-board sources and present the information to the pilot in an easy-to-use format, thereby greatly enhancing the pilot's situational awareness.

design and construction features, result in the F-35 being a 'fifth generation' combat aircraft with a 30-year planned service life and an upgrade path capable of maintaining specified air superiority.

2.8 The program plan for the F-35 includes three basic steps in the development and flight testing of F-35 aircraft capability:[62]

- Block 1 provides initial training capability;
- Block 2 provides initial war-fighting capability, including weapons employment, electronic attack, and interoperability between forces; and
- Block 3 provides the full war-fighting capability, including full sensor fusion and additional weapons.

2.9 Each year of F-35 production delivers a version of one of these capability blocks for government acceptance.[63] This is planned to continue during the F-35 Follow-on Development phase, which is to deliver additional capability blocks in two-year increments.

2.10 Figure 2.1 provides the front, top and side views of the F-35A conventional take-off and landing (CTOL) aircraft, which is the F-35 version selected by the Australian Government for use by the RAAF.[64]

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[62] US Government Accountability Office, *Joint Strike Fighter: DOD actions needed to further enhance restructuring and address affordability risks*, GAO-12-437, June 2012, pp. 19–20, 23.

[63] Department of Defense, Vice Admiral David J. Venlet, Program Executive Officer F-35, *Presentation to the Senate Armed Services Committee Subcommittee on Tactical Air and Land Forces: F-35 Joint Strike Fighter Program*, Washington DC, 8 May 2012, p. 9.

[64] For dimensions and other details of the F-35A, and comparisons with the Hornet and Super Hornet aircraft, see Table 2.1 on page 69.

Figure 2.1

F-35A conventional take-off and landing Joint Strike Fighter

Source: JSF Program Office.

2.11 The JSF Program is managed through the US defense acquisition process, illustrated in Figure 2.2.[65]

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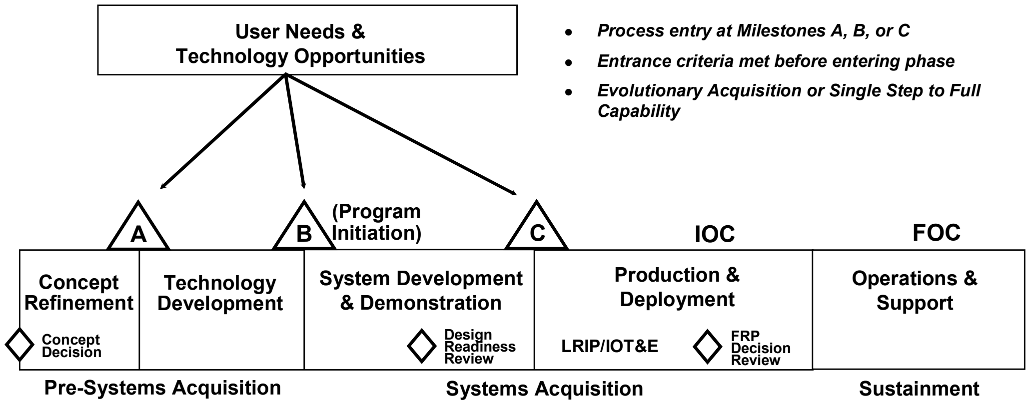
65 Although the US defense acquisition process has undergone a number of changes in recent years, the underlying approach—progression through 'milestones' from concept to demonstration to system development to low-rate production and finally full production—has endured. For a diagram of the highly complex process, see Defense Acquisition University, *Integrated Defense acquisition, technology, and logistics life cycle management system*, version 5.4, 15 June 2010, available from https://ilc.dau.mil [accessed 12 September 2011].

Figure 2.2

United States defense acquisition process, 2003



Source: US Department of Defense Instruction 5000.2, *Operation of the Defense acquisition system*, May 2003.

Notes:

IOC	Initial Operational Capability
FOC	Final Operational Capability
LRIP	Low-Rate Initial Production
IOT&E	Initial Operational Test & Evaluation
FRP	Full-Rate Production

2.12 This chapter discusses the JSF Program's organisational arrangements, the JSF Concept Refinement and Technology Development phases, international participation in these phases, and Australia's AIR 6000 project, which is acquiring F-35 aircraft for the RAAF. Chapter 3 discusses the JSF SDD phase, Chapter 4 discusses the JSF Production, Sustainment and Follow-on Development phases, and Chapter 5 discusses the JSF Program's progress toward achieving its Initial Operational Capability milestone.

Organisational arrangements

2.13 The JSF Program Office is the US Government Program Office managing the F-35 acquisition and sustainment program, on behalf of the US Services and international partner nations.

2.14 Lockheed Martin Aeronautics (Lockheed Martin) is responsible to the JSF Program Office for F-35 system development and integration, production and sustainment, including the roles of Original Equipment Manufacturer and design agency. Lockheed Martin's F-35 production facility is located is located at Fort Worth, Texas. This facility is a US Government-Owned Contractor-Operated (GOCO) facility that has been producing military aircraft since 1942.

2.15 Pratt & Whitney is the JSF Propulsion System contractor, responsible for the F-35 aircrafts' F135 jet engine Original Equipment Manufacture and design, and for delivering the F135 engines directly to the JSF Program Office. The JSF Program Office then provides the engine as Government Furnished Equipment to Lockheed Martin for installation into each F-35. The completed F-35s are then offered to the US Defense Contract Management Agency (DCMA) for government acceptance.

2.16 Defence's acquisition of the F-35 aircraft is being coordinated by Defence's New Air Combat Capability Integrated Project Team (NACC IPT).[66] At the time of the audit, the NACC comprised 99 personnel, of which 90 positions are currently filled. This figure includes the Australian Defence personnel who are located within the JSF Program Office in Arlington Virginia, who indirectly contribute to the NACC IPT. These personnel are drawn from DMO's Aerospace Systems Division, DMO's Industry Division, the RAAF, the Defence Science and Technology Organisation, the Defence Capability Development Group, and a small number of contractors.[67] This structure is ideally suited to the task of coordinating the acquisition of the new combat capability. Through this arrangement, the NACC IPT performs the traditional DMO Acquisition Project Office function, in conjunction with the functions of Capability Sponsor, scientific advisor, execution of agreed Government industry requirements, progression of project Second Pass submissions[68] and Transition Management. However, overall there are fewer than 50 of the 99 personnel employed in the traditional DMO 'acquisition' role.

2.17 On delivery of the F-35A aircraft, the role of the NACC IPT will reduce into that of a traditional DMO Systems Program Office (SPO).[69] However, the JSF Program Office will remain responsible for a significant proportion of the

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66 Defence Materiel Organisation, New Air Combat Capability Integrated Project Team, *NACC project design acceptance strategy*, April 2012.

67 Defence Materiel Organisation, New Air Combat Capability Integrated Project Team, *Organisation chart*, May 2012.

68 Second Pass approval by Government is required for each tranche of aircraft purchased under the NACC project.

69 SPOs are responsible for logistics support, technical airworthiness management, financial management, technical assurance, and other Commonwealth governance functions that cannot, by their nature, be delegated to a third party.

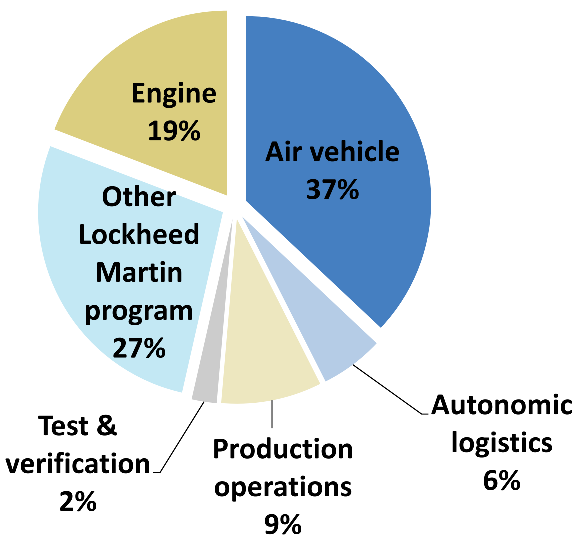
F-35 logistics support roles and responsibilities traditionally performed by a DMO SPO.[70]

JSF Program structure

2.18 At the time of the audit, the JSF Program was predominantly structured for its System Development and Demonstration (SDD) phase and the Low-Rate Initial Production (LRIP) phase. The JSF Program's budget for the SDD phase includes the development of the F-35 aircraft and its F135 engine, and also the production facilities and operations support system for the aircraft, as shown in Figure 2.3. The key elements of the JSF SDD phase and the LRIP phase are outlined in Chapters 3 and 4 respectively.

Figure 2.3

JSF Program SDD phase budget structure, as at June 2012



Includes only F-35 Air System and Engine suppliers

Source: JSF Program Office.

[70] Defence Materiel Organisation, New Air Combat Capability Integrated Project Team, *NACC acceptance into service plan*, version 3.0b, December 2009, p. 51.

2.19 The sectors in Figure 2.3 comprise:

- *Air Vehicle*: Design, Airframe, Vehicle Systems, Mission Systems, Weapons Integration, Laboratory Development and Structural Development;
- *Autonomic Logistics*: including Autonomic Logistics Design Integration, Support System, Training System, Autonomic Logistics Information System (ALIS), Sustainment Implementation, Autonomic Logistics and Global Sustainment (ALGS), and Operations and System Supportability Analysis;
- *Production Operations*: including Production Operations Build, Quality Assurance, Production Operations Systems Engineering, Production Control, Industrial Engineering, Production Transition, Production Engineering, International Production, all for the test aircraft produced under the SDD contract;
- *Test and Verification program*: for three F-35 variants, conducted at US Naval Air Station Patuxent River, Maryland; US Air Force's Edwards Air Force Base, California; plus the Cooperative Avionics Test Bed (CATB) aircraft;
- *Other Lockheed Martin programs*: including all other SDD efforts not cited above, such as Air System Development/Engineering, Lockheed Martin Program Office; and
- *F135 engine development*.

2.20 The JSF Program Office manages the overall program, and relies on the US DCMA to manage the acquisition contracts with the JSF Program's prime contractors, Lockheed Martin and Pratt & Whitney.[71] DCMA's role in the JSF Program is discussed further in Chapter 5.

2.21 Australia, through project AIR 6000, is participating in the JSF Program's SDD phase and Production, Sustainment and Follow-on Development phases. AIR 6000 is outlined later in this chapter and also in Appendix 5: The Establishment of AIR 6000.

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[71] Defence Materiel Organisation, New Air Combat Capability Integrated Project Team, *Phase 2A/B NACC test and evaluation master plan*, version 1.0, August 2009, p. 1.

Concept Refinement and Technology Development

2.22 The purpose of the Concept Refinement and Technology Development phases is to reduce technology risk and to determine the appropriate set of technologies to be integrated into a full system. Concept Refinement involves refinement of the initial operational concepts and the development of a Technology Development Strategy. The JSF Concept Refinement phase was completed in 1996.[72]

2.23 The JSF Technology Development phase[73] commenced in 1996, and some aspects of it are ongoing as JSF technology advances. Technology Development involves a continuous technology discovery and development process, reflecting close collaboration between the science and technology community, the user, and the system developer. It is an iterative process, designed to assess the viability of technologies, while simultaneously refining user requirements.[74]

2.24 Given the JSF Program's adoption of a strategy based on advanced aeronautical and electronic systems technology, there was a need for the Technology Development phase to include an extensive period of concept demonstration. This commenced in November 1996, with competitive contracts being awarded to the Boeing Company and Lockheed Martin, to conduct initial JSF systems engineering under a Concept Demonstration Program. A contract was also awarded to Pratt & Whitney for development of an aircraft engine for the JSF.

2.25 The Boeing and Lockheed Martin Concept Demonstration Programs resulted in:

- JSF concept-unique ground demonstrations;

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[72] *Selected acquisition report (SAR): JSF, as of December 31, 1996*, Washington DC, p. 3. At the time, the early phases of a project were known as Concept Exploration and Concept Development. Since 2008, the first phase has been known as the Material Solution Analysis phase. US Department of Defense, Regulation No. 5000.2-R, 15 March 1996, paragraph 1.4.2.

[73] At the time, the Technology Development phase was known as the Program Definition and Risk Reduction phase, which included the development of prototypes and demonstrators. US Department of Defense, Regulation No. 5000.2-R, 15 March 1996, paragraph 1.4.3.

[74] US Department of Defense Instruction 5000.2, *Operation of the defense acquisition system*, May 2003, paragraph 3.6.1.

- continued refinement of the JSF weapon system concepts, which they proposed to use as the basis for the SDD and Production phases of the JSF Program; and
- development and flight testing of concept demonstrator aircraft (the X-32 by Boeing, and the X-35 by Lockheed Martin).[75]

2.26 As part of the Technology Development phase, user requirements were also developed and refined. By March 2000, the US Air Force, US Navy, US Marines and the Royal Navy had finalised the Joint Operational Requirements Document (JORD), which sets out the operational capability required of the JSF aircraft, which the United States and its international partners have agreed to manufacture.[76]

2.27 Flight testing of the JSF concept demonstrator aircraft was completed in August 2001, and the results were reported to have met or exceeded expectations, to an unprecedented degree in many cases.[77]

2.28 In October 2001, the US Secretary of Defense provided certification to congressional defense committees that the JSF Program demonstrated sufficient technical maturity to enter the SDD phase. This meant in effect that the criteria for Milestone B (Program Initiation) approval had been satisfied (see Figure 2.2).[78]

2.29 On 26 October 2001, the JSF Program's SDD phase commenced, with contracts being awarded to Lockheed Martin and to Pratt & Whitney.[79] Lockheed Martin, teamed with Northrop Grumman and BAE Systems, is producing the F-35 aircraft and support systems. Pratt & Whitney is producing the F135 engine used by all three F-35 variants.[80]

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75 *Selected acquisition report (SAR): F-35 (JSF), as of December 31, 2001*, Washington DC, p. 4.

76 United States–Australia Supplement to the JSF SDD MoU, 31 October 2002, paragraph 2.3; *Capabilities of the F-35 Joint Strike Fighter aircraft*, Defence media release, 21 August 2002, p. 4.

77 *Selected acquisition report (SAR): F-35 (JSF), as of December 31, 2001*, Washington DC, p. 4.

78 *Selected acquisition report (SAR): F-35 (JSF), as of December 31, 2001*, Washington DC, p. 4.

79 *Selected acquisition report (SAR): F-35 (JSF), as of December 31, 2001*, Washington DC, pp. 4, 37–8.

80 For the F-35B STOVL variant, the F135 engine is fitted with a contra-rotating fan assembly that provides vertical lift during short take-offs and vertical landings. In November 2001 a second engine-development contract was awarded—to General Electric and Rolls-Royce—for the development of the F136 engine, which was designed to be an alternative to the Pratt & Whitney F135. *Selected acquisition report (SAR): F-35 (JSF), as of December 31, 2003*, Washington DC, pp. 4, 39.

International participation during initial JSF phases

2.30 International partners have been involved in the JSF Program since the 1990s, through Memoranda of Understanding (MoU) or Memoranda of Agreement (MoA) negotiated with each country. During the Concept Demonstration and Technology Development phases, there were four levels of involvement in the JSF Program:

- Collaborative Development Partnership, whereby Full Partners had the ability to influence requirements:
  - During the JSF Concept Demonstration phase, the United Kingdom's Royal Navy and Royal Air Force joined the JSF Program as full collaborative partners in the definition of requirements and aircraft design. The UK agreed to contribute a total of US$200 million of the then US$2 billion estimated cost of the 1997–2001 Concept Demonstration phase.[81]
- Associate/Limited Partnership, whereby the participant had:
  - limited participation in specific technologies or the core program, with limited ability to influence requirements; and
  - limited access to JSF project information in order to better understand and evaluate the utility of the JSF family of aircraft for their use.
  - Associate Partner MoAs were signed by Norway and the Netherlands in June 1997 and by Denmark in September 1997.
- Informed Partnership, whereby the participant had:
  - access to JSF project information in order to better understand and evaluate the utility of the JSF family of aircraft for their use; and

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[81] The United Kingdom signed a Memorandum of Understanding about the JSF Program with the US Department of Defense in December 1995. *House of Commons debates*, 10 December 1996, vol. 287, col. 159W; DefenseLINK News, *DoD signs Joint Advanced Strike Technology Agreement* [Internet], 28 December 1995, available from http://osd.dtic.mil/news/Jan1996/n01051996_9601055.html [accessed 22 August 2011]; Jeremiah Gertler, *F-35 Joint Strike Fighter (JSF) Program: Background and issues for Congress*, Congressional Research Service, 26 April 2011, p. 15.; UK Parliament, Select Committee on Defence, *Eighth Report*, 'Written Evidence: Memorandum submitted by the Ministry of Defence: Future Carrier Borne Aircraft—FCBA', HC 544, 10 November 1999, p. 1.

  - was unable to influence requirements.
  - Canada entered the program as an Informed Partner in January 1998, followed by Italy in January 1999.
- Major Participant, whereby the participant:
  - participated in the JSF Program as a Foreign Military Sales (FMS) customer, in terms of F-35 aircraft acquisition and JSF studies, technical assistance and access to predetermined data.
  - Singapore, Turkey and Israel became Major Participants in the initial phases of the JSF Program in March, June and September 1999 respectively.[82]

2.31 Australia joined the JSF Program in October 2002, after the completion of these initial JSF phases.

Australia's New Air Combat Capability acquisition arrangements

Beginnings of project AIR 6000

2.32 In May 1999, project AIR 6000 was formed within Defence, with a remit to consider the 'whole of capability' options for providing Australia's ongoing air combat and strike capability, once the F/A-18A/B and F-111 aircraft were withdrawn from service.[83] The Defence White Paper 2000 stated that provision had been made in the Defence Capability Plan for a project to acquire up to 100 new combat aircraft.[84]

2.33 Defence records indicate that in 1998 and 2000, approaches were made by the United States inviting Australia to join the JSF Concept Definition phase and later the SDD phase. After further briefings and ministerial meetings between Australia and the United States, on 27 June 2002 the then Government

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82 Joint Strike Fighter Program Office, *International participation* [Internet], as at 8 March 2002, available from http://web.archive.org/web/20020308191605/http://www.jsf.mil/Program/Prog_Intl.htm [accessed 22 August 2011].

83 Australian Defence Headquarters, Capability Systems, *Briefing on Australia's involvement in Joint Strike Fighter Program—Chronology of Australian involvement in Joint Strike Fighter Program*, 5 September 2002.

84 *Defence 2000: our future defence force*, Defence White Paper, Canberra, 2000, p. 87.

formally announced its intention to become a partner in the SDD phase of the JSF Program. In October 2002, Australia formally joined the JSF Program by signing the JSF SDD Memorandum of Understanding, at a cost of US$150 million to be paid over a period of 10 years.[85] In 2008, Australia committed an additional US$50 million (now US$54 million due to indexation) to the SDD phase, to be paid between 2009 and 2014 (see paragraph 3.13).

2.34 At the time, Australia's decision to participate in the JSF Program's SDD phase was perceived by some media and industry circles as 'short-circuiting' the multi-stage assessment approach, then being undertaken by the AIR 6000 project, to identify the appropriate solution for the ADF's new air combat capability. However, Defence advice to the Minister for Defence was that the direction and management of AIR 6000 was in accordance with the Government's guidance in the Defence White Paper 2000 and Defence Capability Plan.[86]

2.35 The following section discusses how Defence went about defining the capability that it required to be delivered under project AIR 6000, subsequent to the Government's 2002 decision.

New Air Combat Capability definition

2.36 Before Australia established its requirements for a new aircraft fleet, the United States military had, by March 2000, finalised its Joint Operational Requirements Document (JORD), which established the operational criteria that the F-35 would be required to meet. Although the United States is a major arms exporter, it protects its sensitive technology and capability edge by imposing capability restrictions on export versions of its equipment. In October 2002, Australia joined the JSF Program's SDD phase as a Level 3 contributor (see paragraph 3.7), and this entitled Australia to access JSF project

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85 *JSF SDD MoU, Australia-US Supplement*, 31 October 2002.

86 Australian Defence Headquarters, Capability Systems, *Briefing on Australia's involvement in Joint Strike Fighter Program—Chronology of Australian involvement in Joint Strike Fighter Program*, 5 September 2002, p. 1. The initial progress of AIR 6000 is outlined further in Appendix 5: The Establishment of AIR 6000.

information in order to better understand and evaluate the utility of the JSF family of aircraft for its own use.[87]

2.37 In 2003, an 'International Commonality Effort' program was initiated to define a generic JSF Program partner version and a Foreign Military Sales version of the F-35 and to complete the necessary preliminary design activity. This 'delta' SDD phase would produce a partner version JSF Contract Specification, establish the process for handling country-specific requirements, and create separate 'delta' design reviews. Before joining the SDD phase of the JSF project, Australia received high-level assurances of the level of capability it would ultimately receive as a close ally of the United States and as a partner in the JSF Program.[88]

2.38 In 2002, the Vice Chief of the Defence Force (VCDF) and the Head Capability Systems (HCS), whose position is now located within Defence's Capability Development Group (CDG), commenced developing the capability-definition documentation for an air combat capability to replace what was then being provided by the F-111 and F/A-18 fleets. These documents, which define the capability the AIR 6000 project is seeking to acquire, consist of the following:

- *Operational Concept Document (OCD)*: the OCD for AIR 6000 commenced development in 2002, with a Preliminary OCD produced for First Pass to Cabinet in 2006, followed by a Second Pass OCD in 2008;
- *Function and Performance Specification (FPS)*: the FPS defines a validated set of requirements for the New Air Combat Capability. A Preliminary FPS was produced in 2006, followed by a first draft FPS dated March 2008; and
- *Test Concept Document (TCD)*: the TCD defines the strategy for test and evaluation of the New Air Combat Capability, with a Preliminary TCD

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[87] JSF Program Office, *International participation* [Internet], webpage as at 8 March 2002, available from http://web.archive.org/web/20020308191605/http://www.jsf.mil/Program/Prog_Intl.htm [accessed 22 August 2011].

[88] New Air Combat Capability Integrated Project Team, *JSF capability update*, ministerial briefing, 27 June 2003, p. 3.

produced in 2006, followed by a first draft TCD in September 2007, approved in May 2008.[89]

2.39 Defence records indicate that the AIR 6000 requirements definition process used a strategy-to-task framework, which involved the analysis of strategy from the Defence White Paper 2000 in order to establish goals and priorities and determine NACC roles. Endorsed planning scenarios—comprising Australian Illustrative Planning Scenarios (AIPS) supplemented by endorsed high-end air combat scenarios—were then analysed to establish operational needs, critical operational issues, measures of effectiveness and the associated performance criteria. Using thresholds and objective threats identified by the Defence Intelligence Organisation, specific performance measures were then determined for each performance criterion. Operational analysis was performed to establish how well the JSF Block 3 capability met each of the performance criteria.[90]

2.40 Defence records indicate that operational analysis considered how many pilots and JSF aircraft would be required to meet operational demands. The need for supporting assets was also considered, such as how many Airborne Early Warning and Control aircraft and refuelling aircraft would be required to support the new aircraft fleet. Different ratios of pilot, JSF and supporting assets were examined to establish where the optimum capability–cost benefit could be obtained. Further analysis examined what capabilities would be required in the follow-on development phase of the JSF Program.

2.41 Table 2.1 outlines the broad characteristics and performance of the three aircraft considered in this audit report and the companion report. It shows some of the similarities in the aircraft that currently constitute Australia's air combat capability, and the JSF which is to replace them. It also shows the dissimilarities, especially the developments in stealth characteristics and pilot situational awareness, that distinguish the F-35 from its predecessors.

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[89] Department of Defence, Capability Development Group, *New Air Combat Capability test concept document*, version 4.0, 26 August 2009. See also *Defending Australia in the Asia Pacific Century: Force 2030. Defence White Paper 2009*, Canberra, 2009, paragraph 9.60, p. 78.

[90] Block 3 provides the full war-fighting capability, including full sensor fusion and additional weapons; see paragraph 2.8.

Table 2.1

Characteristics and performance of the Hornet, Super Hornet and Lightning II

	F/A-18A Hornet	F/A-18F Super Hornet	F-35A Lightning II
Height	4.66 m	4.87 m	4.38 m
Length	17.01 m	18.38 m	15.67 m
Wing span	12.31 m	13.62 m	10.67 m
Wing area	37.2 m^2	46.45 m^2	42.7 m^2
Empty weight	11 113 kg	14 875 kg	13 290 kg
Internal fuel	4926 kg	6354 kg	8278 kg
Payload	7000 kg	9400 kg	8160 kg
Combat ceiling	50 000+ feet	50 000 feet	50 000 feet
Speed[A]	Mach 1.8	Mach 1.8	Mach 1.6 with internal weapons
Radar cross-section	Observable	Low Observable[B]	Very Low Observable[C]
Combat radius	~400 km	~725 km	~1135 km
Crew	One	Two	One
Service life	6000 hours certified by two-and-a-half-lifetimes durability tests.	6000 hours certified by three-lifetimes durability tests.	8000 hours to be certified by three-lifetimes durability tests (in progress).

Sources: Boeing; RAAF, *F/A-18 Hornet fighter* and *F/A-18F Super Hornet fighter*, fact files; A McLaughlin, *Hornets down under*, Phantom Media, Fyshwick, ACT, 2005; RAAF, *F/A-18 A/B Hornet aircraft structural integrity management plan*, 2011, Volume 1; RAAF, *F/A-18F Super Hornet aircraft structural integrity management plan*, 2010, Volume 1; United States Navy, *F/A-18 Hornet strike fighter*, fact file; *Jane's all the world's aircraft*; Lockheed Martin, *F-35 Lightning II program status and fast facts*, March 2012; JSF Program Office; Defence Material Organisation, *F-35 Lightning II, Australia's next generation combat air power*, June 2011.

Notes: A) Clean configuration with no external stores.

B) Low Observable. The Super Hornet utilises designed-in structural enhancements, platform-aligned edges, specialised materials and coatings to lessen the effectiveness of threat sensors and shorten the range at which the aircraft can be detected, giving it an order-of-magnitude improvement in radar cross-section signature. Source: The Boeing Company.

C) Very Low Observable. The F-35's shape, embedded antennas, aligned edges, internal weapons and fuel, and special coatings all contribute to its Very Low Observable (VLO) stealth capability. Source: Lockheed Martin.

2.42 The F-35 aircraft are expected to provide a capability to allow Australia to dominate its air and sea approaches out to 2030 and beyond, and to effectively contribute to regional security and future coalition operations.[91] The F-35 operational concepts include engaging the full range of air threats and surface threats, either fixed or mobile, day and night, in all weather. To achieve those operational requirements, the F-35 incorporates:

- airframe shape and surface treatments to achieve a very low observable radar signature, in combination with internal carriage of weapons and fuel;
- advanced sensors such as the AN/APG-81 Active Electronically Scanned Array (AESA) radar, providing advanced air and ground-target detection and identification; the AN/AAQ-37 Electro Optic Distributed Aperture System (DAS), which provides 360-degree infrared detection and warning and tracking of incoming aircraft and missiles, with day and night vision;
- an electro-optical targeting system (EOTS), which provides long-range detection and precision targeting;
- advanced Electronic Support Measures, providing an ability to locate threats based on their emissions;
- sensor fusion that combines information from on-board and off-board sensors to increase the pilot's situational awareness to improve target identification and weapon delivery;
- advanced voice and data communication technology, providing data-links to and from other F-35 aircraft and other wider Defence enablers, including the Airborne Early Warning and Control aircraft, Unmanned Aerial Vehicles, Command Centres, and troops on the ground;
- advanced long-range weapons (both radar and infrared guided air-to-air missiles, and advanced laser, Global Positioning System and radar-guided air-to-surface weapons); and

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[91] Senator the Hon. John Faulkner, Minister for Defence, *F-35 Joint Strike Fighter—Australia's next generation air power*, media release, 25 November 2009.

- state-of-the-art aircraft structure and systems prognostics and health management, providing for radically reduced support requirements.

2.43 The F-35's sensors, information processing and display technology, and mission systems, are discussed further at paragraph 2.61.

Australian Government approval to acquire F-35A aircraft

2.44 The Australian Government gave First Pass approval for the purchase of the F-35 Joint Strike Fighter in November 2006, shortly before Australia joined the JSF Production, Sustainment and Follow-on Development MoU (see paragraph 4.3).[92]

2.45 In November 2009, at Second Pass, the Government was presented with two options for acquiring the F-35 capability:[93]

- a 'full' AIR 6000 Phase 2A/B approval option, comprising no fewer than 72 F-35A aircraft, sufficient to establish three operational squadrons and a training squadron of F-35As; and
- a 'staged' AIR 6000 Phase 2A/B approval option, comprising a subset of the 'full' AIR 6000 Phase 2A/B solution.

2.46 The Government:

(a) approved Phase 2A/B Stage 1 funds, at an estimated cost of $3.2 billion, to acquire an initial tranche of 14 F-35A aircraft and the associated support and enabling elements necessary to establish the initial training capability in the US and to allow commencement of operational testing in Australia;

(b) supported target dates of 2018 for Initial Operational Capability (IOC) and 2021 for Final Operational Capability (FOC) for AIR 6000 Phase 2A/B; and

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92 The Hon Dr Brendan Nelson, Minister for Defence, *The Joint Strike Fighter*, media release, 10 November 2006. The First Pass approval process provides the Government with an opportunity to narrow the alternatives being examined by Defence to meet an agreed capability gap. This includes approval to allocate funds from the Capital Investment Program to enable the options endorsed by Government to be investigated in further detail, with an emphasis on cost and risk analysis.

93 The Second Pass approval process leads to the final approval milestone, at which the Government endorses a specific capability solution and approves funding for its acquisition.

(c) agreed that Defence should seek approval in 2012 to procure the remaining (at least) 58 F-35A aircraft in Phase 2A/B.[94]

2.47 In May 2012, in the context of the 2012–13 Federal Budget, the Government announced its decision to delay the acquisition of 12 of the initial tranche of 14 aircraft by two years, with the result that the acquisition of these aircraft would be better aligned with the US Initial Operational Release of the F-35A aircraft.[95] At the time of the audit, Australia had no contractual obligation to purchase more than the long-lead items for two F-35A aircraft.

2.48 The AIR 6000 Phase 2A/B Stage 1 aircraft and associated support and enabling systems will be acquired under the annual contracts for LRIP lots, with Australia's first two F-35As to be delivered in the US in 2014.[96] These Stage 1 aircraft are required to conduct Australian pilot training and operational test and evaluation necessary for the RAAF to achieve an F-35 Initial Operational Capability.

2.49 Following the May 2012 Budget decision, Defence was replanning the F-35 acquisition schedule under AIR 6000, including the schedule for the remaining 12 aircraft to be acquired under Phase 2A/B Stage 1, and this replan was subject to government approval. Defence informed the ANAO that it will be presenting options to the Government later this year on managing the air combat capability, as the RAAF transitions from the F/A-18A/B fleet to a predominantly F-35A fleet. In response to ANAO inquiries about contingency plans, Defence indicated that it had developed strategies, for consideration by the Government, to reduce the risks associated with extending the F/A-18A/B fleet's operational life, and to minimise risks associated with progressing to the F-35A's Initial Operational Capability.

2.50 The delivery of the remaining 12 Stage 1 aircraft needs to occur in a manner that facilitates the training of sufficient RAAF pilots, as well as the conduct of required operational test and evaluation. This is necessary for the

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94 Defence Materiel Organisation, New Air Combat Capability Integrated Project Team, *Acquisition project management plan*, version 1.0a, July 2011, p. 15.

95 *Prime Minister, Minister for Defence, Minister for Defence Materiel—joint press conference—Canberra*, media transcript, 3 May 2012; *Portfolio budget statements 2012–13: Defence portfolio*, p. 166.

96 Defence Materiel Organisation, New Air Combat Capability Integrated Project Team, *Acquisition project management plan*, version 1.0a, July 2011, p. 15.

achievement of Initial Operational Capability by the date approved by the Government.

F-35 Materiel Acquisition Agreement

2.51 Table 2.2 lists the deliverables of AIR 6000 Phase 2A/B Stage 1, as defined in the F-35 Materiel Acquisition Agreement (MAA) between Defence's materiel acquisition organisation (DMO) and its capability development organisation (CDG).

Table 2.2

AIR 6000 Phase 2A/B Stage 1 Materiel Acquisition Agreement

Item	Description of items to be acquired
Aircraft	14 x Block 3 (or later) F-35A aircraft
Weapons	Weapons and countermeasures/expendables required for Australian operational tests
Auxiliary Mission Equipment	Auxiliary Mission Equipment necessary for the first 14 aircraft
Pilot training	Initial US-based Australian pilot training
Maintainer training	Initial US and Australian-based Australian maintainer training
Simulators	Initial flight and maintainer simulator training capability to support Australian operational tests
Support and Test Equipment	Initial complement of Support and Test Equipment
Information Technology integration	Initial NACC Information Technology integration
Electronic Warfare	Initial contribution to the Electronic Warfare (EW) reprogramming facility
Spares	Initial contribution to the global spares pool, sufficient to operate and maintain Australia's first 14 aircraft
SDD & PSFD	Ongoing contributions to the SDD and PSFD MoUs until 2013–14
Project office	Ongoing project office activities out to 2013–14
Industry	Australian industry-support initiatives out to 2013–14
Science and Technology	Science and technology support activities out to 2013–14

Source: Defence Materiel Organisation, New Air Combat Capability Integrated Project Team, *Acquisition project management plan,* July 2011, p. 16.

2.52 At the time of the audit, long-lead items for two F-35 aircraft had been contracted for, and the 14 F-35A Block 3 aircraft approved for acquisition under AIR 6000 Phase 2A/B Stage 1 were to constitute the elements necessary for:

- an initial F-35 training capability located in the United States;

- Australian F-35A operational tests conducted in the United States; and
- F-35A operational tests conducted in Australia.

2.53 Subject to government approval, the next acquisition—AIR 6000 Phase 2A/B Stage 2—is expected to provide the remaining 58 aircraft, which is to enable three RAAF F-35 squadrons to be formed and three F/A-18A/B Hornet squadrons and an operational conversion unit to be retired.

2.54 If approved, AIR 6000 Phase 2C is to provide 28 additional F-35A aircraft, and would result in the RAAF receiving a total of four F-35A squadrons (100 aircraft). The delivery of this last tranche of aircraft was planned to be determined in conjunction with a decision on the withdrawal of the F/A-18F Super Hornet, with a decision not expected before 2015.[97]

2.55 The status of the plans for the delivery of F-35 aircraft is outlined in Table 2.3.

Table 2.3

Air 6000 phases and stages, as at June 2012

Phase/Stage	Number of F-35s to be purchased	Delivery
Phase 2A/B Stage 1	14	Two in 2014, remainder in 2017–2018 (delayed by two years in May 2012 Budget).
Phase 2A/B Stage 2	58	Government approval was to be sought in 2012; in the May 2012 Budget the Government delayed the decision by two years.
Phase 2C	28	To be decided by Government.

Source: ANAO analysis.

Australia's F-35 weapons acquisition program

2.56 DMO's Explosive Ordnance Division is responsible for acquiring the F-35 Weapons and Explosive Ordnance approved under AIR 6000 Phase 2A/B.

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97 Department of Defence, *Defence Capability Plan 2012*, Public Version, p. 54. However, this timetable may be affected by the May 2012 Budget decision outlined in paragraphs 2.47 to 2.50.

The acquisitions are to be conducted in collaboration with the NACC IPT and in consultation with the ADF's Joint Logistics Command.[98]

2.57 Most non-F-35-specific weapons are to be acquired via US Foreign Military Sales (FMS) arrangements in conjunction with other ADF buys. On current planning, the weapons and consumables for the Australian aircraft, while they are operating at the US Integrated Training Center, are to be acquired separately through a provisioning pool arrangement.

2.58 The weapons planned for the F-35 are listed in Table 2.4.

2.59 The scope of AIR 6000 Phase 2A/B includes provision for the integration of a future stand-off maritime-strike weapon and acquisition of weapons and countermeasures/expendables necessary to support operational testing and an initial five years of pilot training.

2.60 Future weapons (including a replacement maritime-strike weapon) and any additional war stock of JSF weapons will be provided through existing weapon stocks or acquired through projects identified in the Defence Capability Plan.

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[98] A 2008 Memorandum of Agreement between DMO's Explosive Ordnance Division and the NACC IPT defines the responsibilities for weapons and Explosive Ordnance aspects of Project AIR 6000 Phase 2A/B, and identifies the weapons to be acquired and their initial delivery dates.

Table 2.4

Planned Weapons for Training, Test and Evaluation for the F-35

Designation	Description	Initial delivery	Intended use
AIM-120	Advanced Medium-Range Air-to-Air Missile (AMRAAM)	June 2018	Training and test and evaluation
AIM-9X	Sidewinder air-to-air missile	June 2019	Training and test and evaluation
Ammunition	25mm multi-purpose ammunition	June 2019	Training and test and evaluation
Electronic Warfare Countermeasures	Infrared Countermeasures	June 2019	Training and test and evaluation
GBU-12	Laser Guided Bomb (LGB)	June 2019	Training and test and evaluation
GBU-31	2000 lb Joint Direct Attack Munition (JDAM)	June 2019	Training and test and evaluation
SDB	Small Diameter Bomb	June 2019	Training and test and evaluation
AGM-154	Joint Stand-Off Weapon (JSOW)	June 2020	Training and test and evaluation

Source: Defence Materiel Organisation, New Air Combat Capability Integrated Project Team, *Acquisition project management plan*, 5 December 2011, p. 16; *NACC acceptance into service plan*, version 3.0b, December 2009, p. 58.

Note: The initial delivery dates shown in the table are presently being revised in the light of the May 2012 Budget decision (see paragraphs 2.47 to 2.50).

F-35 mission data reprogramming

2.61 The F-35 aircraft are designed for high-threat multi-role operations, requiring advanced stealth technology and fully integrated radar and electro-optical sensor systems. The intent is that the F-35 will sense, track and identify targets, and together with target data provided by sources external to the aircraft, fuse this data with its own mission system data and then present target information to the pilot using a Panoramic Cockpit Display and an advanced Helmet Mounted Display system. At the time of the audit, these elements of the JSF Program were undergoing high-risk mitigation management.

2.62 The F-35 aircraft mission system sensors, information processing and display technology, are designed to provide the pilot with a degree of situational awareness and weapons system capabilities unprecedented in currently deployed combat aircraft. The provision of accurate mission data to the F-35 sensor suite is fundamental to the aircraft's ability to provide aircrew with enhanced situational awareness. The F-35 situational awareness system is designed to provide pilots with a coherent visual picture of their area of operational interest via:

- the F-35 sensor suite (outlined in paragraph 2.42), which continuously gathers emission and location information on objects in the area of operations;
- an emitter identification system, which integrates the sensed information with an electronic library of mission-specific emitter data, to be provided by mission data reprogramming laboratories; and
- a data fusion and display system, which provides integrated information to the pilot, in a way that allows the pilot to rapidly assess the situation, anticipate future events, and take appropriate action.

2.63 Mission data reprogramming for Australian, Canadian and United Kingdom F-35 aircraft is to be conducted at a yet-to-be-developed Australia–Canada–United Kingdom Reprogramming Laboratory (ACURL). The ACURL is currently planned to be located at Eglin Air Force Base in Florida, USA, and operated collaboratively by approximately 20 personnel from each of the ACURL partner nations, with the support of approximately 50 US personnel. The ACURL's acquisition and sustainment costs are to be split equally between the ACURL partner nations.[99]

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[99] The United States will operate its own reprogramming laboratory for its own significantly larger F-35 fleets. For discussion of ACURL costs, see paragraphs 4.8 and 4.9.

2.64 At the time of the audit, the NACC IPT was collaborating with Canada and the UK to develop a Statement of Requirements for the JSF Program Office to design and construct the ACURL. The NACC IPT was also developing a Statement of Requirements for Australian in-country reprogramming for unique capabilities not provided by the ACURL.[100] The remaining elements of the situational-awareness system, such as F-35 sensor suite integration, displayed data fusion, and development of the Helmet Mounted Display system, remained under close managerial scrutiny by the JSF Program Office.

Delivery schedule of aircraft and support systems required for IOC

2.65 Figure 2.4 outlines the delivery schedule for the first 14 F-35 aircraft and their associated systems, facilities and personnel training currently included in AIR 6000 Phase 2A/B Stage 1. It also shows the delivery of the additional aircraft required to achieve Australian Initial Operational Capability (IOC). These additional aircraft are subject to government approval.

2.66 The dark blue arrows show activities that were not affected by the May 2012 Budget, and had commenced at the time of the audit. These activities include the acquisition of long-lead items for the first two F-35 aircraft. Expenditure to June 2012 amounted to US$8.2 million, with a residual commitment of US$22 million, covering services, tools and parts for these two aircraft.

2.67 The grey arrows show the plan as it stood until April 2012, whereas the light blue arrows show the initial planning to take account of the May 2012 Budget decision to delay by two years the acquisition of 12 of the 14 aircraft. As at June 2012, this initial replan remained subject to government approval.

2.68 The timetable for the acquisition of the 58 aircraft to be acquired under AIR 6000 Phase 2A/B Stage 2, which was originally to be decided in 2012, has not yet been announced by the Government, and so does not appear in this diagram until 2020. To achieve the Initial Operational Capability milestone, at least one F-35A squadron will be required. There are other elements of capability required to make the F-35 fleet into a fully effective military system, and these are listed in Appendix 6: The Fundamental Inputs to Capability.

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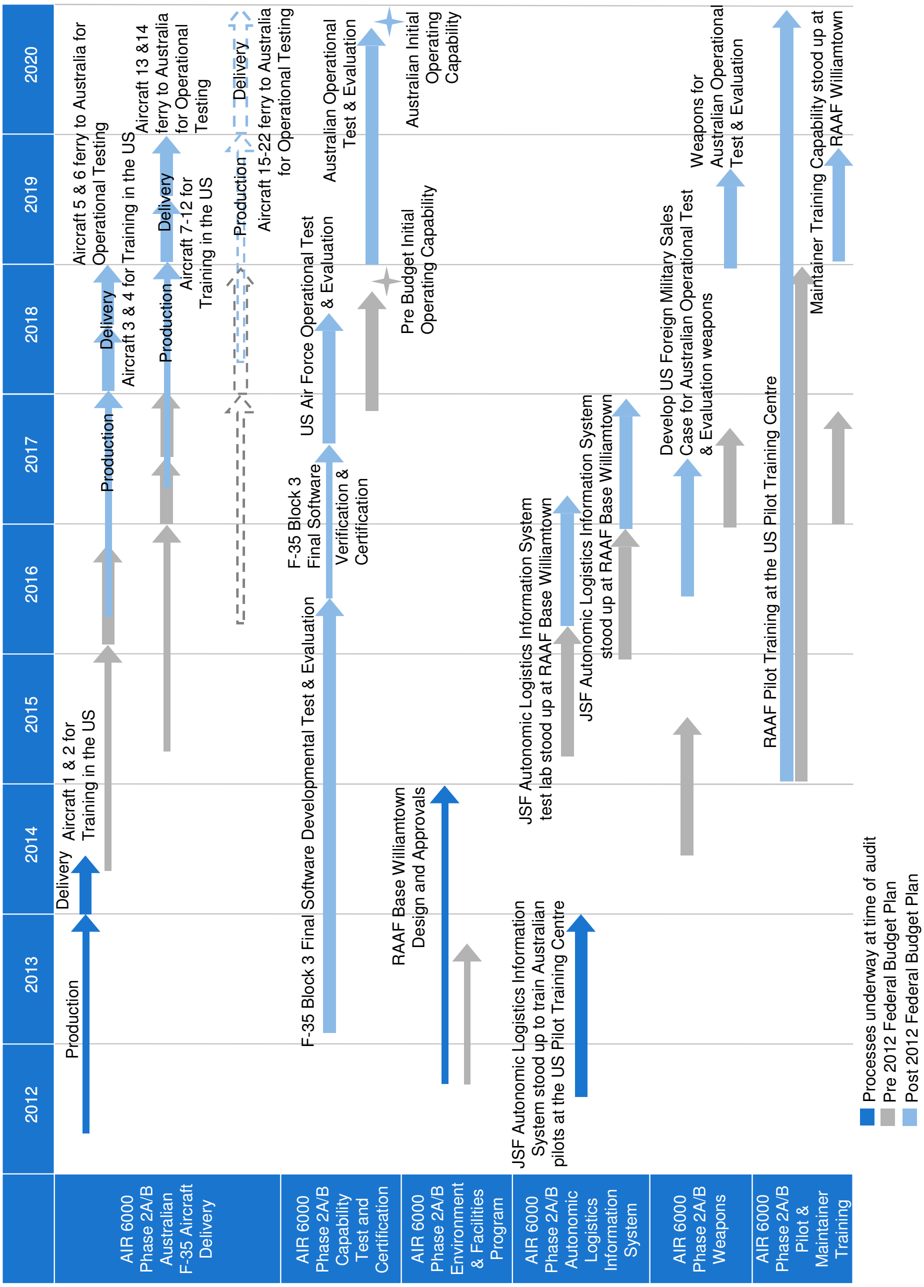
[100] Defence Materiel Organisation, New Aircraft Combat Capability Integrated Project Team, *Project design acceptance strategy*, version 4.0, April 2012, p. 15.

Figure 2.4

AIR 6000 Phase 2A/B Stage 1 materiel delivery schedule, as at June 2012



Source: Defence Materiel Organisation, New Air Combat Capability Integrated Project Team, June 2012.

Conclusion

2.69 The JSF Program is managed under the multi-phase US defense acquisition process. The early phases of the JSF Program developed a validated set of combat aircraft requirements, demonstrated key leveraging technologies, and developed operational concepts for subsequent strike weapon systems. Flight testing of demonstrator aircraft was completed in August 2001, and in October 2001 the US Secretary of Defense provided certification to Congressional Defense Committees that the JSF Program demonstrated sufficient technical maturity to enter the development phase. Although partner nations were involved in the early phases, Australia joined the JSF Program after their completion.

2.70 Australia's own program to find a new air combat capability to replace its F/A-18A/B and F-111 fleets began within Defence in 1999. The traditional competitive process was in its early stages when the then Government decided in October 2002 to join the JSF Program's SDD phase. Since then, AIR 6000 has had two objectives: to deliver a new air combat capability that is characterised by the attributes of balance, robustness, sustainability and cost-effectiveness; and to maximise the level and quality of Australian industry, science and technology participation in the global JSF Program.[101] AIR 6000 aims to achieve these objectives through Australia's partnership in the JSF Program.

2.71 Defence records show that, within that context, the AIR 6000 project has analysed the F-35 capability requirements against performance criteria derived from endorsed planning scenarios and endorsed high-end air combat scenarios, confirming that the capability being developed is consistent with Australia's requirements.

2.72 The Government approved the selection of the F-35 as Australia's new combat aircraft in 2006. In 2009, the Government approved the acquisition of a first tranche of 14 F-35A aircraft, with acquisition of 58 more aircraft to be approved in 2012. The AIR 6000 Phase 2A/B Stage 1 aircraft and associated support and enabling systems will be acquired under the annual contracts for LRIP lots, with Australia's first two F-35As to be delivered in the US in 2014.[102]

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[101] The industry component of Australia's participation is, however, beyond the scope of this audit; see paragraph 1.10.

[102] Defence Materiel Organisation, New Air Combat Capability Integrated Project Team, *Acquisition project management plan*, version 1.0a, July 2011, p. 15.

These Stage 1 aircraft are required to conduct the pilot training and operational tests and evaluations necessary for the achievement of an F-35 Initial Operational Capability for the RAAF.

2.73 Following the May 2012 Budget decision, Defence was replanning the F-35 acquisition schedule under AIR 6000, including the schedule for the remaining 12 aircraft to be acquired under Phase 2A/B Stage 1, and this replan was subject to government approval. The delivery of these 12 aircraft needs to occur in a manner that facilitates the training of sufficient RAAF pilots, as well as the conduct of required operational test and evaluation. This is necessary to demonstrate the achievement of Initial Operational Capability by the date approved by the Government, following its consideration of the advice Defence intends to provide this year on its F-35 air combat capability acquisition options.

3. F-35 System Development and Demonstration

This chapter examines the JSF Program's System Development and Demonstration (SDD) phase, which has constructed F-35 engineering development aircraft in the three variants of the F-35 Lightning II. This phase is also developing F-35 manufacturing processes and sustainment arrangements, which are specified to be affordable and executable. The chapter also considers the F-35's design approval and acceptance process, and Australian Military Type Certification.

Background

3.1 The United States defense acquisition system's Concept Demonstration and Technology Development phases are followed by the System Development and Demonstration (SDD) phase, which aims to:

- develop a system or an increment of capability;
- reduce integration and manufacturing risk (technology risk reduction occurs during the Technology Development phase);
- ensure operational supportability, with particular attention to reducing the logistics footprint;
- implement human–systems integration;
- design for producibility;
- ensure affordability and the protection of critical program information by implementing appropriate techniques such as anti-tamper; and
- demonstrate system integration, interoperability, safety, and utility.[103]

3.2 The JSF Program's SDD phase includes the following activities:

- production of F-35 engineering development aircraft[104] and the refinement of F-35 production facilities and processes, in preparation

[103] US Department of Defense Instruction 5000.2, *Operation of the defense acquisition system*, May 2003, paragraph 3.7.1.1. In subsequent editions of this instruction, the System Development and Demonstration phase is called the Engineering and Manufacturing Development phase.

for the F-35 Production, Sustainment and Follow-on Development phases;

- development of the sustainment system for the F-35 aircraft and their associated ground systems; and
- test and evaluation of the F-35 engineering development aircraft in their operational and sustainment environment to verify and validate the aircrafts' design, the production facilities and processes, and the sustainment arrangements.

3.3 The SDD phase commenced in October 2001 and is currently expected to end in 2019. At that stage, the F-35 aircraft are to have received the Block 3 level of capability specified in the US and UK Joint Operational Requirements Document.[105]

3.4 The ANAO examined the arrangements with the US JSF Program that allow for DMO to adequately verify that the F-35A aircraft has achieved its specified capability requirements through a government-approved test program. It also examined the arrangements for Australia's involvement in the F-35 test program, and the arrangements for access to the F-35A aircraft data required by the ADF's airworthiness certification process.

International agreements

3.5 The international framework for the SDD phase was established in a Memorandum of Understanding (MoU) signed between the United States and United Kingdom on 17 January 2001. During 2002, Denmark, Norway, the

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[104] Under the US defense acquisition process, the SDD phase (now known as the Engineering & Manufacturing Development phase) typically includes the demonstration of production prototype articles or engineering development models. When the necessary industrial capabilities are available, the system satisfies approved requirements, and the system meets or exceeds exit criteria and Milestone C entrance requirements, the SDD effort may end. The engineering development models for the F-35's SDD phase are described in paragraphs 3.17 to 3.22. Defense Acquisition University, *Defense acquisition guidebook*, as at 10 January 2012, section 4.3.3.1.

[105] The F-35 aircraft are scheduled to be progressively upgraded via a follow-on development program, with new 'blocks' of capability delivered approximately every two years—see paragraph 2.8. Defence Materiel Organisation, New Air Combat Capability Integrated Project Team, *Acquisition project management plan*, version 1.0a, December 2011, p. 11.

Netherlands, Canada, Italy and Turkey also signed this MoU.[106] Australia was the last to sign, in October 2002.

3.6 A 2003 Defence brief described the prime objectives for joining the JSF Program as to:

(a) obtain access to a comprehensive range of data to support an acquisition decision to be presented to Government;

(b) to a limited extent modify the JSF capabilities to suit Australia's operational requirements; and

(c) maximise Australian industry participation as a global supplier in the broader JSF Program.[107]

3.7 The level of financial commitment by each partner nation determines that nation's rights within the JSF Program, as outlined in Table 3.1. A Level 1 contribution entitles a nation to a fully integrated office staff (6–10) within the JSF Program Office, and a National Deputy at Director level. A Level 2 contribution entitles a partner nation to 3–5 staff within the JSF Program Office, and a National Deputy. A Level 3 contribution entitles a partner nation to one office staff within the JSF Program Office, and a National Deputy.[108] The NACC IPT currently has seven Cooperative Project Personnel, a National Deputy, a Deputy National Deputy and one Integrated Office Staff member in the JSF Program Office. There are an additional two DSTO Cooperative Project Personnel, and up to two Industry staff also in the JSF Program Office at any one time. These staff play a role in promoting capability outcomes for Australia as program decisions are made.

3.8 All SDD partner nations gained:

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106 This 2001 MoU is officially titled the 'JSF EMD Framework MoU'. The United States defense acquisition system introduced the term 'Engineering and Manufacturing Development' (EMD) in 2008 in replacement of what was until then called 'System Development and Demonstration' (SDD). However, since the term SDD continues to be used for the JSF Program, it is preferred in this audit report. The JSF SDD MoU can be downloaded from http://www.state.gov/documents/treaties/129524.pdf.

107 Defence Materiel Organisation, New Air Combat Capability Integrated Project Team, *Brief for Strategic and International Policy Division: Outcomes of US/AS collaboration–Joint Strike Fighter*, August 2003, p. 1.

108 JSF Program Office, *International participation* [Internet], webpage as at 30 April 2003, available from http://web.archive.org/web/20030625071115/http://www.jsf.mil/Program/Prog_Intl.htm [accessed15 August 2012].

- access to JSF Program information to assist in determining if the JSF meets national requirements for a strike fighter;
- use of modelling and simulation tools to assist in the requirement validation effort;
- the right for their industry to participate in tender processes under the JSF Program; and
- the ability to influence requirements if mutually beneficial to participants.[109]

3.9 Australia's status as a partner nation enables it to have a representative on the JSF Executive Steering Board (JESB). JESB membership provides the partner nations with deep insights into the JSF Program and an ability to influence decision-making by the JSF Program in a wide variety of areas to suit national requirements. Other benefits of participation in the SDD phase include increased interoperability amongst partner nations by influencing and making more visible the evolving JSF system design, facilitated entry into the PSFD MOU phase, and priority over FMS customers for access to SDD/PSFD capacity and resources.

3.10 While the partner nation contributions to the SDD and production phases are separate from the costs of Australia's acquisition of its own F-35 aircraft, in due course Australia will also benefit by acquiring F-35 aircraft at the same price as the US Government, rather than with the additional fees incurred through the Foreign Military Sales process.

3.11 In 2001, the JSF SDD MoU specified a financial cost ceiling of US$28.283 billion for the SDD phase of the JSF Program, and a financial cost target of US$25.712 billion (then-year dollars).[110] Most of this cost would be borne by the United States.

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[109] JSF Program Office, *International participation* [Internet], webpage as at 30 April 2003, available from http://web.archive.org/web/20030625071115/http://www.jsf.mil/Program/Prog_Intl.htm [accessed 15 August 2012].

[110] Then-year dollars are based on the cost of labour and materials and currency exchange rates at the time the expenditure occurred.

Table 3.1

International contributions in SDD phase of JSF Program

Level	Partner nations	Financial contribution for SDD phase (US$)
Level 1	United Kingdom	$2 billion
Level 2	Italy Netherlands	$1 billion $800 million
Level 3	Turkey Australia Canada Denmark Norway	$175 million $150 million $150 million $125 million $125 million

Source: JSF Program Office, *International participation* [Internet], http://www.jsf.mil/program/prog_intl.htm, [accessed 22 August 2011]. Amounts are in then-year dollars.

Note: Australia later committed an additional US$50 million, brought forward from the PSFD phase; see paragraph 3.13.

3.12 The initial 2001 contract price between the US Department of Defense and Lockheed Martin for the SDD phase (that is, excluding the cost of production aircraft) was US$18.981 billion. By early 2012, however, the JSF Program manager's estimated cost for completion of SDD was US$31.762 billion (2012 prices). The cost of engine development similarly increased from the 2001 estimate of US$4.827 billion to a 2012 estimated price at completion of nearly US$8.334 billion (2012 prices).[111]

3.13 In 2008, Australia agreed to make an additional contribution to the SDD phase, by bringing forward funds that had already been allocated for the first upgrade (Block 4) of the F-35 aircraft, as part of contributions to follow-on development (see section beginning at paragraph 4.3, and especially Table 4.1 on page 118). Australia committed an additional US$50 million (now US$54 million due to indexation) to the development effort under this arrangement,

[111] The US Government also funded the development of an alternative engine until March 2011, and this program cost over US$2 billion. *Selected Acquisition Report (SAR): F-35, as of December 31, 2010*, Washington DC, p. 46; *Selected acquisition report (SAR): F-35, as of December 31, 2011*, Washington DC, pp. 74–5.

to be paid between 2009 and 2014.[112] This brings Australia's total projected commitment to the JSF Program's SDD phase to US$205 million (see Table 4.1).

3.14 Subsequent cost increases for the SDD phase are predominantly being borne by the United States. In January 2010, for example, more than US$2.8 billion was moved from the procurement phase to the development phase,[113] and in January 2011 the Secretary of Defense announced that US$4.6 billion in additional developmental funding would be provided to the JSF Program.[114] No additional contribution was sought from the partner nations.

3.15 The international contribution to the development of the F-35 aircraft from 1996 to 2014 is calculated as some US$4.18 billion, with an additional US$1.02 billion for the engine (then-year dollars).[115]

3.16 Australia's initial contribution to the JSF SDD MoU of US$150 million was paid over a period of ten years.[116] It consisted of a financial contribution of US$144 million, paid to the United States over the years 2002–11, and a non-financial contribution of US$6 million consisting principally of engineering and technical services provided during 2002–08. Australia also committed US$1 million during 2005 and 2006 for Australian unique requirements, including an Advanced Short Range Air-to-Air Missile (ASRAAM) Phase 1 Study, a Modelling Support Study, and a Pilot Training Study. At the same time, the United States was providing some US$9.26 million to Australia for a number of JSF Science and Technology projects.[117]

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[112] CEO Defence Materiel Organisation, *Additional contribution to JSF System Development and Demonstration phase*, ministerial submission, 13 October 2008.

[113] Jeremiah Gertler, *F-35 Joint Strike Fighter (JSF) Program: Background and issues for Congress*, Congressional Research Service, 26 April 2011, p. 21.

[114] *Selected acquisition report (SAR): F-35, as of December 31, 2010*, Washington DC, p. 4.

[115] *Selected acquisition report (SAR): F-35, as of December 31, 2011*, Washington DC, pp. 33, 49

[116] Australia's contribution was sometimes referred to as '$300 million', reflecting the exchange rate in late 2002, when US$150 million amounted to some A$275 million. *JSF System Development and Demonstration MoU, Australia-US Supplement*, 31 October 2002.

[117] *JSF System Development and Demonstration MoU, US–Australia financial management procedures document, Revision 5*, 16 May 2006.

F-35 engineering development aircraft

3.17 The first engineering development test aircraft, an F-35A conventional take-off and landing (CTOL) variant designated AA-1, entered the test program on 15 December 2006, but it was heavier than subsequent test aircraft, and lacked many of the redesign modifications planned for them. AA-1 was used to validate advanced manufacturing techniques, models and simulators, Test and Evaluation (T&E) processes, the adequacy of T&E infrastructure, and a majority of design elements. Following its flight test, the AA-1 was effectively destroyed while being used in the F-35 live fire test and evaluation program. The live fire tests were designed to verify that technical performance specifications concerning the F-35 aircrafts' vulnerability and survivability have been met, prior to the JSF Program proceeding into its Full-Rate Production phase.

3.18 The second test aircraft, which is the first F-35B short take-off and vertical landing (STOVL) variant (designated BF-1), conducted its first flight on 11 June 2008. The first 'optimized' F-35A variant (designated AF-1) conducted its first flight on 14 November 2009. The first F-35C carrier variant (CV) (designated CF-1) flew for the first time on 6 June 2010.[118]

3.19 By August 2012, 13 of the 14 planned F-35 flight test aircraft had been delivered as part of the SDD phase, with the last SDD aircraft (CF-5) scheduled for delivery later in 2012. These SDD aircraft are specially fitted with systems dedicated to Development T&E, and each successive aircraft has contributed to F-35 system development and full-system integration, and to the process of refining the F-35 manufacturing facilities and manufacturing processes.

3.20 In addition to the 14 planned SDD flight test aircraft, five production aircraft (two F-35As, two F-35Bs and an F-35C) each fitted with flight test instrumentation, are to be loaned for SDD purposes. By May 2011, two production F-35As (AF-6 and AF-7) had been transferred to SDD, and the transfer of the remaining three was expected in late 2012. At the time of the audit, therefore, 15 of the 19 aircraft to be dedicated to the SDD effort had been delivered.

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[118] F-35 Lightning II Joint Strike Fighter Program Office, *F-35 Lightning II Joint Strike Fighter: Test and evaluation master plan (TEMP)*, Third Revision, January 2009, pp. 132, 190, 399.

3.21 These 15 aircraft consisted of:

- seven F-35As (one of which has been effectively destroyed, see paragraph 3.17);
- five F-35Bs; and
- three F-35Cs.[119]

3.22 There are also six F-35 airframes (also known as ground test articles) undergoing structural strength and durability (fatigue) testing, and two pole-model airframes used for radar signature testing.[120]

Production aircraft used for testing

3.23 As well as the production aircraft that are to be loaned to the SDD effort, other production aircraft may also to be used for flight test purposes. In all, 27 Low-Rate Initial Production (LRIP) F-35 aircraft (including the five that are to be loaned to the SDD effort) are to be fitted with flight test instrumentation required for operational test and evaluation.[121]

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[119] See Table 3.2 for details; the aircraft yet to join the SDD effort are BF-17, BF-18, CF-5 and CF-8. F-35 Lightning II Joint Strike Fighter Program Office, *F-35 Lightning II Joint Strike Fighter: Test and evaluation master plan (TEMP)*, Third Revision, January 2009, p. 187; US Department of Defense, Director, Operational Test and Evaluation, *FY2011 annual report*, pp. 26, 27.

[120] F-35 Lightning II Joint Strike Fighter Program Office, *F-35 Lightning II Joint Strike Fighter: Test and evaluation master plan (TEMP)*, Third Revision, January 2009, p. 190. A pole model is affixed to a tall pole and tested in the open air, and is used in tests to provide data about the radar-signature characteristics of the F-35 aircraft.

[121] The 22 aircraft assigned to flight test include 20 OT&E jets (three of which—BF-17, BF-18, and CF-8—are loaned to SDD until Development T&E is complete) and two F-35As (AF-6 and AF-7) on loan from the USAF force-development evaluation unit at Nellis Air Force Base.
F-35 Lightning II Joint Strike Fighter Program Office, *F-35 Lightning II Joint Strike Fighter: Test and evaluation master plan (TEMP)*, Third Revision, January 2009, pp. 53, 54, 201.

Figure 3.1

F-35A engineering development aircraft

Source: F-35 Lightning II Joint Strike Fighter Program Office.

Note: Although the internal weapons bay provides the most stealthy weapons-carriage configuration, the external-carriage options provide the JSF with substantial additional weapon-load capability.

3.24 The 19 engineering development aircraft and eight ground-based test articles are listed in Table 3.2.

Table 3.2

List of F-35 engineering development aircraft and test articles

Variant	Designation	Comments
Aircraft		
F-35A	AA-1	First flight 15 December 2006 Fort Worth. Used for flight sciences (testing controls and expanding the envelope). Retired in 2009 after 91 flights and assigned to the F-35 live-fire testing program.
F-35A	AF-1	The first optimised CTOL version. To be used for flight sciences. Rolled out 19 December 2008. First flight 14 November 2009. To Edwards Air Force Base 17 May 2010.
F-35A	AF-2	To be used for flight sciences. First flight 20 April 2010. To Edwards Air Force Base 17 May 2010.
F-35A	AF-3	To be used to develop and test mission systems. First flight 6 July 2010. To Edwards Air Force Base 11 December 2010.
F-35A	AF-4	To be used for flight sciences. First flight 30 December 2010. To Edwards Air Force Base 22 January 2011.

Variant	Designation	Comments
F-35B	BF-1	Final assembly began 1 June 2007. Rolled out 18 December 2007. To be used for flight sciences (specifically STOVL). First flight 11 June 2008. To Naval Air Station Patuxent River 16 November 2009.
F-35B	BF-2	To be used for flight sciences. Rolled out 16 August 2008. First flight 25 February 2009. To Naval Air Station Patuxent River 29 December 2009.
F-35B	BF-3	To be used for flight sciences. First flight 2 February 2010. To Naval Air Station Patuxent River 17 February 2010.
F-35B	BF-4	To be used to develop and test mission systems. Rolled out 21 January 2009. First flight 7 Apr 2010. To Naval Air Station Patuxent River 7 Jun 2010. Flew with Block 1.0 software on 5 November 2010. First STOVL flight 7 April 2011.
F-35B	BF-5	To be used for flight sciences. First flight 27 January 2011. To Naval Air Station Patuxent River 16 July 2011.
F-35C	CF-1	First CV version. Rolled out 28 July 2009. To be used for flight sciences. First flight 6 June 2010. To Naval Air Station Patuxent River 6 November 2010.
F-35C	CF-2	To be used for flight sciences. First flight 29 April 2011. To Naval Air Station Patuxent River 16 May 2011.
F-35C	CF-3	To be used for carrier-suitability testing and mission systems. First flight 21 May 2011. To Naval Air Station Patuxent River 2 June 2011.
F-35C	CF-5	An SDD asset being produced under the LRIP 4 contract. To be used to develop and test mission systems. Expected at Naval Air Station Patuxent River in mid-to-late 2012.
Production aircraft on loan to the SDD Program		
F-35A	AF-6	Produced as part of LRIP 1. Second production-model F-35 sold to the US Department of Defense. To be used to develop and test mission systems. First flight 24 February 2011. To Edwards Air Force Base 13 May 2011. On loan to SDD after early 2010 program restructure.
F-35A	AF-7	Produced as part of LRIP 1. First production-model F-35 sold to the US Department of Defense. To be used to develop and test mission systems. First flight 4 March 2011. To Edwards Air Force Base 6 May 2011. On loan to SDD after early 2010 program restructure.

Variant	Designation	Comments
F-35B	BF-17	Produced as part of LRIP 3. To be used to develop and test mission systems. Expected at Edwards Air Force Base in late 2012. On loan to SDD from US Marine Corps. Post-SDD will return to the Marine Corps to conduct Operational T&E.
F-35B	BF-18	Produced as part of LRIP 3. To be used to develop and test mission systems. Expected at Edwards Air Force Base in late 2012. On loan to SDD from US Marine Corps. Post-SDD will return to the Marine Corps to conduct Operational T&E.
F-35C	CF-8	Being produced as part of LRIP 4. To be used to develop and test mission systems. Expected at Edwards Air Force Base in late 2012. On loan to SDD from US Navy. Post-SDD will return to the Navy to conduct Operational T&E.
Ground-test articles		
F-35A	AG-1	CTOL static ground-test airframe. Rolled out 17 Dec 2008. To BAE Systems in Brough, UK on 25 April 2009 for stress testing.
F-35B	BG-1	STOVL static ground-test airframe. Delivered June 2008.
F-35C	CG-1	CV static ground-test / drop / barricade-test article.
F-35A	AJ-1	CTOL durability article.
F-35B	BH-1	STOVL durability article.
F-35C	CJ-1	CV durability article.
F-35A	None	CTOL pole test article.
F-35C	None	CV pole test article.

Source: JSF Program Office.

JSF engine development and the Alternative Engine Program

3.25 A significant element of the JSF SDD phase was the parallel development of two competing engines, the F135 manufactured by Pratt & Whitney, and the F136 manufactured by General Electric/Rolls-Royce. Each engine comes in two variants, one for the F-35A and F-35C, the other for the F-35B. The JSF Alternative Engine Program, which created the F136, was established in order to achieve the financial and performance benefits of competition.[122]

[122] US Department of Defense, Director, Operational Test and Evaluation, *FY2001 annual report*, p. V-69.

3.26 However, in March 2011 a stop-work order on the F136 System Development and Demonstration contract was issued by the US Government's F-35 Primary Contracting Officer to the General Electric/Rolls-Royce Fighter Engine Team. On 25 April 2011 a notice of termination for convenience was issued, ending the Alternative Engine Program.[123] This was in response to the US Government finding that the alternative engine was unnecessary and could not be afforded.

F-35 production facilities and process development

3.27 As outlined in the introduction to this chapter, the SDD phase includes the production of F-35 engineering development aircraft and the development of F-35 production facilities and processes, in preparation for the JSF Production, Sustainment and Follow-on Development phases. This is being done with the participation of the eight nations that signed the JSF SDD MoU with the United States. This has led to a geographically widespread industry program, comprising the F-35 Global Supply Team arrangements shown in Figure 3.2. Each of the nine SDD participants has established various production and test facilities for various F-35 assemblies.

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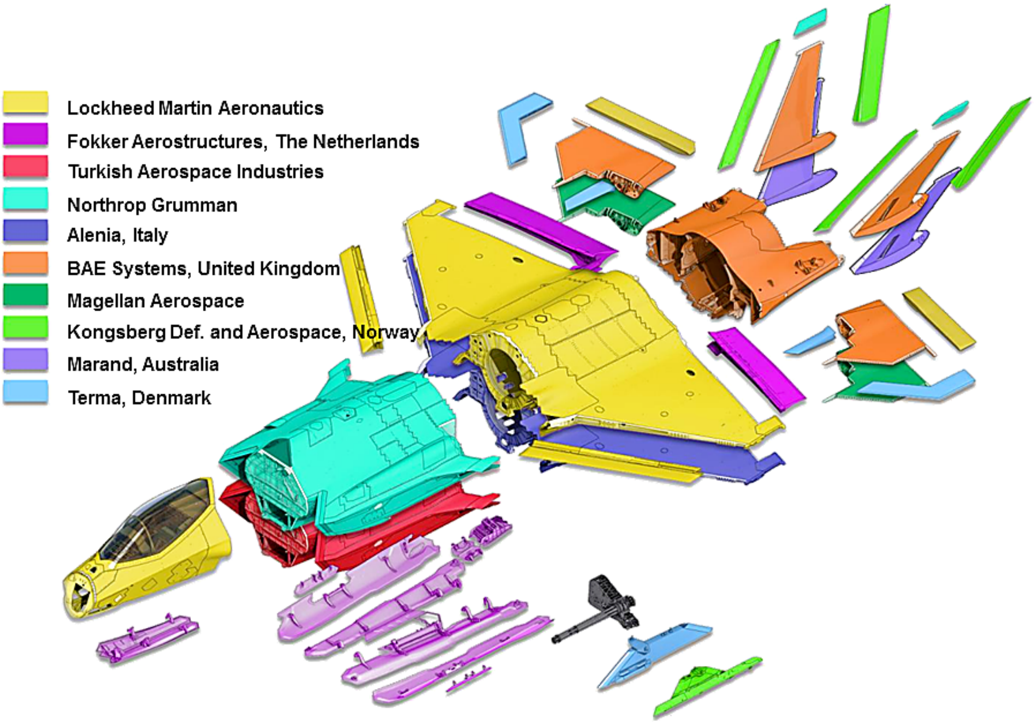
[123] *Selected acquisition report (SAR): F-35, as of December 31, 2010*, Washington DC, p. 46; *Selected acquisition report (SAR): F-35, as of December 31, 2011*, Washington DC, pp. 6, 76.

Figure 3.2

JSF Global Supply Team

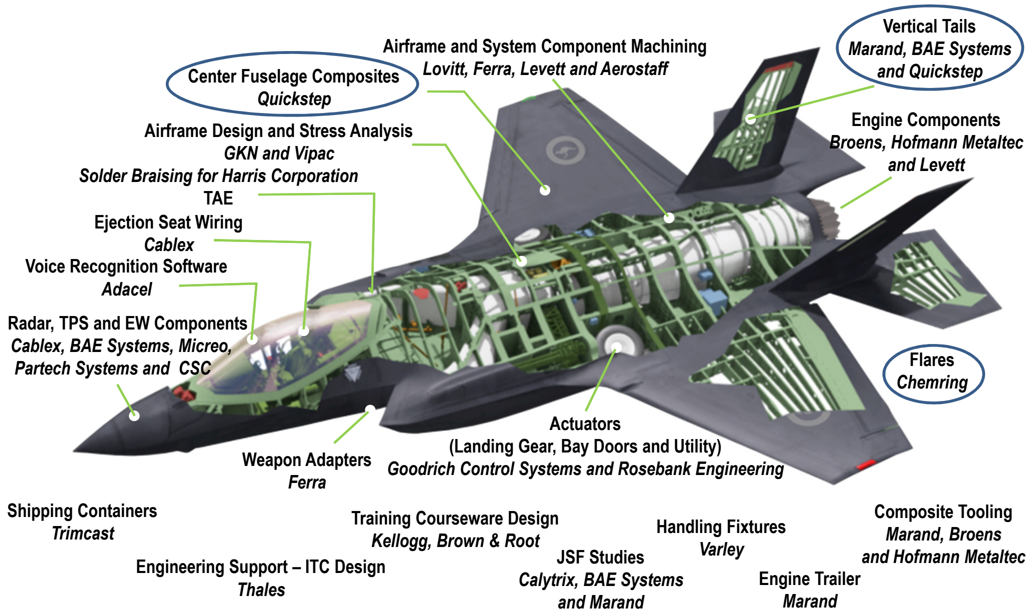


Source: Lockheed Martin.

3.28 The contribution of Australian industries to the F-35 Global Supply Team is illustrated in Figure 3.3.

Figure 3.3

Participation of Australian industry in the JSF Program



Source: Lockheed Martin, presentation to the ANAO, March 2012.

3.29 Australian participation in the JSF Program was planned to provide opportunities for the expansion of Australia's innovative and technologically leading aerospace industry.[124] In July 2012, the NACC IPT informed the ANAO that there were A$300 million of firm SDD and production contracts signed with Australian industry, with further long-term contracts expected in the future.

F-35 system demonstration

3.30 System demonstration—one of the two major efforts in the SDD phase—is intended to demonstrate, through an approved T&E program, the ability of the system to operate in a way consistent with the requirements set

124 Senator the Hon. Robert Hill, Minister for Defence, and the Hon. Ian MacFarlane, Minister for Industry, *Australia's future air combat capability*, transcript of joint press conference, 27 June 2002, p. 2.

out in the system's approved Key Performance Parameters. System Demonstration generally commences when a system prototype (or Engineering Development Model) has been produced and ends when:

- the system is demonstrated to meet its approved requirements in its intended environment using the selected prototype;
- industrial capabilities are reasonably available; and
- the system meets or exceeds the criteria for entrance into its Full-Rate Production & Deployment (Milestone C) phase.[125]

3.31 The JSF Program Executive Officer (PEO) is ultimately responsible for fielding an Air System that satisfies the specifications in the 2001 Joint Operational Requirements Document. The PEO has final flight clearance approval authority for all flight tests during the SDD phase.[126] At the time of the audit, the F-35 SDD contract holds Lockheed Martin responsible for Total Integrated System Performance, which includes planning and execution of the F-35 Air System's Integrated Test Program.[127]

3.32 The JSF Program Office Integrated Test Force Director is the US Government representative responsible to the Program Executive Officer for monitoring the Integrated Test Program, and for ensuring its consistency with the test strategy outlined in the *Test and Evaluation Master Plan* (TEMP).[128]

3.33 The F-35 TEMP defines the T&E strategy for the F-35 Air System during SDD. It serves as an agreement between the F-35 PEO, in coordination with the UK Ministry of Defence, and the acquisition chain of command within the US Department of Defense. The T&E strategy is designed to provide the

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[125] US Department of Defense Instruction 5000.2, *Operation of the defense acquisition system*, May 2003, paragraph 3.7.5. For most acquisition programs, Milestone C marks the passage from the SDD or Engineering & Manufacturing Development phase to the Low-Rate Initial Production phase. For the F-35, however—because of the high level of concurrency in the program (see paragraph 4.27)—Milestone C will mark the beginning of Full-Rate Production. *Selected acquisition report (SAR): F-35, as of December 31, 2011*, Washington DC, p. 10.

[126] F-35 Lightning II Joint Strike Fighter Program Office, *F-35 Lightning II Joint Strike Fighter: Test and evaluation master plan (TEMP)*, Third Revision, January 2009, p. 55.

[127] F-35 Lightning II Joint Strike Fighter Program Office, *F-35 Lightning II Joint Strike Fighter: Test and evaluation master plan (TEMP)*, Third Revision, January 2009, p. 55.

[128] F-35 Lightning II Joint Strike Fighter Program Office, *F-35 Lightning II Joint Strike Fighter: Test and evaluation master plan (TEMP)*, Third Revision, January 2009, p. 55.

information necessary to determine whether the F-35 will satisfy user requirements.[129]

3.34 The TEMP covers the developmental, operational and live-fire T&E, including measures to evaluate F-35 performance during these test periods. It contains an integrated test schedule and identifies the resources required to accomplish all T&E activities. The TEMP is event-driven, rather than time-driven, and so is compatible with the program's overall acquisition strategy.[130] At the time of the audit, the F-35 TEMP had been approved and published in a series of three versions, each reflecting a particular stage of the JSF Program. Version 4 of the TEMP was being developed to reflect the need for additional testing identified by the 2010 Technical Baseline Review. (This review is discussed in Chapter 5.)

3.35 The SDD phase has an F-35 System Verification Plan, which sets out how verification of the F-35 Air System is to be conducted. It calls for Integrated Product Teams to coordinate with T&E laboratories and the Integrated Test Force in the execution of both ground and flight-based verification activities. The Integrated Test Force is specifically tasked to execute Development Test and Evaluation (DT&E) flight tests, while integrating Operational Test and Evaluation (OT&E) flight test objectives where possible.[131] The integration of developmental and operational testing (where possible) is aimed at preventing weapon-systems failures, resulting from design and development issues that should have been identified and corrected during development testing, from being discovered during operational testing. For that reason, the United States Weapon Systems Acquisition Reform Act of 2009 requires the integration of developmental test and evaluation with operational test and evaluation.[132]

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[129] F-35 Lightning II Joint Strike Fighter Program Office, *F-35 Lightning II Joint Strike Fighter: Test and evaluation master plan (TEMP)*, Third Revision, January 2009, pp. 36, 37.

[130] F-35 Lightning II Joint Strike Fighter Program Office, *F-35 Lightning II Joint Strike Fighter: Test and evaluation master plan (TEMP)*, Third Revision, January 2009, pp. 36, 37.

[131] F-35 Lightning II Joint Strike Fighter Program Office, *F-35 Lightning II Joint Strike Fighter: Test and evaluation master plan (TEMP)*, Third Revision, January 2009, p. 37.

[132] 10 US Code §139b(a)(5)(A)(ii), as amended by *The Weapon Systems Acquisition Reform Act* of 2009 (Public Law 111–23), section 102. DT&E and OT&E are followed by a third phase of testing, Live Fire T&E (LFT&E).

3.36 OT&E is being conducted by the Operational Test Agencies through the JSF Operational Test Team, to determine the F-35 system's operational effectiveness and suitability. OT&E consists of a series of Operational Assessments followed by dedicated OT&E periods involving operational flight test. The JSF Operational Test Team is integrated into the Integrated Test Force throughout the SDD phase, and the team reports its Operational Assessments and dedicated operational T&E results independently.[133] The US Department of Defense's Director, Operational Test and Evaluation (DOT&E) (see paragraph 5.11) has continuously participated in JSF OT&E and monitored Live-fire Test and Evaluation planning activities since June 1995, when the JSF Program was known as the JAST Program.[134] Since 1995, the DOT&E has published annual reports that include the JSF aircraft.

Ground-based laboratories

3.37 F-35 Laboratories support all phases of F-35 development. Almost all F-35 systems are tested and evaluated in laboratories, which use Hardware-in-the-Loop (HITL) and Man-in-the-Loop (MITL) T&E techniques.

3.38 The F-35 laboratories consist of the following major installations:

- Mission Systems Integration Lab (MSIL);
- Verification Simulator/Manned Tactical Simulator (VSim/MTS1);
- Design Simulator/Partner Manned Tactical Simulator (DSim/PMTS);
- Vehicle Systems Processing/Flight Control System Integration Facility (VIF);
- Autonomic Logistics Labs (ALIS/ALL);
- Vehicle Systems Integration Facility (VSIF); and
- Utilities and Subsystems Integration Facility (USIF).[135]

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133 F-35 Lightning II Joint Strike Fighter Program Office, *F-35 Lightning II Joint Strike Fighter: Test and evaluation master plan (TEMP)*, Third Revision, January 2009, p. 37.

134 US Department of Defense, Director, Operational Test and Evaluation, *FY99 annual report*, p. V-112. Live-fire Test and Evaluation enables the evaluation of system vulnerability to realistic threat munitions, as well as system lethality against realistic threat targets. F-35 Lightning II Joint Strike Fighter Program Office, *F-35 Lightning II Joint Strike Fighter: Test and evaluation master plan (TEMP)*, Third Revision, January 2009, p. 37.

135 JSF Program Office, *F-35 Labs overview*, Fall 2011.

3.39 By 2011, HITL laboratories had been used for over 140 000 hours of mission-system testing, and this was typically increasing at a rate of 700 hours per week. At the same time, MITL laboratories had been used for over 150 000 hours of mission-system testing.[136] Table 3.3 (see page 102) lists the total hours of laboratory testing completed for each mission system, as at June 2012.

3.40 Airframe strength and durability testing is carried out using six F-35 static airframes, and several structural-test facilities. The tests conducted by these facilities include static load testing, testing of the STOVL engine in a 'hover pit', and drop-testing of the F-35C carrier variant.[137]

Airborne laboratories

3.41 The JSF Program includes aircraft configured as flying laboratories for developing and demonstrating the avionics for the F-35, particularly mission system avionics. There are two primary groups of aircraft configured for that purpose: firstly two civilian aircraft extensively modified to function as flying laboratories, and secondly a variety of other aircraft configured for specific test purposes, and which are representative of all three F-35 variants.[138]

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[136] Mission systems provide the pilot with situational awareness, through hardware such as radar; electronic warfare suite; integrated communications, navigation, and identification system; integrated core processor; targeting sensor; distributed aperture system; and the Helmet Mounted Display. Lockheed Martin, *Ground and lab tests: ensuring strength and technological capability* [Internet], available from <https://f35.com///building-the-f-35/testing/structural-evaluation.aspx> [accessed 15 May 2012].

[137] Airframe static strength and durability tests are conducted in laboratories to ensure that a structure, such as an aircraft wing, can withstand the extreme loads likely to be encountered in flight, and to provide assurance that the aircraft will remain airworthy for its designed service life. During static testing, the actual strength of an airframe structure is compared to design specifications. During durability (fatigue) tests, airframe assemblies are subjected to smaller repeated forces that can cause cumulative damage over time. These tests are conducted to verify and certify the safe life of airframe structures, to help determine inspection requirements and inspection intervals for the fleet of aircraft, identify critical areas of the airframe not previously identified by analysis, and certify that the structure can meet or exceed durability life requirements. See Table 3.2 for details of the ground-test articles.

[138] These include an F-4, F-16, F-35 AA-1, and a Sabreliner aircraft.

Figure 3.4

BAC 1-11 aircraft

Source: Lockheed Martin.

3.42 The laboratory-configured aircraft include an extensively modified Boeing 737 known as the Cooperative Avionics Test Bed (CATB), which is used by Lockheed Martin to conduct F-35 system development and software integration testing. In addition, each F-35 sensor supplier continues to use surrogate aircraft to test their particular sensors; for example, Northrop Grumman conducts radar and Distributed Aperture System testing in its BAC 1-11 aircraft.

3.43 The BAC 1-11 flight tests, which began during the JSF Concept Demonstration phase, are configured with the AN/APG-81 Active

Electronically Scanned Array (AESA) radar and the AN/AAQ-37 Distributed Aperture System (DAS) infrared system.[139]

Figure 3.5

Cooperative Avionics Test Bed (CATB) aircraft

Source: Lockheed Martin.

3.44 The Boeing 737 CATB is also fitted with the AESA radar, the DAS infrared system, the F-35 Electronic Warfare System and data communications systems, all of which are installed in an 'F-35-like' configuration. This enables Lockheed Martin to use the CATB aircraft for developmental testing of sensors, in addition to the tests carried out by the sensor manufacturers. The CATB also enables Lockheed Martin to conduct Mission Systems integration testing as an extension of the ground-based Mission System Integration Laboratory, and to

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[139] The AN/APG-81 AESA radar and the infrared AN/AAQ-37 DAS, both developed by Northrop Grumman, are to provide the required air-to-ground and air-to-air reconnaissance capabilities of the F-35. The AN/APG-81 active electronically scanned array (AESA) radar is capable of the full range of air-to-surface and air-to-air functions and is complemented by electronic-warfare, reconnaissance and surveillance capabilities. The AN/AAQ-37 Distributed Aperture System (DAS) delivers passive spherical awareness, tracks and detects missiles and aircraft threats, provides day/night vision and supports the navigation of the aircraft. The DAS is a 360° spherical situational-awareness system, designed to warn the pilot of incoming aircraft and missile threats from any direction; it provides day and night vision, fire-control capability, and precision tracking of wingmen and friendly aircraft for tactical manoeuvring.

conduct verification and model-validation of the Mission Systems flight test requirements. It also enables Lockheed Martin to develop and mature the F-35 Operational Flight Program software prior to installation in an F-35 test aircraft.

3.45 The overall aim is to use these flight test aircraft to reduce F-35 system-development risks by uncovering and resolving issues with mission-system hardware and software as early as possible, before they reach the F-35 fleet. They also minimise dedicated flight tests on the F-35 Air Vehicle, and complement the F-35 flight test program with a dedicated modelling, simulation and analysis capability. The objective is to increase test and evaluation efficiencies and achieve a reduction in JSF Program risk.[140]

3.46 By June 2012, the F-35 mission systems had completed some 18 500 hours of flight test and nearly 345 000 hours of laboratory testing, as shown in Table 3.3. Since the F-35 Lightning II commenced flight testing in December 2006, they have accumulated a total of 3700 flight test hours.[141]

Table 3.3

Testing of F-35 mission systems, as at 15 June 2012

System	Flight hours	Laboratory hours
Helmet Mounted Display (HMD)	3298	32 032
AN/APG-81 Active Electronically Scanned Array Radar (AESA)	1203	42 383
AN/AAQ-37 Distributed Aperture System (DAS)	2123	49 945
Electro Optical Targeting System (EOTS)	4593	21 981
Integrated Communication, Navigation & Identification (CNI)	1575	>98 786
Inertial Navigation System and GPS (INS&GPS)	3961	>43 100
Electronic Warfare/Counter-measures (EW/CM)	1702	56 607
Total hours	**18 455**	**344 834**

Source: JSF Program Office, June 2012.

140 F-35 Lightning II Joint Strike Fighter Program Office, *F-35 Lightning II Joint Strike Fighter: Test and evaluation master plan (TEMP)*, Third Revision, January 2009, p. 57. F-35 Lightning II Joint Strike Fighter Program Office, *System verification plan (SVP), revision E, for the Joint Strike Fighter (JSF) System Development and Demonstration (SDD) Program, contract no. N00019-02-C-3002*, February 2009, pp. 61, 62.

141 Lockheed Martin, *Lockheed Martin F-35 flight test progress report*, media release, 10 July 2012.

Verification progress

Status of F-35 requirements

3.47 As of December 2010, estimates for all Key Performance Parameters (KPP) were within threshold requirements with the exception of the F-35A Combat Radius KPP, which fell short of the 590 nautical miles threshold by 6 nautical miles.[142] The F-35A Combat Radius KPP was revisited by the Joint Requirements Oversight Council in February 2012.[143] The ground rules for assessing the KPP were revised to reflect the aircraft's optimum airspeed and altitude values, as obtained through testing. A December 2011 report to the US Congress (tabled in March 2012) stated that:

> Once these values were applied to the mission profile, the performance of the aircraft exceeded the original, unchanged KPP value.[144]

3.48 Although current estimates of the F-35's performance are close to those required, performance will not be fully demonstrated until the completion of initial operational testing, presently scheduled for February 2019.[145]

Requirements verification

3.49 A combined US Government and Lockheed Martin team is responsible for managing and executing the verification activities which will constitute the elements of the DT&E program.

3.50 The full set of requirements in the December 2002 JSF Contract Specification is divided into Functional Areas to be managed through the remainder of the SDD phase, with the goal of incremental verification of requirements where possible. Blocks of testing are undertaken as the system

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[142] The Key Performance Parameters for a US defense acquisition program generally have both an objective value and a threshold value. Objective values represent the desired operational goal associated with a performance attribute, beyond which any gain in utility does not warrant additional expenditure. Thresholds, on the other hand, represent the minimum acceptable operational value, below which the utility of the system becomes questionable. Defense Acquisition University, *Defense acquisition guidebook*, as at 10 January 2012, section 2.1.1; *Selected acquisition report (SAR): F-35, as of December 31, 2010*, Washington DC, pp. 4, 10.

[143] The Joint Requirements Oversight Council oversees the most important US defense acquisition programs; it is chaired by the Vice Chairman of the Joint Chiefs of Staff, and the other members are the Vice Chiefs of each US military service. 10 US Code §181.

[144] *Selected acquisition report (SAR): F-35, as of December 31, 2011*, Washington DC, p. 6.

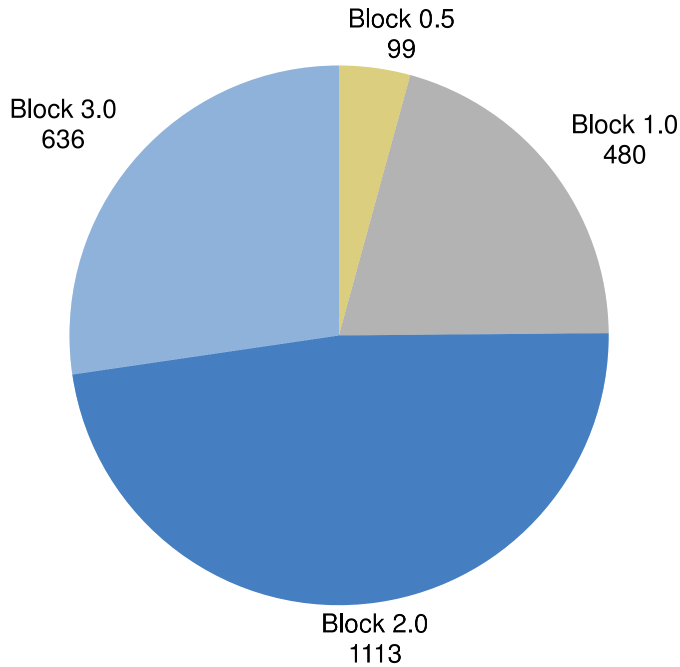
[145] *Selected acquisition report (SAR): F-35, as of December 31, 2011*, Washington DC, pp. 9, 11–15.

matures, and encompass the entire Air System, including its Air Vehicle, Autonomic Logistics and Mission Systems elements. When practical, each Block corresponds to mission-system software releases as well as LRIP deliverables.[146]

3.51 Figure 3.6 shows the planned incremental verification of 2328 success criteria during the SDD phase, with each criterion representing a requirement set out in the JSF Contract Specification.[147]

Figure 3.6

Success criteria planned per Block



Source: F-35 Lightning II Joint Strike Fighter Program Office, *F-35 Lightning II Joint Strike Fighter: Test and evaluation master plan (TEMP)*, Third Revision, January 2009, p. 76.

3.52 By April 2012, the JSF Program Office's Verification Test and Evaluation had completed 292 success criteria, and the total number of success

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146 Block 3, which Australia is to purchase (see Table 2.2 on page 67), correlates to LRIP 6 and onwards. Defence Materiel Organisation, New Air Combat Capability Integrated Project Team, *Phase 2A/B NACC test and evaluation master plan,* version 1.0, August 2009, p. 24.

147 F-35 Lightning II Joint Strike Fighter Program Office, *F-35 Lightning II Joint Strike Fighter: Test and evaluation master plan (TEMP)*, Third Revision, January 2009, pp. 75, 76.

criteria to be achieved had been revised to 2808.[148] On that basis, requirements verification is around 10 per cent complete.

Progress through the static and durability test programs

3.53 As outlined in Chapter 4 of the companion audit,[149] an aircraft's structural integrity is initially established through the application of design principles and production techniques, and is verified and validated through tests and evaluations of structural fatigue and degradation, conducted by aircraft designers and manufacturers.[150] These activities allow designers to determine an aircraft's theoretical service life—known as its Life of Type. This is the period of time for which that type of aircraft may be flown, within its expected usage pattern, without an excessive risk of a catastrophic structural failure. The JSF Program Office has established the Prognostic Health Monitoring (PHM) system to accomplish health monitoring of the JSF structure and systems and to prompt their maintenance.[151]

3.54 The SDD phase includes structural testing of all three F-35 variants through full-scale static and durability tests.[152] All three F-35 variants are designed and manufactured by Lockheed Martin to a Joint Services specification, which includes a structural fatigue safe life of 8000 airframe hours for aircraft operating within specified flight profiles.

3.55 By September 2011, airframe structural strength (static) testing of the three F-35 variants was complete, and the tests had demonstrated the aircrafts'

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148 F-35 Lightning II Joint Strike Fighter Program Office, *F-35 test and verification brief*, presentation to the ANAO, 20 March 2012.

149 ANAO Audit Report No.5 2012–13, *Management of Australia's Air Combat Capability—F/A-18 Hornet and Super Hornet Fleet Upgrades and Sustainment*, 27 September 2012.

150 *Verification* is the confirmation, by examination and provision of objective evidence, that specified requirements to which a product or service, or aggregation of products and services, is built, coded, assembled and provided have been fulfilled. *Validation* is the proof, through evaluation of objective evidence, that the specified intended end use of a product or system is accomplished in an intended environment. International Organization for Standardization, ISO 9000:2006 Quality Management System—Fundamentals and Vocabulary; Department of Defence, *Defence Materiel Verification and Validation Manual*, Defence Materiel Manual (ENG) 12-0-001, November 2008, p. 9.

151 F-35 Lightning II Joint Strike Fighter Program Office, *F-35 Lightning II Airworthiness Management Plan*, March 2012, p. 33.

152 F-35 Lightning II Joint Strike Fighter Program Office, *F-35 Lightning II Joint Strike Fighter: Test and evaluation master plan (TEMP)*, Third Revision, January 2009, p. 36.

ability to withstand 1.5 times their theoretical maximum airframe load (13.5 positive g).[153]

3.56 On current plans, by 2015 airframe full-scale durability testing (also known as fatigue testing) to two airframe lifetimes is to be complete.[154] In August 2012, durability testing of the F-35A had passed 8000 airframe hours, which is one Equivalent Flight Hours (EFH) or one aircraft lifetime. This is 50 per cent of the two lifetimes of testing required for SDD.[155]

3.57 Full-scale durability testing to three airframe lifetimes was decided as part of the 2010 Technical Baseline Review and the subsequent replan of the SDD phase (see paragraph 5.27). This additional testing will provide increased assurance that a structural-fatigue safe life of 8000 hours has been achieved by the F-35 design and production process. At the time of the audit, this additional testing was being scoped into the SDD replan, in the form of Over-Target Baseline items, which are expected to be entered into contract during the latter half of 2012. The F-35 Structural Health Monitoring system and three-lifetimes testing are the subject of F-35 structural risk mitigation management.

Progress through the flight test program

3.58 By August 2012, 15 F-35 flight test aircraft had been delivered to the test program (see Table 3.2), of which ten were flight sciences and five mission-systems aircraft.[156] One of these aircraft (AA–1) was retired in 2009, and assigned to the F-35 live-fire testing program.

3.59 The overall flight test plan calls for the verification of 59 585 test points through developmental test-flights by the end of the SDD phase.[157] This testing

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[153] *Selected acquisition report (SAR): F-35, as of December 31, 2010*, Washington DC, p. 4; Lockheed Martin, *F-35 program completes static structural testing*, media release, 19 September 2011.

[154] Department of Defense, Vice Admiral David J. Venlet, Program Executive Officer F-35, *Presentation to the Senate Armed Services Committee Subcommittee on Tactical Air and Land Forces: F-35 Joint Strike Fighter Program*, Washington DC, 8 May 2012, p. 8.

[155] F-35 Lightning II Joint Strike Fighter Program Office, *AJ-1 CTOL durability test performance tracker—replan*, June 2012.

[156] *Selected acquisition report (SAR): F-35, as of December 31, 2011*, Washington DC, p. 5.

[157] Flight test points are specific, quantifiable objectives in flight test plans that are needed to verify aircraft design and performance. Completion of a test point means that the test point has been flown and that flight engineers ruled that the point has met the need for flight data. Further analysis may be necessary for the test point to be closed out, that is, that a particular design and performance specification has been achieved.

needs to be done in line with the development of the software and each of the Block capabilities (see paragraph 2.8), and is therefore being conducted while F-35 aircraft production continues. This is in accordance with the October 2001 US Defense Acquisition Board approval of the timing and extent of the JSF Program's production phase (see paragraphs 4.18 and 4.27 to 4.29).

3.60 In relation to the F-35A variant to be purchased by Australia, the T&E program requires the achievement of 24 951 flight test points covering all F-35A Initial Operational Capability requirements. By March 2012, F-35A capability testing was ongoing, and a total of 5282 test points had been achieved. This represents some 21 per cent of the overall test points required to verify Initial Operational Capability achievement.[158]

F-35 software development

3.61 Software is critical to the success of the JSF Program, as it provides the means by which all safety-of-flight and mission-critical systems are monitored, controlled and integrated. At the time of the audit, widespread improvements in the software development, integration and testing were being pursued by Lockheed Martin, in order to reduce cost, schedule and technical risks.[159] As noted in paragraph 2.8, the JSF Program's software development is divided into three basic release Blocks:

- Block 1 provides initial training capability. This Block completed its test phase in the second quarter of 2012, and was released to the F-35 pilot training program;
- Block 2 provides initial war-fighting capability, including weapons employment, electronic attack, and interoperability between forces. At the time of the audit, the initial release of Block 2—known as Block 2A—was undergoing flight testing and was scheduled for release to the F-35 flight test program in September 2012, and for released to the F-35 pilot training program in the second quarter of 2013. The final release of Block 2 capability—known as Block 2B—is scheduled for 2015; and

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[158] JSF Program Office, *F-35 test and verification brief*, presentation to the ANAO, 20 March 2012.

[159] Lockheed Martin, *F-35 Lightning II: mission systems*, presentation to the ANAO, March 2012.

- Block 3 provides the full war-fighting capability, including full sensor fusion and additional weapons. At the time of the audit, 61 per cent of initial Block 3 capability had been developed against a target of 81 per cent, and its integration into F-35 aircraft was planned to commence from November 2012. Block 3 fleet release is scheduled for mid-2017.[160]

3.62 Each year of production delivers a version of one of these software blocks for government acceptance.[161] This is planned to continue during the F-35 Follow-on Development phase, which is to deliver additional capability blocks in two-year increments. In order to achieve Block 3 capability, LRIP Lot 5 aircraft and prior LRIP aircraft will need the Block 3 software upgrade as well as being retrofitted with an improved Integrated Core Processor via the F-35 Technical Refresh 2 (TR-2). From LRIP Lot 6, F-35 aircraft will be produced with TR-2 and so will only need Block 3 software upgrades in order to achieve Block 3 capability.[162] At the time of the audit, other changes were under consideration by the JSF Program Office. These included improved Helmet Mounted Display hardware and software, which, like TR-2, were found to be necessary during test and evaluation of F-35 aircraft, and at the time of the audit each were the subject of high-risk mitigation management.

3.63 In terms of the overall size of the software development task, by December 2010, approximately 20 million out of 24 million software lines of code (81 per cent) estimated to be required by ground support systems and on-board F-35 flight control and mission systems had been developed, passed through unit test, and placed under developmental configuration management. Systems integration testing of the F-35 Block 1 capabilities was ongoing, through the use of F-35 mission-systems test aircraft, the CATB aircraft, and environment simulation laboratories.[163]

3.64 By March 2012, JSF Program Office records indicated that software deliveries against F-35 Block 1 capability requirements were fully developed, were 80 per cent fully integrated, had completed 73 per cent of flight test and

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[160] *Selected acquisition report (SAR): F-35, as of December 31, 2011*, Washington DC, p. 9.

[161] US Department of Defense, Vice Admiral David J. Venlet, Program Executive Officer F-35, *Presentation to the Senate Armed Services Committee Subcommittee on Tactical Air and Land Forces: F-35 Joint Strike Fighter Program*, Washington DC, 8 May 2012, p. 9.

[162] US Department of Defense, Director, Operational Test and Evaluation, *FY2011 annual report*, p. 28.

[163] *Selected acquisition report (SAR): F-35, as of December 31, 2010*, Washington DC, p. 4.

overall were 80 per cent delivered.[164] By July 2012, Block 1 was 1–2 months behind schedule, with some capability being delayed to Block 2. In software volume terms, 8.7 million lines of software that provide the F-35 Block 1 and Block 2 capabilities had been coded (93.5 per cent of the final target) and 8 million lines had been lab-tested. By 2016, F-35 airborne software required for Block 3 capability is expected to reach 9.3 million software lines of code.

F135 propulsion system testing

3.65 By December 2011, the F135 propulsion contractor, Pratt & Whitney, had delivered the Flight Test Engines and the first 25 production propulsion systems, which included all the LRIP Lot 1 propulsion system requirements and 90 per cent of LRIP Lot 2 propulsion system requirements.[165] These requirements include the F-35B short take-off and vertical landing (STOVL) variant's lift system.

3.66 By August 2012, the F135 propulsion system had completed a total of 23 201 hours of testing in the three test modes set out in Table 3.4. The results obtained, including successes achieved by the F-35B STOVL initial operational tests, have resulted in the F-35B being removed from probationary status,[166] and the overall F135 propulsion system tests progressing as planned.

Table 3.4

F-35 Engines operational test durations, as at 27 August 2012

F-35 variant	Ground test hours	Flight test hours	Ground running of flight test engines	Total hours
F-35A and F-35C	5477	2589	3303	11 369
F-35B	7784	1119	2929	11 832
Total	**13 261**	**3708**	**6232**	**23 201**

Source: Joint Strike Fighter Program Office.

[164] Lockheed Martin, *F-35 Lightning II: mission systems*, presentation to the ANAO, March 2012; JSF Program Office, *Software development status*, presentation to the ANAO, 20 March 2012.

[165] *Selected acquisition report (SAR): F-35, as of December 31, 2011*, Washington DC, pp. 6, 77.

[166] *Selected acquisition report (SAR): F-35, as of December 31, 2011*, Washington DC, p. 5.

AIR 6000 involvement in the test program

3.67 As discussed in paragraphs 2.36 to 2.42, the Australian Defence Force's requirements of the F-35 capability have been developed within the F-35 JSF partnership agreements. The agreements enable the NACC IPT to participate in the US-led multinational F-35 JSF test and evaluation program. That program includes Developmental Test and Evaluation (DT&E)[167] and Acceptance Test and Evaluation (AT&E), both of which are managed and conducted by the JSF Program Office or contracted development organisations.[168]

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[167] The F-35 JSF Development Test and Evaluation (DT&E), from Australia's viewpoint, is to be conducted in three phases:

- DT&E Phase 1 refers to developmental testing that will be undertaken to develop the system to Block 3 capability. Testing will be conducted by Lockheed Martin, subcontractors and Propulsion System Contractors under the System Development and Demonstration contract Statements of Work. This activity includes weapons integration DT&E. During the Production, Sustainment and Follow-on Development (PSFD) phases, Lockheed Martin will be contracted to sustain and upgrade the system, and DT&E will be included in this work. The JSF Program Office is responsible for contract management of Australian DT&E.
- DT&E Phase 2 refers to Australian Weapons DT&E, which will be conducted as part of the weapons acquisition. This testing is expected to be procured through Foreign Military Sales (FMS). The US program office delivering the weapons will contract manage the acquisition of the weapons, with the weapons Original Equipment Manufacturer, in each case, conducting DT&E for their particular weapon system.
- DT&E Phase 3 comprises the testing of all ADF integration elements, as part of the acquisition of these elements. This acquisition will be managed by either the NACC IPT, or other Defence agencies on behalf of NACC (such as Defence Support Group (DSG) for facilities and Chief Information Officer Group (CIOG) for information technology products. The development contracts will include work to conduct Australian DT&E on the subject systems. As contract manager, the relevant Defence agency is to monitor the DT&E.

Defence Materiel Organisation, New Air Combat Capability Integrated Project Team, *Phase 2A/B NACC Test and Evaluation Master Plan*, version 1.0, August 2009, Annex E.

[168] System Acceptance Test and Evaluation (SAT&E) refers to System Acceptance Testing for JSF Air System (Block 3), and is to be conducted in two phases:

- SAT&E Phase 1 is to verify that the system meets the performance measures and requirements defined in JSF Program Office contract documentation. This testing will be managed by the JSF Program Office and conducted by JSF Program Office and contractor personnel. JSF AT&E test results will be provided to Australia by the JSF Program Office under the SDD MoU. Where practicable, Australian personnel will participate as observers or monitors during this phase.
- SAT&E Phase 2 refers to SAT&E for FMS-acquired weapons, and their integration into the F-35 aircraft and mission system. This testing will be managed and conducted by the US Services/US program office responsible for contract management of particular weapon acquisitions. Results of weapons SAT&E are to be reviewed by relevant Australian Defence agencies, which are to contribute to building a case for weapons certification.

Defence Materiel Organisation, New Air Combat Capability Integrated Project Team, *Phase 2A/B NACC Test and Evaluation Master Plan*, version 1.0, August 2009, Annex E.

3.68 Development test is followed by operational test. Collaborative Operational Test and Evaluation (OT&E) is being planned by the US, the United Kingdom and the Netherlands.[169] At the time of the audit, Australian observation of or participation in these programs had not been fully determined.[170]

F-35 design approval, acceptance and type certification

3.69 From an Australian perspective, the JSF Air System, comprising the F-35 and associated support systems, is being acquired under a number of MoUs with the US Government. The JSF Program Office is the organisation responsible for effectively managing the JSF Program, including deliveries to the partner nations of information they require for type certification.

3.70 The basis for the Australian Defence Force's (ADF's) acceptance of the F-35 will be Informed Recognition of Prior Acceptance, based on the type-acceptance activities conducted by the United States Air Force (USAF). A significant proportion of the USAF activity will be based on the work to be undertaken by the JSF Program Office in its role as the prime contracting authority. The JSF Program Office will coordinate relevant documentation and verification activities with the contractors and other government agencies. The USAF has been recognised as a Military Airworthiness Authority by the Director General Technical Airworthiness (DGTA). Those elements of the capability which are not managed in the above manner will be the subject of design verification by the ADF. These are predominantly related to the integration of the JSF Air System into the ADF.[171]

3.71 Design development and design approval of the F-35 aircraft is conducted by Lockheed Martin and the other Original Equipment

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[169] United States and United Kingdom, *Memorandum of Understanding on Cooperative Initial Operational Test and Evaluation of the Joint Strike Fighter* (JSF IOT&E MoU), December 2006. The Netherlands joined this process in 2008. US Federal News, *Netherlands to co-test Joint Strike Fighter*, 6 March 2008.

[170] Australia is seeking observer status in this collaborative OT&E program. Observer status would result in Australia not flying in the program or being able to direct program or flight objectives, but being involved in test planning, data processing and reporting, and having access to flight test data (except where excluded by US National Disclosure Policy). Defence Materiel Organisation, New Air Combat Capability Integrated Project Team, *Phase 2A/B NACC Test and Evaluation Master Plan*, version 1.0, August 2009, Annex E.

[171] Defence Materiel Organisation, New Aircraft Combat Capability Integrated Project Team, *Project Design Acceptance Strategy*, version 3.2, March 2010, p. 14.

Manufacturers. These design outputs are independently reviewed by the JSF Program Office before it issues Design Acceptance Recommendations, which will be used by the USAF as the basis for the Type Certification for each F-35 variant and block of capability.[172]

3.72 The F-35 also needs to gain an Australian Military Type Certificate from the ADF Airworthiness Authority, following a Defence Airworthiness Board review. This requirement is factored into the JSF Program's acquisition contract and engineering management systems, which allow visibility of the design, development, modification, integration and verification of the F-35 aircraft.[173] The participation of ADF staff in the overall process in both the SDD and PSFD phases provides further assurance that the appropriate management systems, personnel, processes and data are being applied to design approval and type certification.[174]

3.73 The JSF PSFD MoU (outlined at paragraph 4.3) also requires the JSF Program Office to make available to Defence the data and documentation necessary as part of these certification activities, for use by Defence to obtain an Australian Military Type Certificate, or for any other certifications that may be required.[175] That includes Certificates of Conformance that attest that each delivered F-35 aircraft conforms to the approved type design. The JSF Program Office is also required to document any known variations or non-conformances from the type design for each production article.[176]

3.74 See Appendix 7: F-35 Design Approval, Acceptance and Type Certification for additional coverage of this issue.

Conclusion

3.75 Australian participation in the SDD phase has enabled Defence staff to be stationed in the JSF Program Office, and to play a role in promoting

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172 F-35 Lightning II Joint Strike Fighter Program Office, *F-35 Lightning II Airworthiness Management Plan*, March 2012, pp. 15, 20.

173 F-35 Lightning II Joint Strike Fighter Program Office, *F-35 Lightning II Airworthiness Management Plan*, March 2012, pp. 15–16.

174 JSF SDD MoU, paragraph 4.8; JSF PSFD MoU, paragraph 4.7.

175 JSF PSFD MoU, paragraph 3.2.1.1.2.

176 F-35 Lightning II Joint Strike Fighter Program Office, *F-35 Lightning II Airworthiness Management Plan*, March 2012, p. 20.

capability outcomes for Australia as program decisions are made. Other benefits of SDD participation are the ability of Australian industry to bid for work in the JSF Program, increased interoperability amongst partner nations, facilitated entry into the production phase, and priority over FMS customers.

3.76 The US Government has invested extensively in the JSF Program's SDD phase, in terms of system development and test laboratories, airborne system integration, test aircraft, and production facilities and processes. By August 2012, 13 of the 14 planned F-35 engineering development aircraft had been delivered as part of the SDD phase, with the last SDD aircraft scheduled for delivery later in 2012. The SDD phase also includes six static and durability test articles, used to verify the structural integrity of the three F-35 variants, and two pole-model airframes used for radar signature testing. In addition to the SDD aircraft, five LRIP aircraft fitted with flight test instrumentation are to be loaned for SDD purposes. By May 2011, two of these aircraft had been transferred to SDD, and the transfer of the remaining three was expected in late 2012.

3.77 The ANAO found that the US JSF Program has arrangements whereby the NACC IPT can access data used to verify that the F-35A aircraft have achieved their specified capability requirements through a government-approved test program. The most recent reports indicate that conclusive evidence as to how effectively the specified requirements can be achieved is some years off, given that at the time of the audit, the F-35 LRIP aircraft had been delivered into the F-35 pilot training program with Block 1 capability. Various aspects of Block 2 initial war-fighting capability and Block 3 full war-fighting capability were under test and evaluation at the time of the audit, with the Block 3 capability to be fully validated and delivered on the completion of Initial Operational Test and Evaluation in February 2019. Australia's participation in the F-35 Collaborative Operational Test and Evaluation program being planned by the US, the United Kingdom and the Netherlands is yet to be fully determined.

3.78 The ANAO found that agreements are in place for the JSF Program Office to make available to Defence the data and documentation necessary as part of the F-35A certification activities, for use by Defence to achieve Australian Military Type Certification of the F-35A, and any other certifications that may be required.

4. F-35 Production and Sustainment

This chapter examines the Low-Rate Initial Production (LRIP) phase of the JSF Program, which is taking place concurrently with the project's System Development and Demonstration (SDD) phase. The chapter also discusses the issues arising in the concurrent development and production of F-35 aircraft, and outlines the planned approach to sustainment of the Australian F-35 fleet.

Introduction

4.1 The purpose of the Production and Deployment phase of the United States defense acquisition system (see Figure 2.2) is to achieve an operational capability that satisfies mission needs. This phase commences when the US Department of Defense authorises entry of major new systems into Low-Rate Initial Production (LRIP),[177] and it ends with the Full-Rate Production and deployment of the new system. This is followed by the Operations and Support phase, covering Life-Cycle Sustainment and eventual disposal of the system.

4.2 LRIP is the production of a system in limited quantity to provide articles for Initial Operational Test and Evaluation and to demonstrate production capability. It also permits an orderly increase in the production rate, sufficient to lead to Full-Rate Production upon successful completion of operational testing. For technologically advanced systems such as the F-35, there may be an overlap between the SDD phase (discussed in the previous chapter) and the production phase (discussed in this chapter). The number of systems to be produced during the LRIP phase is determined at the time of SDD phase initiation.

International agreements

4.3 As the JSF Program approached its LRIP phase, a second MoU was signed in late 2006–early 2007 by the nine nations that were partners in the JSF. This MoU, known as the Production, Sustainment and Follow-on Development Memorandum of Understanding (JSF PSFD MoU) established the acquisition, support, information access and upgrade arrangements for the JSF Air System

[177] US Department of Defense Instruction 5000.2, *Operation of the defense acquisition system*, May 2003.

over its service life.[178] Australia's Minister for Defence signed this MoU on 12 December 2006.

4.4 The JSF PSFD MoU, which is to remain in effect until 2051, among other things outlines the numbers of aircraft proposed to be purchased by each nation. The United States estimated in 2006 that it would purchase 2443 aircraft (down from its original intention to purchase 2852 aircraft), while Australia estimated that it would purchase 100 aircraft between 2012 and 2018, with delivery expected about two years after contract.[179] The original estimates of the acquisition of aircraft by Australia have been revised four times since 2006, pushing the initial contract year back from 2010 to 2012.[180]

4.5 Under the JSF PSFD MoU, the partner nations have also committed to contribute financially to subsequent phases of the F-35. The estimated total cost for the nine partner nations, when the JSF PSFD MoU was signed in 2006, was US$21.876 billion, with the US share set at US$16.843 billion.[181] Australia's financial cost ceiling under the JSF PSFD MoU in 2006 amounted to a maximum of US$690 million, which was estimated to be allocated as follows: US$230 million for production, US$42 million for sustainment and US$418 million for follow-on development (then-year dollars).[182] These figures were revised in 2008, when it was agreed that US$50 million funded out of AIR 6000 Phase 2A/B would be used for the development effort being carried out under

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[178] Defence Materiel Organisation, New Air Combat Capability Integrated Project Team, *Acquisition Project Management Plan*, version 1.0a, 5 December 2011, p. 13.

[179] JSF PSFD MoU, November 2006, articles 3.2, 19.9 and 19.10, and Annex A, available from <http://www.jsf.mil/downloads/_down_documentation.htm>. Other nations, including Israel and Japan, are purchasing the F-35 through Foreign Military Sales, on which see the section beginning at paragraph 4.12. *Selected Acquisition Report (SAR): F-35, as of December 31, 2010*, Washington DC, p. 5.

[180] Australia's expectations for contracting its first purchases have been revised as follows since the JSF PSFD MoU was signed:
2006: first eight aircraft by 2011;
2007: first four aircraft by 2011;
2009: first two aircraft by 2012;
2012: first two aircraft by 2012, but others delayed by two years (see paragraph 2.47).
JSF PSFD MoU, Annex A, 2006, 2007, and 2009; JSF Program Office, *F-35 Production Status*, briefing for the ANAO, March 2012.

[181] JSF PSFD MoU, November 2006, Annex F.

[182] JSF PSFD MoU, November 2006, Annex F. These financial figures are estimates, calculated from the number of aircraft to be purchased by Australia, the number of partners, and the total cost, but each country's maximum contribution may not be exceeded without an amendment to the MoU (JSF PSFD MoU, paragraph 5.1). Then-year dollars are based on the cost of labour and materials and currency exchange rates at the time the expenditure occurred.

the JSF SDD MoU (see paragraph 3.13). The figures are also revised annually in line with US Department of Defense indices (see Table 4.1 on page 118). Items covered by the MoU include:

- *Shared Production Non-recurring Costs*: Costs associated with efforts including, but not limited to, production test and tooling equipment and production line shutdown.
- *Non-recurring Tooling Costs*: Any development or production costs related to the replication, modification, and replacement of original tooling, equipment, and manufacturing aids that is needed by a contractor to achieve the maximum production rate required in the performance of a production contract. This includes costs incurred by the prime contractor, subcontractors and suppliers, and encompasses the entire manufacturing stream: fabrication, assembly, test, inspection, and transportation.
- *Project Overhead and Administration Costs*: Facilities (leases, utilities, office equipment), supplies, government administrative and technical support services, field site support, contractor support services, information technology support, temporary duty costs, and training.
- *Shared Follow-on Development Non-recurring Costs*: Costs associated with identifying and developing common upgrades that will ensure that the JSF Air System remains affordable, interoperable, operationally effective, operationally safe, and operationally suitable throughout its service life.
- *Shared Sustainment Non-recurring Costs*: Costs associated with sustainment activities for the Participants' joint benefit, including common sustaining engineering services and common efforts for the expansion of Original Equipment Manufacturer and other required repair capacity.

4.6 In December 2006, contingent on government approvals, Australia's estimated total combined commitment, under this MoU, for JSF production and for the purchase of Australia's 100 F-35A aircraft, amounted to US$9.685

billion, to be paid in the years to 2025.[183] This figure was revised in April 2009 to US$10.734 billion (to be paid in the years to 2022), again revised in February 2011 to US$11.013 billion (to be paid in the years to 2025), and most recently in February 2012 to US$12.362 billion (to be paid in the years to 2037).[184]

4.7 The JSF PSFD MoU is supported by a Financial Management Procedures Document that has three subsidiary documents:

- a multilateral annex that details the estimated annual allocation of shared costs for the partner nations;
- a bilateral annex between each partner nation and the United States, detailing the partner nation's payment schedule for its costs, and the unique financial management procedures of that partner; and
- a Partner Reprogramming Laboratory Annex signed in 2008.[185]

4.8 As of 2008, the Partner Reprogramming Laboratory was estimated to cost some US$500 million (then-year dollars), and was scheduled for development between 2009 and 2017. Each partner nation committed US$610 000 as its share of costs for the first two years, with cost shares for remaining years yet to be determined.[186] By June 2012, AIR 6000 spend under the Partner Reprogramming Laboratory Annex was US$620 000.

4.9 The Partner Reprogramming Laboratory for the Commonwealth partner nations (namely the UK, Canada and Australia) is to be known as the Australia–Canada–United Kingdom Reprogramming Laboratory (ACURL).[187] A recent Non Advocate Review by the JSF Program Office has reaffirmed the requirement for reprogramming laboratories, and the JSF Program Office has

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183 JSF PSFD MoU, *Financial Management Procedures Document. US–Australia Bilateral Annex*, December 2006, p. 5. Figures are in then-year dollars (that is, the amount spent, or expected to be spent, in the respective year).

184 JSF PSFD MoU, *Financial management procedures document. US–Australia Bilateral Annex*, Revision 1, April 2009, p. 5; JSF PSFD MoU, *Financial Management Procedures Document. US–Australia Bilateral Annex*, Revision 2, February 2011, p. 6; JSF PSFD MoU, *Financial Management Procedures Document. US–Australia Bilateral Annex*, February 2012 Revision. Figures are in then-year US dollars.

185 JSF PSFD MoU, *Financial Management Procedures Document*, Revision 1, 19 November 2008.

186 JSF PSFD MoU, *Financial Management Procedures Document*. *Partner Reprogramming Laboratory Annex*, 19 November 2008.

187 A technical outline of the Australia–Canada–United Kingdom Reprogramming Laboratory (ACURL) is provided in paragraphs 2.61 to 2.64.

initiated a design review process that will lead to a refined cost basis. The outcome of this activity, and therefore the final ACURL costs, will not be known until mid-2013. As at August 2012, the latest estimated cost of the ACURL was US$600 million.

4.10 Table 4.1 outlines Australia's total projected commitment to the JSF Program under the two international MoUs, as at June 2012, contingent on government approvals. The costs of follow-on development, (that is, future upgrades) will be shared by the partner nations in proportion to the number of aircraft they purchase. In Australia's case, our PSFD investment represents around 3 per cent of the overall shared non-recurring production cost identified in the JSF PSFD MoU.[188]

Table 4.1

Australia's projected financial commitments to the JSF Program, September 2012

Commitment	Amount (then-year US$)
Under JSF SDD MoU	
JSF development	$150 million
JSF development (Reallocated JSF PSFD MoU funding)	$54 million
Australian unique requirements (see paragraph 3.16)	$1 million
Under JSF PSFD MoU	
Project costs and purchase of 100 F-35A aircraft (as at February 2012), subject to government approval	$12 362 million
Estimated shared costs (as at December 2011) —Production —Sustainment —Follow-on development	 $270 million $40 million $333 million
Partner Reprogramming Laboratory	$0.62 million to date†
Total	**$13 210.62 million**

Source: ANAO analysis of JSF MoUs and subsidiary documents; Defence Materiel Organisation, New Air Combat Capability Integrated Project Team. Joint Strike Fighter Program Office, 4 September 2012, p. 2.

Note: †Costs for the Partner Reprogramming Laboratory (ACURL, see paragraphs 4.8 and 4.9), may amount to US$600 million, to be shared equally between Australia, Canada and the United Kingdom.

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[188] Defence Materiel Organisation, New Air Combat Capability Integrated Project Team, *Acquisition Project Management Plan*, v. 1.0, 3 September 2010, p. 55.

4.11 By June 2012, the AIR 6000 project's spend under the JSF PSFD MoU was $170 million, including $8.195 million for LRIP 6 long-lead items and $620 000 for the Partner Reprogramming Laboratory.

Foreign Military Sales

4.12 An alternative to Australia's joining the SDD phase and the Production, Sustainment and Follow-on Development phases was the acquisition of F-35 aircraft and their associated systems and logistics support through the US Government's Foreign Military Sales (FMS) program.

4.13 FMS 'cases' under the FMS program are government-to-government agreements for the sale of US defence articles and services authorised by the US Arms Export Control Act.[189] The FMS program is operated on a 'no profit/no loss' basis, and must be funded in advance by the FMS customer. The cases include not only the prime equipment, but can include the support articles and services required to introduce and sustain equipment over an initial support period.[190]

4.14 Australian FMS purchases of US military equipment peaked in 2006 and 2007 (when the Super Hornet fleet was being purchased). In 2010–11, there were 520 FMS cases to a value of US$17.1 billion, and expenditure that year amounted to US$1.4 billion. The most recent major FMS cases are the MH-60R helicopter acquisition and sustainment cases, with a combined total cost of US$2.8 billion.

4.15 An FMS Administrative Surcharge is applicable to all purchases made through the US FMS program, and from 1 August 2006 this surcharge rose from 2.5 per cent to 3.8 per cent. Other additional FMS fees include a Contract Administration Services Surcharge of 1.5 per cent, and a Nonrecurring Cost fee for pro rata recovery of development costs. The amount of cost recovery is decided during negotiation of an FMS case, although it may be waived.[191] As a

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[189] 22 US Code §2751ff.

[190] Foreign Military Sales are also discussed in ANAO Audit Report No.5 2012–13, *Management of Australia's Air Combat Capability—F/A-18 Hornet and Super Hornet Fleet Upgrades and Sustainment*, 27 September 2012.

[191] US Defense Security Cooperation Agency, *Security assistance management manual*, section C9.5, 'FMS charges'.

PSFD partner, Australia will not be acquiring the JSF via the US FMS program, and therefore will not incur any FMS fees for its aircraft.

4.16 However, some ancillary items associated with the New Air Combat Capability project, such as weapons and expendable countermeasures, will be acquired outside of the PSFD MoU, and these are likely to attract FMS fees.

Low-Rate Initial Production

4.17 The LRIP effort is intended to result in the completion of manufacturing development, in order to:

- ensure adequate and efficient manufacturing capability;
- produce the minimum quantity necessary to provide production or production-representative articles for Initial Operational Test and Evaluation;
- establish an initial production base for the system; and
- permit an orderly increase in the production rate sufficient to lead to Full-Rate Production upon successful completion of operational (and live-fire, where applicable) testing.[192]

4.18 In October 2001 the JSF Program was approved to enter the SDD phase (see paragraph 2.29). At the same time, in accordance with US law,[193] the US Defense Acquisition Board also approved the number of aircraft to be produced during the LRIP phase: 465 aircraft in six production lots. This quantity—more than 10 per cent of the then planned total of 2852 production aircraft—was stated to be necessary to meet Service Initial Operational

[192] US Department of Defense Instruction 5000.2, *Operation of the defense acquisition system*, May 2003, paragraph 3.8.3.1; Defense Acquisition University, *Introduction to defense acquisition management*, 9th edn, Fort Belvoir, Virginia, September 2009, pp. 48, 49.

[193] 10 US Code §2400 specifies that the *quantity* of articles of a new system to be produced during the LRIP phase shall be decided at Milestone B (that is, at approval for entry into the SDD phase). Where this quantity exceeds 10 per cent of the total number to be produced, a statement of reasons is to be included in the next Selected Acquisition Report.

Capability requirements, prevent a break in production, and to ramp-up to Full-Rate Production.[194]

4.19 At the time of the audit, Full-Rate Production of F-35 aircraft was not expected until after the completion of the F-35's Initial Operational Test and Evaluation, scheduled for completion in February 2019. Overall, the decision to enter Full-Rate Production has been delayed by seven years from 2012 to 2019.[195]

4.20 The JSF Program's LRIP phase commenced in April 2006, with advanced production contracts being awarded for the first lot of F-35 LRIP aircraft—LRIP 1.[196] Production of these F-35s commenced in 2007.

4.21 Since 2001, the number of LRIP lots and the overall quantity of LRIP aircraft have been revised on occasion, after US Department of Defense restructures of the JSF Program. In 2007, for example, the overall quantity of LRIP aircraft was reduced to 275. The subsequent February 2010 restructure revised the number of LRIP lots to nine and increased the overall quantity of LRIP aircraft to 420.[197] Program changes to December 2011 have resulted in the number of LRIP aircraft to be produced for the US Armed Services decreasing from 465 to 365. This is in accordance with the US *Fiscal Year 2012 Budget Request,* which sought to balance development and concurrency risk, while leaving room for procurement by the international partner nations and for procurements by other nations through the US Government's Foreign Military Sales arrangements. As at August 2012, 205 F-35 LRIP aircraft were planned for procurement by these nations, bringing the total LRIP production planning to

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[194] Milestone B Acquisition Decision Memorandum of 26 October 2001, cited in *Selected Acquisition Report (SAR): F-35 (JSF), as of December 31, 2001*, Washington DC, p. 14.
US Department of Defense instructions state that LRIP quantities shall be minimised, and the numbers determined for major systems at Milestone B, with the rationale for quantities exceeding 10 percent of the total production quantity documented in the acquisition strategy and included in the first Selected Acquisition Report after its determination. When approved LRIP quantities are expected to be exceeded because the program has not yet demonstrated readiness to proceed to Full-Rate Production, the Milestone Decision Authority shall assess the cost and benefits of a break in production versus continuing annual buys. US Department of Defense Instruction 5000.2, *Operation of the defense acquisition system*, May 2003, paragraph 3.8.3.2.

[195] US Government Accountability Office, *Joint Strike Fighter: DOD actions needed to further enhance restructuring and address affordability risks*, GAO-12-437, June 2012, pp. 5, 17.

[196] *Selected Acquisition Report (SAR): F-35 (JSF), as of December 31, 2006*, Washington DC, p. 4.

[197] *Selected Acquisition Report (SAR): F-35 (JSF), as of December 31, 2007*, Washington DC, p. 34; *Selected Acquisition Report (SAR): F-35, as of December 31, 2009*, Washington DC, p. 35.

570 aircraft. Since 2001, the number of production lots has increased from six to 11, with each LRIP lot the subject of separate contracts negotiated between the United States Government and Lockheed Martin. The first LRIP contract commenced in 2006, and the final one is expected in 2018.[198]

4.22 Changes to the F-35 production schedule have become necessary to date and further changes may occur in the future, because of changes in funding for the JSF Program brought about by the budget process in the US Congress. That process currently awards funding to the JSF Program on an annual basis.

4.23 From 2007 to 2009, following on from the advance contracts for LRIP 1 issued in April 2006 (see paragraph 4.20), contracts were finalised for 31 aircraft to be produced in the first three LRIP lots. In November 2010, the contract for LRIP 4, for the production of another 32 aircraft, was finalised.[199] Contracts for additional LRIP lots are expected to extend until 2018, when the JSF Program is to transition into its Full-Rate Production phase. Full-Rate Production is presently expected to commence in 2019 and end in 2037.[200]

Progress of the Low-Rate Initial Production phase

4.24 The first production F-35 aircraft, AF-7, was delivered to the US Air Force in May 2011.[201] Table 4.2 lists the number of F-35 LRIP aircraft to be produced based on firm orders from the US and the partner nations. It does not include other orders for F-35 aircraft through US Foreign Military Sales.

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198 *Selected Acquisition Report (SAR): F-35, as of December 31, 2011*, Washington DC, p. 59.

199 *Selected acquisition report (SAR): F-35, as of December 31, 2010*, Washington DC, pp. 47–51.

200 *Selected acquisition report (SAR): F-35, as of December 31, 2011*, Washington DC, pp. 9, 39–40.

201 *Selected acquisition report (SAR): F-35, as of December 31, 2010*, Washington DC, p. 8.

Table 4.2

Low-Rate Initial Production (LRIP) quantities in Lots 1–6, as at July 2012

F-35 variant and purchaser / Lot and buy year	LRIP 1 2007	LRIP 2 2008	LRIP 3 2009	LRIP 4 2010	LRIP 5 2011	LRIP 6 2012	Total
F-35A US Air Force	2	6	7	10	22	18	65
F-35B US Marines		6	7	16	3	6	38
F-35C US Navy				4	7	7	18
F-35A partner nations			1	1		5	7
F-35B partner nations			2	1			3
F-35C partner nations							0
Total	2	12	17	32	32	36	131

Source: Joint Strike Fighter Program Office.

Notes: One production aircraft (CF-5) being built during LRIP 4 is to be used as an additional asset for flight test, and is considered as an SDD asset, even though it is being produced under the LRIP 4 contract; LRIP 4 is therefore sometimes stated as including 33 aircraft.

4.25 Table 4.3 shows details of the individual aircraft produced to date in LRIP 1–3, and the orders placed or presently expected to be placed in LRIP 4–6.

Table 4.3

Low-Rate Initial Production Lots 1–6, quantities and distribution

Low-Rate Initial Production Lot 1				
F-35 variant	**Designation**	**Serial**	**Notes**	
F-35A	AF-6	07-0744	First production aircraft. Assembly started 24 Mar 2008. Made its maiden flight at Fort Worth on 25 Feb 2011. To Edwards AFB 13 May 2011. On loan to SDD after early 2010 program restructure. (Therefore also appears in Table 3.2).	
F-35A	AF-7	07-0745	Second production aircraft. Made its maiden flight at Fort Worth on 4 Mar 2011. First aircraft delivered to USAF on 5 May 2011. To Edwards AFB 6 May 2011. On loan to SDD after early 2010 program restructure. (Therefore also appears in Table 3.2).	
Low-Rate Initial Production Lot 2				
12 aircraft. Contract awarded in July 2007, and definitised in May 2008. Deliveries completed in May 2012.				
F-35 variant	**Designation**	**Serial**	**Unit**	**Notes**
F-35A	AF-8	08-0746	33rd FW	Made its maiden flight at Fort Worth on 6 May 2011. To Eglin AFB 20 Jul 2011.

F-35 variant	Designation	Serial	Unit	Notes
F-35A	AF-9	08-0747	33rd FW	Made its maiden flight at Fort Worth on 13 May 2011. To Eglin AFB 14 Jul 2011.
F-35A	AF-10	08-0748	33rd FW	Made its maiden flight at Fort Worth on 26 Jun 2011. To Eglin AFB 31 Aug 2011.
F-35A	AF-11	08-0749	33rd FW	Made its maiden flight at Fort Worth on 1 Jul 2011. To Eglin AFB 31 Aug 2011.
F-35A	AF-12	08-0750	33rd FW	Made its maiden flight at Fort Worth on 9 Jul 2011. To Eglin AFB 19 Oct 2011.
F-35A	AF-13	08-0751	33rd FW	Made its maiden flight at Fort Worth on 14 Jul 2011. To Eglin AFB 26 Oct 2011.
F-35B	BF-6	168057	VMFAT-501	Made its maiden flight at Fort Worth on 25 Oct 2011. To Eglin AFB 12 Jan 2012.
F-35B	BF-7	168058	VMFAT-501	Made its maiden flight at Fort Worth on 21 Dec 2011. To Eglin AFB 19 Jan 2012.
F-35B	BF-8	168059	VMFAT-501	Made its maiden flight at Fort Worth on 29 Nov 2011. To Eglin AFB 12 Jan 2012.
F-35B	BF-9	168060	VMFAT-501	Made its maiden flight at Fort Worth on 6 Mar 2012. To Eglin AFB 10 May 2012.
F-35B	BF-10	168061	VMFAT-501	Made its maiden flight at Fort Worth on 15 Mar 2012. To Eglin AFB 10 May 2012.
F-35B	BF-11	168062	VMFAT-501	Made its maiden flight at Fort Worth on 21 Mar 2012. To Eglin AFB 15 May 2012.
Low-Rate Initial Production Lot 3				
17 aircraft. Includes one F-35A for the Netherlands and two F-35B for the UK. Contract awarded in May 2008 and definitised in June 2009. Deliveries due from late 2011 to mid-2012.				
F-35A	AF-14	09-5001	58th FS	Made its maiden flight at Fort Worth on 2 Mar 2012. To Eglin AFB 13 Jul 2012.
F-35A	AF-15	09-5002	58th FS	Made its maiden flight at Fort Worth on 3 Mar 2012. To Eglin AFB 13 Jul 2012.
F-35A	AF-16	09-5003	58th FS	Made its maiden flight at Fort Worth on 5 Mar 2012. To Eglin AFB 13 Jul 2012.
F-35A	AF-17	09-5004	422 TES	Made its maiden flight at Fort Worth on 17 May 2012. Held at Fort Worth awaiting delivery to Edwards AFB.
F-35A	AF-18	09-5005	422 TES	Made its maiden flight at Fort Worth on 17 May 2012. Held at Fort Worth awaiting delivery to Edwards AFB
F-35A	AF-19	09-5006	422 TES	Made its maiden flight at Fort Worth on 9 Jun 2012. Held at Fort Worth awaiting delivery to Edwards AFB.

F-35 variant	Designation	Serial	Unit	Notes
F-35A	AF-20	09-5007	422 TES	Maiden flight 6 Aug 2012, Held at Fort Worth awaiting delivery to Edwards AFB.
F-35A	AN-1	F-001		For Netherlands. Made its maiden flight on 6 Aug 2012. Due delivery Sep 2012.
F-35B	BF-12	168308	VMFAT-501	Made its maiden flight at Fort Worth on 30 Mar 2012. Delivered to Eglin AFB 11 Jul 2012.
F-35B	BF-13	168309	VMFAT-501	Made its maiden flight at Fort Worth on 12 Mar 2012. Delivered to Eglin AFB 1 Aug 2012.
F-35B	BF-14	168310	VMFAT-501	Made its maiden flight at Fort Worth on 24 Apr 2012. Delivered to Eglin AFB 1 Aug 2012.
F-35B	BF-15	168311	VMFAT-501	Made its maiden flight at Fort Worth on 13 Jul 2012. Awaiting delivery to Edwards AFB.
F-35B	BF-16	168312	VMFAT-501	Maiden flight expected 25 Jul 2012. Awaiting delivery to Eglin AFB.
F-35B	BF-17	168313	VMFAT-501	Maiden flight expected 25 Jul 2012. Awaiting delivery to Edwards AFB. On loan to SDD. (Therefore also appears in Table 3.2).
F-35B	BF-18	168314	VMFAT-501	Maiden flight 21 Aug 2012. Due delivery Sep 2012. On loan to SDD. (Therefore also appears in Table 3.2).
F-35B	BK-1	ZM135		For UK. Made its maiden flight at Fort Worth on 13 Apr 2012. To Eglin AFB 23 Jul 2012.
F-35B	BK-2	ZM136		For UK. Made its maiden flight at Fort Worth on 11 Jul 2012. Due delivery in Sep 2012.
Low-Rate Initial Production Lot 4				
32 aircraft: 11 F-35A (including one for the Netherlands), 17 F-35B (including one for the UK) and 4 F-35C. Contract awarded in March 2009 and definitised in November 2010. Deliveries due from late 2012 to early 2013. One SDD asset (CF-5) is also being produced under this LRIP contract (see Table 3.2).				
F-35A	AF-21	10-5009		Rolled out of factory on 9 Jul 2012. Maiden flight due 3 Oct 2012. Due delivery Dec 2012.
F-35A	AF-22	10-5010		Rollout due 26 Jul 2012. Maiden flight due 17 Sep 2012. Due delivery Dec 2012.
F-35B	BF-19	168717		Rolled out of factory on 7 Jun 2012. Maiden flight due 25 Sep 2012. Due delivery Nov 2012.
F-35B	BF-20	168718		Rolled out of factory on 27 Jun 2012. Maiden flight due 19 Sep 2012. Due delivery Dec 2012.
F-35C	CF-6	168733		Due delivery Feb 2013.

F-35 variant	Designation	Serial	Unit	Notes
F-35C	CF-8			To be used to develop and test mission systems. Expected at Edwards Air Force Base in mid-year 2013. On loan to SDD from US Navy. Post-SDD will return to the Navy to conduct Operational T&E. (Therefore also appears in Table 3.2).
Low-Rate Initial Production Lot 5				
32 aircraft: 22 F-35A, 3 F-35B and 7 F-35C. Contract awarded in December 2011 and to be definitised in 2012. Deliveries due from mid-2013 to early 2014.				
Low-Rate Initial Production Lot 6				
36 aircraft: 18 F-35A for the USAF; 3 F-35A for Italy; 2 F-35A for Australia; 6 F-35B for the US Marine Corps; 7 F-35C for the US Navy. First deliveries due in 2014.				

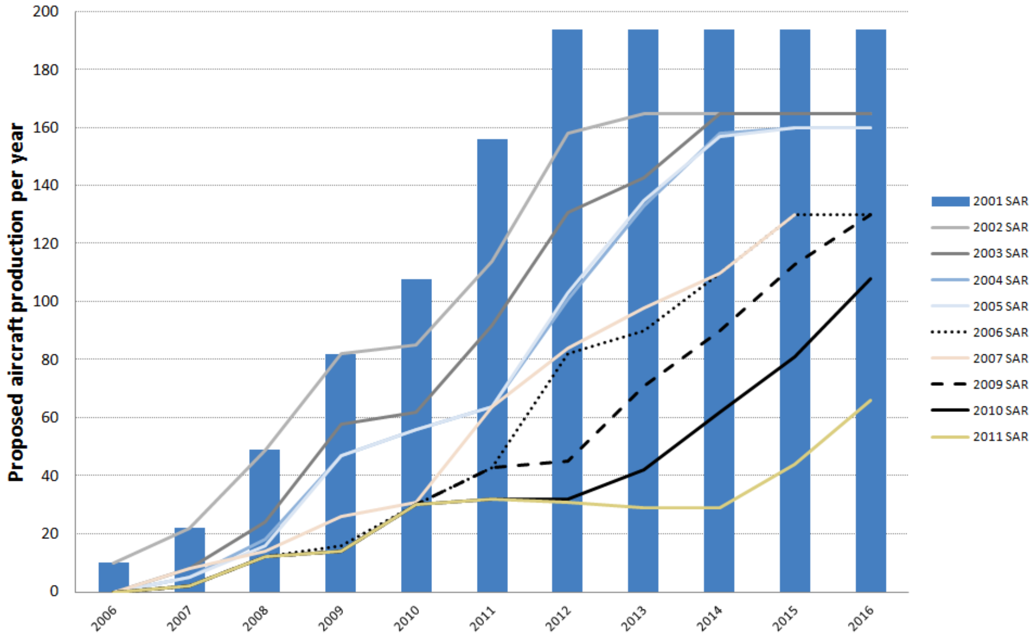
Source: JSF Program Office.

Notes: 33rd FW—33rd Fighter Wing
VMFAT-501—Marine Fighter Attack Training Squadron 501
58th FS—58th Fighter Squadron
422 TES—422nd Test and Evaluation Squadron

4.26 Successive changes to the JSF Program have meant large reductions in the numbers of aircraft proposed to be manufactured during LRIP, consequent postponement in the beginning of Full-Rate Production, and appreciable growth in the numbers to be produced in later years. The recurrent 'shift to the right' of production numbers is shown in Figure 4.1, which illustrates the reduction in proposed LRIP numbers since the JSF Program's inception in 2001, and covers production plans from 2006–16.

Figure 4.1

Evolution of F-35 LRIP production plans for US military, 2001–12



Source: ANAO analysis of successive Selected Acquisition Reports 2001–11 (SAR 2011 was published in March 2012).

Note: This figure includes only proposed purchases for the US military.

Concurrent development and production

4.27 A period of overlap between the SDD phase and the Production and Deployment phase is not unusual in advanced technology programs.[202] Such a strategy of 'concurrency', however, requires a high degree of confidence in the maturity of a design. This confidence is necessary in order to understand and treat the risks associated with commencing production before the T&E processes have verified that designs meet their specified function and performance requirements.

4.28 The T&E process is generally expected to result in design changes (and regression testing) before satisfactory design verification is achieved, product baselines are fixed, and Full-Rate Production commences. An excessive number of design changes would indicate that a design had not been sufficiently mature to produce production items that satisfied their specified function and performance requirements. LRIP items produced before the design has been finalised may require expensive retrofitting of design changes, to ensure that a fleet has a standard configuration which has been validated as meeting specified requirements. The undoubted potential costs of concurrency need to be balanced against the potential savings or benefits, which may include uninterrupted production lines or earlier introduction into service.

4.29 In the case of the JSF Program, as noted in paragraph 4.18, the US Department of Defense opted for a measured degree of concurrency, with the following objectives in mind:

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[202] The latest annual GAO report on selected weapon programs (the equivalent of the ANAO's Major Projects Report on Defence projects) mentions concurrency risk in relation to eight US Department of Defense programs, and observes that concurrent development and production strategies increase manufacturing risk, and can result in increased cost and schedule if problems are discovered late in design or production. However, the realisation of concurrency risk is mentioned only in relation to two programs (Ballistic Missile Defense System—Ground-based Midcourse Defense, and the Littoral Combat Ship).

The Littoral Combat Ship program, for example, which was approved in February 2011, included LRIP production of 24 out of a total planned production of 55 ships. Although the concurrent design–build strategy ultimately led to increases in construction costs, the US Navy has commented that, due to the complex nature of ship design and construction, lead ships generally have design changes that are incorporated into follow-on ships as a result of extensive testing and ship-underway lessons learned. This is common practice in ships, even with a stable baseline; according to the US Navy, subsequent Littoral Combat Ships have experienced minimal design changes and reflect learning, with both shipbuilders investing in their shipyards.

US Government Accountability Office, *Defense acquisitions: assessments of selected weapon programs*, GAO-12-400SP, March 2012, pp. 10, 57, 107–08.

- to meet the US Services' requirements for Initial Operational Capability, in light of the ageing of their in-service fleets of fighter aircraft;
- to prevent a break in the industry and production program, which would have increased the overall costs of the JSF Program; and
- to ensure maturity in the production line prior to Full-Rate Production, by enabling an early start to production-line learning, particularly with regard to concurrent production of the three variants on one production line. This increases confidence that when LRIP increases, and eventually Full-Rate Production is authorised, then the ramp-up in production would be smoother than it would otherwise be.[203]

4.30 As events transpired, risks associated with concurrency grew as a result of the slower than envisaged production of engineering test aircraft, and the technical difficulties encountered with particular features of the F-35 aircraft, particularly the F-35B Short Take-Off and Vertical Landing (STOVL) variant. The Pentagon's Director, Operational Test and Evaluation noted in late 2008 that:

> High production rates concurrent with a relatively slow increase in flight test production over the next three years commit the [Department of Defense] and Services to high risk test, training, and deployment plans.[204]

4.31 A year later, some of these risks in program concurrency were being realised:

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203 *Selected Acquisition Report (SAR): F-35 (JSF), as of December 31, 2001*, Washington DC, p. 14. Similar objectives motivated the use of concurrency in the development of electronic countermeasures for F/A-18 aircraft.
In certifying the JSF Program as 'essential to the national security' in June 2010, the Under Secretary of Defense informed Congress of the following issues at program inception and their consequences:

> Unrealistic baseline estimates for cost and schedule are root causes of the subsequent growth. The Milestone (MS) B cost estimate was too low because the estimated airframe weights were too low, the escalation rates used were incorrect, and the acquisition strategy was incorrectly modeled in the cost model. These factors accounted for 23 percentage points of the [Program Acquisition Unit Cost] cost growth. Additionally, a very aggressive and concurrent development schedule was assumed in order to meet externally mandated Initial Operational Capability dates and to reduce acquisition cycle time'.

Under-Secretary of Defense, letter to Hon. Ike Skelton, Chairman, Committee on Armed Services, Washington DC, 1 June 2010, available from <http://pogoarchives.org/m/ns/jsf/f35-nunn-mccurdy-certification-20100601.pdf> [accessed 31 May 2012].

204 US Department of Defense, Director, Operational Test and Evaluation, *FY2008 annual report*, p. 17.

Concurrency of production, development, and testing increased in FY09 as verification and flight test did not attain the planned pace due to the failure to deliver SDD test aircraft.[205]

4.32 In December 2011, the JSF Program Executive Officer stated that the strategy of concurrency had assumed that less design change would happen than was in fact proving necessary:

> 'Fundamentally, that was a miscalculation,' [the Program Executive Officer] said. 'You'd like to take the keys to your shiny new jet and give it to the fleet with all the capability and all the service life they want. What we're doing is, we're taking the keys to the shiny new jet, giving it to the fleet and saying, "Give me that jet back in the first year. I've got to go take it up to this depot for a couple of months and tear into it and put in some structural [modifications], because if I don't, we're not going to be able to fly it more than a couple, three, four, five years." That's what concurrency is doing to us.'[206]

4.33 The practical effect of concurrency is that F-35 production aircraft are being built at the same time as—or concurrently with—development efforts under the SDD contract. The budget impact of this concurrency lies in the high cost of the design changes that must be retrofitted to finished aircraft. At issue is the US Government's ability to secure an agreement to share concurrency modification costs with Lockheed Martin.[207]

4.34 As at February 2012, the number of change requests—requests to alter the production design, arising from SDD test results—was descending toward some 200 per month, significantly less than the peak of some 880 per month in 2007, and a later peak of 700 per month in 2009.[208] Each change request represents an improvement of the original design, and a benefit arising from the SDD T&E program.

4.35 The US Government contracted for the first three lots of production aircraft, LRIP 1–3, through cost-plus-incentive-fee contracts, under which the

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205 US Department of Defense, Director, Operational Test and Evaluation, *FY2009 annual report*, p. 21.

206 Vice Admiral David Venlet, USN, JSF Program Executive Officer, cited in Richard Whittle, 'JSF's build and test was "miscalculation," Adm. Venlet says; production must slow', *AOL Defense*, 1 December 2011, available from <http://defense.aol.com/2011/12/01/jsf-build-and-test-was-miscalculation-production-must-slow-v/> [accessed 19 March 2012].

207 JSF Program Office, *Joint Strike Fighter Program Office statement on LRIP 5 UCA*, media release, 26 October 2011.

208 JSF Program Office, presentation to the ANAO, March 2012.

government bore almost all the risk of cost overruns. However, in 2010, under pressure to reduce cost and schedule overruns, the US Department of Defense adopted a contract strategy under which LRIP 4 would be a Fixed Price Incentive Firm Target contract. Under this arrangement, Lockheed Martin and the US Government would equally share the burden of any cost overrun up to a ceiling price, with the ceiling price 6.5 per cent higher than the target price. Any cost above that ceiling would be Lockheed Martin's responsibility.[209]

4.36 Actual cost overruns on the LRIP Lot 4 contract are projected to be approximately 7 per cent, which is approximately half the overrun experienced in the LRIP 1–3 contracts.[210]

4.37 Nonetheless, in the first four LRIP contracts, all *concurrency*-related recurring costs have been borne 100 per cent by the US Government. In a significant change from previous practice, however, on 19 August 2011 the US Department of Defense's Under Secretary for Acquisition, Technology and Logistics (USD AT&L) issued an Acquisition Decision Memorandum (ADM) requiring any LRIP 5 production contract to reflect a reasonable allocation for Lockheed Martin to share in the concurrency-cost risk associated with achieving F-35 configuration and capability requirements.[211]

4.38 In late 2011, the US Department of Defense initiated an internal review of the JSF Program to evaluate whether there was adequate confidence in the stability of the basic F-35 design to justify additional concurrent procurement. The *F-35 Joint Strike Fighter concurrency quick look review*, completed in November 2011, determined that the program was continuing to discover issues at a rate more typical of early design experience, questioning the assumed design maturity that supported the highly concurrent acquisition strategy. In conjunction with the concurrency-driven consequences of the required fixes, the review concluded that a lack of confidence in design

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209 JSF Program Office, *Amendment of solicitation/modification of contract N00019-09-C-0010, no. P0009*, 9 November 2010.

210 Vice Admiral David J. Venlet, USN, JSF Program Executive Officer, *Written testimony for Senate Armed Services Committee, Subcommittee on Tactical Air and Land Forces*, Washington DC, 8 May 2012, p. 12.

211 JSF Program Office, *Joint Strike Fighter Program Office statement on LRIP 5 UCA*, media release, 26 October 2011.

maturity supported a serious reconsideration of procurement and production planning.[212]

4.39 In its conference report on the Fiscal Year 2012 defense budget, the United States House of Representatives observed that:

> for a variety of reasons, the Joint Strike Fighter program is burdened with what could be the highest level of concurrency ever seen in an acquisition program.[213]

4.40 The outcome of the US federal budget negotiations in late 2011 was that US$100 million saved from reduced procurement was set aside to help offset concurrency costs for aircraft produced during LRIP Lots 1–6.[214] From LRIP Lot 6 onwards, legislation provided that contracts must be fixed-price contracts, and must require the contractor to assume full responsibility for costs above the target cost specified in the contract.[215]

4.41 In January 2012, as part of its deficit-reduction efforts, the US Government made substantial reductions to programs that were experiencing schedule, cost, or performance issues. For the F-35, the US Government stated that it was committed to the JSF Program, including all three aircraft variants, but had decided to slow procurement to complete more testing and make developmental changes to minimize concurrency issues before buying in significant quantities.[216] The production of 179 aircraft was postponed by five years, bringing the total number of LRIP aircraft delayed to 410 since 2008.[217]

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[212] US Government Accountability Office, *Joint Strike Fighter: restructuring added resources and reduced risk, but concurrency is still a major concern*, GAO-12-525T, 20 March 2012, p. 17.

[213] US House of Representatives, *Military Construction and Veterans Affairs and Related Agencies Appropriations Act 2012: Conference Report to accompany H.R. 2055*, Report 112–331, 15 December 2011, pp. 584–5. See also Jeremiah Gertler, *F-35 Joint Strike Fighter (JSF) Program*, Congressional Research Service, 16 February 2012, p. 37.

[214] US House of Representatives, *Military Construction and Veterans Affairs and Related Agencies Appropriations Act 2012: Conference Report to accompany H.R. 2055*, Report 112–331, 15 December 2011, pp. 584, 651.

[215] *National Defense Authorization Act for Fiscal Year 2012*, Public Law 112–81, section 143.

[216] US Department of Defense, *Defense budget priorities and choices*, Washington DC, January 2012, p. 10.

[217] US Government Accountability Office, *Joint Strike Fighter: restructuring added resources and reduced risk, but concurrency is still a major concern*, GAO-12-525T, 20 March 2012, p. 5.

4.42 In March 2012, the US Government Accountability Office estimated the costs of concurrency to date as US$373 million.[218] In May 2012, the LRIP Lot 4 contract was increased by US$237 million, increasing the threshold at or under which Lockheed Martin is obligated to incorporate government-authorised concurrency changes.[219]

4.43 Recent testimony to Congress on the issue of concurrency, also in May 2012, was that it is a transient issue in which risks progressively decline until the end of the SDD phase:

> The JSF Program is currently experiencing changes driven by design maturity discoveries as ground test, flight test, and overall system qualification efforts proceed. As more testing is completed, concurrency risks are progressively reduced as the design is confirmed or issues identified requiring changes are incorporated. Earlier aircraft are open to a greater need for changes, and as succeeding Low-Rate Initial Production lots are built, their cumulative requirements for retrofit modifications decline.[220]

4.44 On the same occasion, the JSF Program Executive Officer informed Congress that:

> Concurrency changes have also been taking an unacceptable time, two to three production lots, to incorporate into the build baseline. These issues are being addressed with the incorporation of strong contract incentives to the prime contractor and by slowing the rate of production in 2013 and 2014. Concurrency risk will progressively recede between now and 2015, when second-life fatigue testing should complete for all variants and flight test will be through 80% of the loads envelope.[221]

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[218] US Government Accountability Office, *Joint Strike Fighter: restructuring added resources and reduced risk, but concurrency is still a major concern*, GAO-12-525T, 20 March 2012, p. 5.
The US Government Accountability Office had raised its concerns about concurrency as early as March 2001, when it stated that a decision to allow the JSF to proceed into the SDD phase as planned, without mature critical technologies, 'would perpetuate conditions that have led to cost growth and schedule delays in many prior DOD weapon system acquisition programs'. US Government Accountability Office, *Joint Strike Fighter acquisition: development schedule should be changed to reduce risks*, GAO/T-NSIAD-00-132, 16 March 2000, p. 16.

[219] US Department of Defense, *Contracts*, media release, 7 May 2012; Andrea Shalal-Esa, *Lockheed wins $237 million more for F-35 work*, Reuters, 7 May 2012.

[220] Vice Admiral W. Mark Skinner, Principal Military Deputy, Assistant Secretary of the Navy (Research, Development and Acquisition), *Statement before the Airland Subcommittee of the Senate Armed Services Committee*, Washington DC, 8 May 2012, p. 4.

[221] Vice Admiral David J. Venlet, JSF Program Executive Officer, *Written testimony for Senate Armed Services Committee, Subcommittee on Tactical Air and Land Forces*, Washington DC, 8 May 2012, p. 9.

4.45 Besides benefiting from the incorporation of strong contract incentives for Lockheed Martin to implement concurrency changes in a timely and cost-effective manner, Australia's exposure to concurrency costs is limited in three ways. Australia presently intends to order its first two F-35A aircraft in 2012, in time for inclusion in the 2014–15 LRIP Lot 6 production program. The purchase of the F-35A variant is likely to contain Australia's exposure to concurrency-related costs to the aircraft variant with the least design and production risk, provided the discovery of defects continues to diminish and the correction of defects by the contractor remains timely and effective. Since Australia is ordering its first aircraft from LRIP Lot 6, this further contains Australia's exposure to only those design and production defects that were not discovered in the earlier five LRIP production lots. Further, as the bulk of Australia's F-35A orders are scheduled to occur between 2015 and 2020, it is expected that the risk of F-35 design and production defects being discovered for the first time during that period, and their remediation costs, would decrease significantly from present levels.

F-35 sustainment

4.46 The F-35 support concept seeks to maximise affordability through globalised asset pooling, platform-level performance-based logistics with Lockheed Martin, and best-value placement of global support capacity. Known as Autonomic Logistics Global Sustainment (ALGS), this common global support arrangement is to be contracted by the JSF Program Office to Lockheed Martin and Pratt & Whitney (for propulsion only), based on the aggregated needs of all US Services and partner nations. Performance requirements are authorised through performance-based agreements with each partner. Deeper Maintenance of US aircraft will largely be performed in US-owned and operated depots according to US law, but business decisions on the location of common support capacity for non-US partners will be decided in coming years, based on best-value analysis currently under way.

4.47 Australia has defined the minimum F-35 sustainment activities that must be performed locally, based on sovereign needs and performance requirements. Australian F-35 sustainment planning was influenced by the intent to keep the RAAF workforce constant between the F/A-18A/B and F-35 fleets, and to ensure that, once the aircraft have arrived in Australia, all Australian aircraft maintenance and pilot training occurs in Australia.[222] The ANAO was informed that the range of in-country contracted support needs has been supplied by the NACC IPT to both Lockheed Martin and the JSF Program Office, to determine the business and contracting approach to Australian sustainment, and so that Autonomic Logistics Global Sustainment arrangements and local delivery can be integrated. The ANAO was further informed that Lockheed Martin has agreed to be the Australian Sustainment Integrator for global and local supplies, with local delivery potentially being delivered by a direct contract.

4.48 The primary Commonwealth support agency for the NACC System will be the DMO's yet-to-be-established Aerospace Combat Systems Program Office (ACSPO). Although a significant proportion of F-35 logistic support roles will be the responsibility of the JSF Program Office, ACSPO also will remain responsible for a NACC logistic support roles and responsibilities and other Commonwealth governance functions that cannot be delegated to a third party.[223]

4.49 At the time of the audit, the F-35 sustainment cost estimates were being refined and updated with 'actual' sustainment costs, which were becoming available from late 2011, when the first F-35s commenced service at the US Air Force's Eglin Air Force Base.

4.50 The JSF mature sustainment cost has grown from the 2009 estimate (based on 2008 US figures), but has steadied since 2011. At the time of the audit, overall sustainment costs were not tender quality due to the early stage of the program, and will not achieve high confidence until JSF system maturity is achieved around 2018. The cost increases were largely due to fuel price

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[222] New Air Combat Capability plans published at the time of the audit specified that training of Australian pilots was to commence in the US in 2014 and continue until late 2019, and that pilot training in Australia was to commence at the beginning of 2019 at RAAF Base Williamtown. There was to be some overlap of training during 2019 when pilot training would have been conducted in both the US and Australia. This was intended to mitigate risks related to the establishment of the Australian training facility. Training of Australian F-35 maintainers was to commence in the US in 2014, and transition to RAAF Base Williamtown in 2017.
Department of Defence, Defence Materiel Organisation, New Air Combat Capability Integrated Project Team, *NACC acceptance into service plan*, version 3.0b, December 2009, pp. 3, 4.

[223] Defence Materiel Organisation, New Air Combat Capability Integrated Project Team, *NACC acceptance into service plan*, version 3.0b, December 2009, pp. 4–5.

increases, additional maintenance workload due to the continuous modification program, and a higher predicted rate of consumption of spares. The JSF Program Office is investing in 'targeted affordability initiatives' which seek to counter the cost growth, the results of which are expected to be realised before delivery of Australian F-35A aircraft.

Conclusion

4.51 Australia is one of the nine international partners in the JSF Production, Sustainment and Follow-on Development phases. In September 2012, contingent on government approvals, Australia's total projected commitment, with respect to JSF development, production of Australia's 100 F-35A aircraft, and other costs shared with JSF partner nations, amounted to US$13.211 billion (then-year dollars).

4.52 The estimated costs of sustaining Australia's planned F-35 fleet are under review, and high-confidence figures may not be available until JSF system maturity is achieved, currently expected around 2018. In the meantime, the JSF Program Office's 'targeted affordability initiatives' seek to counter the cost growth in the program, including sustainment costs.

4.53 The JSF Program's LRIP phase is taking place concurrently with the project's SDD phase. This strategy has distinct advantages in terms of systems engineering and production-facility development, but it has disadvantages in terms of the need to modify LRIP aircraft in order to rectify design and construction deficiencies discovered during the SDD phase. In an effort to minimise the need for this often costly remedial work, the JSF Program Office is seeking to incorporate strong contract incentives for Lockheed Martin to minimise and rectify concurrency issues in a timely and cost-effective manner.

4.54 From Australia's perspective, exposure to concurrency costs is expected to be relatively less risky—as long as the discovery of defects continues to diminish and the correction of defects by the contractor remains timely and effective.

5. JSF Program Reviews and Progress

This chapter examines program issues that have resulted in delays in the JSF Program, drawing upon recent program reviews conducted in both the United States and Australia. It also examines the performance metrics for the JSF Program in terms of cost and schedule, and provides current Unit Recurring Flyaway (URF) cost estimates for the F-35A aircraft out to 2037.

Background

5.1 The JSF Program is often acknowledged as the Pentagon's most expensive current weapons program.[224] Managing such a large acquisition program is extremely difficult, given the inherently long and expensive task of designing and manufacturing aircraft with leading-edge technology, and maintaining a leading-edge capability for up to 30 years. The variables that could be taken into account include:

- the number of F-35 variants and their capability requirements;
- the effect of the number of aircraft produced on the per-unit and sustainment costs; and
- estimates of, and adjustments for, future inflation.

5.2 The ANAO examined several reports and statistics on the development of the JSF Program, which provide insights into the program's cost and schedule variations and the achievement of specified capability.

Organisational arrangements

5.3 Given the JSF Program's cost, size and technical and organisational complexity, it undergoes extensive management and technical reviews and audits from various US Defense organisations. Since 2002, the JSF Program has encountered technical problems and funding reprogramming, which have resulted in the program progressing more slowly than originally planned. The

[224] The US Government Accountability Office has reported that the future procurement funding needed to complete the JSF Program is enough to fund the remaining procurement costs of the next 15 largest Defense acquisition programs. US Government Accountability Office, *Defense acquisitions: assessments of selected weapon programs*, GAO-12-400SP, March 2012, pp. 12–14.

JSF Program Office, other US Department of Defense authorities, and the US Government Accountability Office have conducted regular reviews and audits of the JSF Program, and these have resulted in significant cost and schedule revisions, affecting the JSF Program's progress toward achieving its Initial Operational Capability milestone. The key US Defense organisations that conduct the reviews and audits are outlined below.

US Defense Contract Management Agency

5.4 The US Defense Contract Management Agency (DCMA) was established in March 2000, under the direction and authority of the Under Secretary of Defense for Acquisition, Technology and Logistics. The DCMA supervises and administers contracts with the thousands of suppliers who deliver goods and services to the US military each year, and is integral to the entire end-to-end acquisition process from pre-award to contract closeout.

5.5 Prior to contract award, the DCMA joins the pre-award team to help construct effective solicitations; identify potential performance risks; select capable contractors; and develop contracts that are easily administered, with less risk of costly modifications. After the contract is awarded, the DCMA oversees the contract to ensure product, cost and schedule compliance[225] and, in cases of contractual delays and other unforeseen issues, the DCMA helps the military make alternative arrangements to ensure that defense personnel have the supplies and services they need.

5.6 At the time of the audit, the DCMA had a total of 108 personnel stationed at Lockheed Martin's Fort Worth plant, including 18 F-35 quality assurance specialists. These personnel are engaged in the full range of DCMA processes for ensuring that US Government contracts for manufacture of the F-35 are fulfilled with respect to wide-ranging requirements covering: quality assurance, delivery and schedule management, cost and pricing, earned-value management, engineering support, software-acquisition management, property and plant clearance, contracting, contract safety, transportation, and aircraft safety of flight. The DCMA provides regular reports to the JSF Program Office on the progress of the prime contractor and subcontractors.[226]

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[225] See the section on 'Measuring progress', beginning at paragraph 5.40.

[226] US Defense Contract Management Agency, presentation to the ANAO, March 2012.

5.7 One of the most significant roles of the DCMA in relation to the JSF Program is established in a memorandum of agreement with the JSF Program Office. This memorandum commits the DCMA to perform production-acceptance activities for F-35 Air System products on behalf of all partner nations. Once manufacturing is complete, the DCMA flies each F-35 through an Acceptance Test profile prior to accepting it from the contractor on behalf of the US Government. The aircraft's behaviour is documented in an Acceptance Test Checklist, which is then incorporated into the data pack that accompanies each aircraft, and the aircraft is then ready for delivery to the US military or for sale to a partner nation.[227] At the time of this audit, the process from factory roll-out of an aircraft to its acceptance by the DCMA on behalf of the US Government was taking some five months to complete.

US Defense Contract Audit Agency

5.8 The US Defense Contract Audit Agency (DCAA) is the largest audit organisation in the US Government. The DCAA performs all necessary contract audits for the US Department of Defense, and provides accounting and financial advisory services regarding contracts and subcontracts to all Defense components responsible for procurement and contract administration. These services are provided in connection with negotiation, administration, and settlement of contracts and subcontracts, to ensure taxpayer dollars are spent on fair and reasonable contract prices. The DCAA also provides contract audit services to other federal agencies as appropriate. The DCAA's mission does not include the auditing of government agencies.

5.9 The DCAA's major areas of activity are audits of:

- historical costs and internal control systems;
- forward pricing, including price proposals and estimating systems;
- special audits, such as progress payments and Earned Value Management Systems; and

[227] F-35 Lightning II Joint Strike Fighter Program Office, *F-35 Lightning II Airworthiness Management Plan*, March 2012, pp. 20–1; US Defense Contract Management Agency, presentation to the ANAO, March 2012.

- other audits, such as those arising from the Truth in Negotiations Act (defective pricing).[228]

5.10 At the time of the audit, the DCAA had some 88 personnel involved in overseeing JSF Program activities at Fort Worth, Marietta and Palmdale. These personnel were engaged in auditing all F-35 pricing proposals, reviewing F-35 vouchers and progress payments, and elevating significant issues to the Defense Contract Management Agency.[229]

US Director, Operational Test & Evaluation

5.11 The US Department of Defense's Director, Operational Test & Evaluation (DOT&E) is the principal staff assistant and senior advisor to the Secretary of Defense on Operational Test and Evaluation (OT&E). DOT&E is responsible for:

- reviewing and analysing the results of OT&E conducted for each major defense acquisition program;
- providing independent assessments to the US Department of Defense and Congress;
- making budgetary and financial recommendations on OT&E; and
- providing oversight to ensure OT&E for major acquisition programs is adequate to confirm the operational effectiveness and suitability of the defense system in combat use.

5.12 DOT&E has continuously participated in JSF OT&E and monitored Live-fire Test and Evaluation planning activities since June 1995, when the JSF Program was known as the JAST Program.[230] Since 1995, the DOT&E has published annual reports that include the JSF aircraft.

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228 US Defense Contract Audit Agency, presentation to the ANAO, March 2012.

229 US Defense Contract Audit Agency, presentation to the ANAO, March 2012.

230 US Department of Defense, Director, Operational Test and Evaluation, *FY99 annual report*, p. *V*-112. Live-fire Test and Evaluation permits the evaluation of system vulnerability to realistic threat munitions, as well as system lethality against realistic threat targets. F-35 Lightning II Joint Strike Fighter Program Office, *F-35 Lightning II Joint Strike Fighter: Test and Evaluation Master Plan (TEMP)*, Third Revision, January 2009, p. 37.

US Office of Cost Assessment and Program Evaluation

5.13 The US Department of Defense's Office of Cost Assessment and Program Evaluation (CAPE) provides independent analytic advice to the Secretary of Defense on all aspects of the Defense program, including alternative weapon systems and force structures, the development and evaluation of defense program alternatives, and the cost-effectiveness of defense systems. Consistent with its advisory role, the office has no decision authority or line responsibility and has no vested interest in any sector of the defense budget.

US Defense Inspector General

5.14 The Inspector General of the US Department of Defense performs audits of the entire procurement and acquisition process, including the performance of contractors and contract administration officials.[231]

5.15 In February 2012 the Inspector General initiated a quality assurance assessment of the JSF Program. This audit was expected to conclude in December 2012. The objective was to assess conformity of the JSF Program to specified quality-management system(s), contractual quality clauses and internal quality processes and procedures.[232]

5.16 The extensive management and technical reviews and audits from various US Defense organisations, as outlined above, provide a level of assurance that the JSF Program is progressing with an appropriate level of US Government oversight focused on improving program outcomes.

Selected Acquisition Reports (SARs) for Congress

5.17 US federal law requires the US Department of Defense to provide Selected Acquisition Reports (SARs) containing cost, schedule, and performance data on all Acquisition Category 1 (ACAT 1) projects.[233] SARs are to include system characteristics, an outline of significant progress and

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[231] US Defense Contract Audit Agency, presentation to the ANAO, March 2012.

[232] US Department of Defense, Inspector General, *Memorandum for Program Executive Office Joint Strike Fighter*, 13 February 2012, available from < http://www.pogo.org/resources/national-security/ns-dodig-f-35-audit-announcement.html> [accessed 13 March 2012].

[233] 10 US Code §2432.

problems encountered, and tests completed and issues identified during testing.

5.18 The JSF Program's annual SARs since 2002 report that the estimated cost of the F-35 development phase has increased from US$34.4 billion to US$55.234 billion (in then-year dollars), a rise of 61 per cent. Also, the estimated total cost of the entire program, for the United States, has risen from US$233.0 billion to US$395.712 billion (in then-year dollars), a rise of 70 per cent since 2002.[234] Then-year cost estimates are based on the estimated cost of labour and materials and currency exchange rates, at the time expenditure is to occur.

5.19 In prices indexed to 2012 US dollars, the estimated cost of the F-35 development phase has increased from US$39.441 billion to US$59.677 billion (51 per cent) since 2002. As at December 2011, the development effort was reported to be 80 per cent complete.[235] The estimated total cost of the entire program, for the United States, has risen from US$216.254 billion to US$330.511 billion (2012 US dollars), a rise of 53 per cent since 2002. This growth is illustrated in Figure 5.1, which also shows the JSF Program's cumulative total expenditure (then-year US dollars) since 2001.[236] Part of the increases in development costs can be attributed to US Government decisions to increase the scope of F-35 development and demonstration effort. At the time of the audit, US Department of Defense agencies were conducting a coordinated, in-depth cost analysis of the production program to achieve increased efficiency and so reduce project costs (see paragraphs 5.57 to 5.64).

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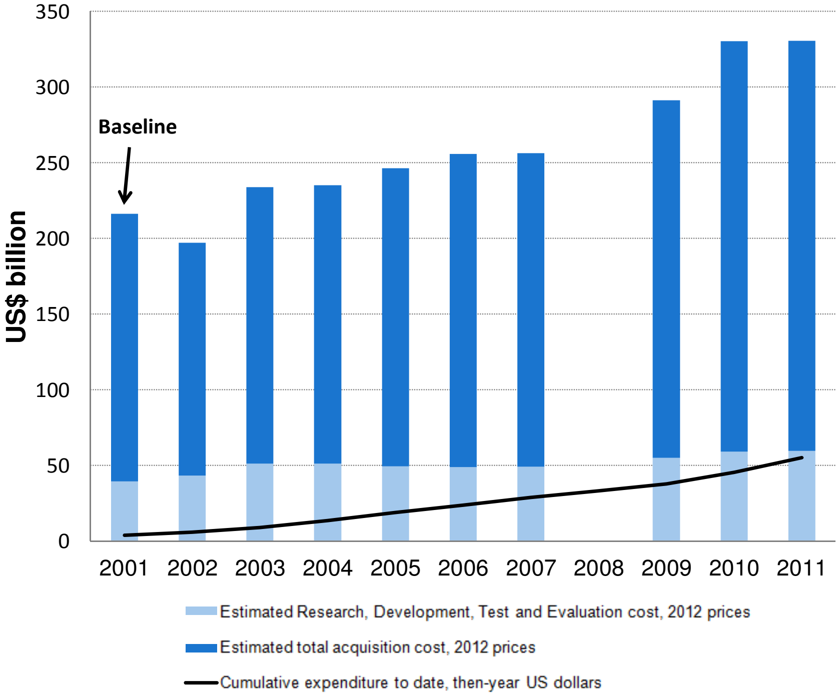
[234] These figures do not include the spending by partner nations, but do assume the quantity benefits of the 697 aircraft that were to be produced for partner nations under the 2006 JSF Production, Sustainment and Follow-on Development MoU. As at December 2011, 697 aircraft were to be produced for the partner nations, as well as 19 aircraft through Foreign Military Sales. For the JSF Production, Sustainment and Follow-on Development MoU, see paragraph 4.3.

[235] *Selected acquisition report (SAR): F-35, as of December 31, 2011*, Washington DC, pp. 21, 22.

[236] By 2011, total expenditure on the JSF Program amounted to US$55.236 billion. *Selected acquisition report (SAR): F-35, as of December 31, 2011*, Washington DC, p. 83.

Figure 5.1

JSF Program, estimates of development and acquisition costs, 2002–11



Source: ANAO analysis of Selected Acquisition Reports, 2001–11, adjusted from Base Year 2002 to Base Year 2012 US dollars using a deflator of 1.221082 (*Selected acquisition report (SAR): F-35, as of December 31, 2011*, p. 21).

Notes: There was no Selected Acquisition Report in 2008, because the new US administration reworked the budget for that year.
Expenditure to date includes acquisition of engineering development aircraft as well as production aircraft, and therefore covers both RDT&E and acquisition costs.

JSF Program reviews

5.20 In August 2004, even though problems with the weight of the F-35B STOVL variant had been resolved, the report of an Independent Review Team led to an F-35 production re-plan, a revised capability block plan, a revised test plan, revised cost and schedule estimates, and a one-year delay to initial STOVL procurement.[237]

[237] *Selected acquisition report (SAR): F-35 (JSF), as of December 31, 2004*, Washington DC, p. 4.

5.21 In 2005, it became evident that the original plan was not achievable, and the United States Government Accountability Office commented that:

> The original business case for the JSF program has proven to be unexecutable. DOD now plans to buy 535 fewer aircraft than originally planned. Development costs have grown over 80 percent, from $25 billion to $45 billion, since the program started in 1996. Total program costs have increased by 5 percent, or $12 billion, and program acquisition unit costs have increased by 23 percent, or $19 million, since first estimates in 2001.[238]

5.22 In April 2007, a further delay in the aircraft production schedule prompted Australia's AIR 6000 project to plan the signing of contracts for only four aircraft by 2011, rather than eight. By November 2009, this schedule was further delayed, with Australia to contract for two aircraft by 2012.[239]

5.23 In October 2008, the US Department of Defense's JET I (Joint Estimating Team) review concluded that the program would take longer and cost more than both the JSF Program Office and the contractor were projecting. As a consequence to this finding, an additional sum of US$476 million was added to the SDD phase.[240] A year later, the JET II review concluded that the program was now 30 months behind the mid-2009 estimate of the flight test schedule.[241]

5.24 Further department-wide reviews in November 2009–January 2010 led to a restructuring of the JSF Program on 1 February 2010—involving additional test aircraft, withholding of US$614 million in performance fees, and a slower ramp-up to full production—such that the 30 months of schedule slippage was to be reduced to 13 months.[242] Key aspects of the restructure, reflected in the Fiscal Year 2011 President's Budget (PB-11), included the following:

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[238] US Government Accountability Office, *Tactical aircraft: opportunity to reduce risks in the Joint Strike Fighter program with different acquisition strategy*, GAO-05-271, March 2005, pp. 2–3.

[239] For details, see paragraph 4.4.

[240] Carter, Dr. Ashton B, Under Secretary of Defense for Acquisition, Technology and Logistics, *Submitted statement to Senate Armed Services Committee*, Washington DC, 11 March 2010, p. 2.

[241] Carter, Dr. Ashton B, Under Secretary of Defense for Acquisition, Technology and Logistics, *Submitted statement to Senate Armed Services Committee*, Washington DC, 11 March 2010, p. 2.

[242] *DoD news briefing with Secretary Gates and Adm. Mullen from the Pentagon*, media transcript, 1 February 2010, http://www.defense.gov/transcripts/transcript.aspx?transcriptid=4549; US House of Representatives Committee on Armed Services, Air and Land Forces Subcommittee meeting jointly with Seapower and Expeditionary Forces Subcommittee, Joint Hearing transcript, Washington DC, 24 March 2010, H.A.S.C. No. 111–146, pp. 7–9; *Selected Acquisition Report (SAR): F-35 (JSF), as of December 31, 2009*, Washington DC, p. 4.

- extend the SDD development-test schedule to March 2015, and move Full-Rate Production to April 2016, commensurate with completion of Initial Operational Test and Evaluation;
- add a ninth LRIP lot;
- add one incrementally funded carrier variant (CV) to the SDD phase in order to expand development testing capacity;
- expand JSF software integration capability by adding an additional software integration line;
- utilize up to three LRIP aircraft in support of development testing;
- fully fund the SDD phase to the Joint Estimating Team's (JET) current estimate;
- lower the planned procurement quantity profile to 2015; and
- fund the Future Years Defense Program (FYDP) buy profile to the JET's current estimate.[243]

5.25 In December 2009, it was reported that the recent US Department of Defense review of the program found no fundamental technology or manufacturing problems, and that the performance requirements for the F-35 had not changed as a result of the review.[244]

5.26 In March 2010, the Secretary of the Air Force notified Congress that the JSF Program was breaching a 1982 law—the Nunn-McCurdy Act—that requires cancellation of projects whose costs are 25 per cent or more over the current baseline estimate or 50 per cent or more over the original baseline estimate. The Under Secretary of Defense was therefore required to certify to Congress that the program was 'essential to the national security'.[245] The

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243 *Selected Acquisition Report (SAR): F-35 (JSF), as of December 31, 2009*, Washington DC, p. 4.

244 *Selected Acquisition Report (SAR): F-35 (JSF), as of December 31, 2009*, Washington DC, p. 4.

245 A 'critical Nunn-McCurdy breach' occurs when the program acquisition cost or the procurement unit cost increases 25 per cent or more over the current baseline estimate or 50 per cent or more over the original baseline estimate. The Nunn-McCurdy breach was discussed in a US House of Representatives hearing on 24 March 2010, and was formally notified to the US Senate on 12 April 2010; the corresponding national-security certification was tabled in the US House of Representatives on 29 June 2010. 10 US Code §2433a; Congressional Research Service, *The Nunn-McCurdy Act: background, analysis, and issues for Congress*, 21 June 2010, p. 2; Under-Secretary of Defense, letter to Hon. Ike Skelton, Chairman, Committee on Armed Services, 1 June 2010, available from <http://pogoarchives.org/m/ns/jsf/f35-nunn-mccurdy-certification-20100601.pdf> [accessed 26 August 2010].

Milestone B approval of the project—first granted in October 2001, and enabling the program to enter the SDD phase—was rescinded, and a milestone review was scheduled for May 2011, then delayed until late 2011.[246] The milestone review finally occurred in January–February 2012, and the Milestone B approval for the JSF Program was renewed in March 2012.[247]

US Technical Baseline Review

5.27 In June 2010, the JSF Program Executive Officer commissioned a comprehensive Technical Baseline Review (TBR) of the JSF Program, in order to determine the remaining costs and time needed to complete the F-35 Program's SDD phase. The TBR involved more than 120 technical experts, who conducted a detailed technical review of the program from the lowest levels upward. They drew on knowledge from the aircraft and engine contractors as well as the government test bases, to gain a thorough understanding of the content of the work required to complete the development program.[248]

5.28 The TBR's scope covered the JSF Contractor Statement of Work and Contract Specification. Its aim was to identify SDD capabilities at risk of not meeting current capability definitions for LRIP deliveries. It was to identify gaps as system development and demonstration work was migrated to future contracts (LRIP and Follow-on Development) or vice versa, including certification and service-integration gaps. The Technical Baseline Review covered the following three primary JSF Program elements:

- the Lockheed Martin SDD contract;
- the Pratt & Whitney SDD contract; and
- Other Government Costs for SDD.[249]

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246 *Selected acquisition report (SAR): F-35, as of December 31, 2010*, Washington DC, p. 4; US Government Accountability Office, *Joint Strike Fighter: Restructuring places program on firmer footing, but progress still lags*, GAO-11-325, April 2011, p. 8.

247 'JSF production might be further slowed', *Defense News*, 22 February 2012; Tony Capaccio, 'Pentagon approves Lockheed F-35 for continued development', *Bloomberg*, 29 March 2012; *Selected acquisition report (SAR): F-35, as of December 31, 2011*, Washington DC, p. 5.

248 Department of the Air Force and Department of the Navy, *Presentation to the House Armed Services Committee, Subcommittee on Tactical Air and Land Forces: Air Force tactical aviation programs*, Washington DC, 15 March 2011, pp. 5–6.

249 JSF Program Office, *F-35 technical baseline review PEO (JSF) re-planning summary*, 11 January 2011.

5.29 The TBR found the following factors were complicating the JSF Program:

- unreliable performance measures:
  - Schedule Performance Indices and Cost Performance Indices should have been the basis for derating [assigning a lesser value to]; and
  - there was no credible Integrated Master Schedule, Lockheed Martin could not present a critical path forward, and there were separate, unlinked Integrated Master Schedules for Verification Test and Evaluation, program milestones, training and production.
- it was uncertain that detailed design requirements were a complete and accurate reflection of operational requirements:
  - a System Functional Review that complied with the systems engineering technical review process had never been conducted;[250] and
  - a formal functional analysis of the system (mission decomposition)[251] had only recently been completed, and there was inadequate government involvement in the project.
- subsystem contracts had been let prior to mission decomposition:
  - the performance specification for the radar subsystem was found to be inadequate to meet system performance requirements; and

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[250] The System Functional Review is a multi-disciplined technical review to ensure that the system's functional baseline is established and has a reasonable expectation of satisfying the requirements of the Initial Capabilities Document or draft Capability Development Document within the currently allocated budget and schedule. Defense Acquisition University, *Defense acquisition guidebook*, as at 29 July 2011, sections 4.5.9 and 4.3.2.4.2.2.

[251] Mission decomposition breaks down the overarching objectives of an organisation into individual tasks. Burke, C. Shawn, Linda G. Pierce and Eduardo Salas (eds), *Understanding adaptability: a prerequisite for effective performance within complex environments*, Elsevier JAI, London, 2006, pp. 253–4. In the case of the F-35, mission decomposition analysed the various types of mission that the F-35 would be expected to carry out, such as Offensive Counter Air, Defensive Counter Air, etc.

– the Helmet Mounted Display met the subsystem performance requirements, but was operationally unsuitable.[252]

5.30 The TBR found that the following systemic issues needed attention:

- systems engineering practices needed improvement through a reconstituted systems engineering team, and the conduct of scheduled systems engineering reviews with independent panels and agreed entry criteria;
- the poor capability management of block configuration needed to be addressed; and
- the entire software development and integration effort needed to be rebalanced to minimise rework and the loss of expertise.[253]

Response to the Technical Baseline Review

5.31 In January 2011, the US Secretary of Defense announced program decisions arising from the TBR. These decisions included:

- adding US$4.6 billion to the SDD phase;
- again extending the schedule for SDD;
- de-coupling testing of the F-35B (STOVL) from the F-35A (CTOL) and F-35C (CV) variants;
- placing the F-35B on a two-year probationary period; and
- slowing production of the F-35 by reducing the aircraft buys by 124 jets over the Future Years Defense Plan.[254]

5.32 The Secretary also announced that the program was completing a Technology Readiness Assessment on the Helmet Mounted Display, and was awaiting an Independent Cost Estimate before returning for a milestone review of the approval of the SDD phase, which was then scheduled for May 2011.

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252 JSF Program Office, *F-35 technical baseline review PEO (JSF) re-planning summary*, 11 January 2011.

253 JSF Program Office, *F-35 technical baseline review PEO (JSF) re-planning summary*, 11 January 2011.

254 *Selected Acquisition Report (SAR): F-35, as of December 31, 2010*, Washington DC, p. 4; US Department of Defense, *Fiscal Year 2012 Budget Request: overview*, February 2011, p. 4–3; *DOD news briefing with Secretary Gates and Adm. Mullen from the Pentagon*, media transcript, 6 January 2011.

5.33 JSF Program action taken since 2011 has resulted in the SDD phase's approval milestone (Milestone B) being reviewed, and subsequently renewed (see paragraph 5.26).[255] Also, as a result of successful sea trials in 2011, the US Secretary of Defense made the decision in January 2012 to remove the F-35B from probationary status.[256]. The slowing of production of F-35 aircraft by reducing LRIP aircraft production numbers has resulted in an overall delay in LRIP aircraft delivery of 410 since 2008, and this is primarily a response to the need to reduce concurrency risks (see paragraphs 4.27 to 4.45).[257]

5.34 In late March 2012, the US Department of Defense established a new JSF acquisition program baseline, which projects a total F-35 SDD and production cost of US$395.7 billion (then-year dollars) (see paragraphs 5.53 to 5.56).[258]

5.35 As at July 2012, the F-35 Helmet Mounted Display, which is a key contributor to the pilot's situational awareness, remained subject to intensive engineering development and demonstration activity and JSF Program Office scrutiny (see paragraph 2.64).

Manufacturing Review

5.36 At the same time as the TBR was occurring, a Manufacturing Review Team conducted a separate audit of the contractor's ability to produce aircraft and their ability to ramp-up production efforts.

5.37 In response to the report of the Manufacturing Review Team, the ramp-up of production was established at a factor of approximately 1.5 per year beginning from October 2012.[259] This ramp-up factor was seen to balance development and concurrency risk, while leaving room for procurement by the

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255 *Selected Acquisition Report (SAR): F-35, as of December 31, 2010*, Washington DC, p. 4.

256 US Department of Defense, *Secretary of Defense Leon Panetta. Naval Air Station Patuxent River, Md.*, media transcript, 20 January 2012; *Selected Acquisition Report (SAR): F-35, as of December 31, 2011*, Washington DC, p. 5.

257 US Government Accountability Office, *Joint Strike Fighter: Restructuring Added Resources and Reduced Risk, But Concurrency Is Still A Major Concern*, GAO-12-525T, 20 March 2012, p. 5.

258 US Government Accountability Office, *Joint Strike Fighter: DOD actions needed to further enhance restructuring and address affordability risks,* GAO-12-437, June 2012, p. 4.

259 In other words, Low-Rate Initial Production each year would be 50 per cent greater than the previous year.

international partners and for procurements by other nations through the US Government's Foreign Military Sales arrangements.[260]

Australian Schedule Compliance Risk Assessment

5.38 In October and November 2011, the Defence Materiel Organisation conducted a Schedule Compliance Risk Assessment Methodology (SCRAM) review, which found the following:

- systems engineering technical reviews had been reinstated with active participation by the JSF Program Office, and a renewed focus was applied to Technical Performance Measures;
- improvements had been made on the LRIP production line to reduce out-of-station work, which caused delays and additional expense later in production;[261]
- ambiguity in the success criteria for requirement verification was removed for each requirement, through a process where the success criteria were defined in conjunction with the JSF Program Office and formally agreed between the JSF Program Office and its prime contractors. However, development of the requirements Verification Cross Reference Matrix Index and the Certification Basis Description remained incomplete;[262] and
- the Master Schedule was reviewed to ensure that all test and evaluation tasks needed to verify the success criteria were scheduled, and that the

[260] *DOD news briefing with Secretary Gates and Adm. Mullen from the Pentagon*, media transcript, 6 January 2011; US Department of Defense, *Fiscal Year 2012 Budget Request: overview*, February 2011, p. 4–3.

[261] Out-of-station work occurs when manufacturing steps are not completed at the designated work station and must be finished elsewhere later in production. This is highly inefficient, increasing labour hours, causing delays, and sometimes introducing quality problems. Department of Defence, Defence Materiel Organisation, *F-35 Joint Strike Fighter. DMO Schedule Compliance Risk Assessment Methodology (SCRAM). SCRAM review team report,* January 2012, p. 19.

[262] Department of Defence, Defence Materiel Organisation, *F-35 Joint Strike Fighter. DMO Schedule Compliance Risk Assessment Methodology (SCRAM). SCRAM review team report,* January 2012, pp. 20, 22.

Master Schedule identified for each requirement a critical path of success criteria.[263]

5.39 The SCRAM review's key findings specific to the AIR 6000 project were that the re-establishment of a Performance Management Baseline for cost and schedule needed to be accelerated. This would allow for improved performance monitoring and control, identification of schedule slippage, and workforce planning.[264]

Measuring progress

5.40 A progress measurement system for a project to acquire equipment should provide information for general project management purposes, risk management, and financial-performance management. The progress measurement system also forms an integral part of the system's engineering control process, because contractors need to measure technical progress in terms of cost and schedule linked to the achievement of systems engineering requirements.

5.41 The JSF Program uses five principal processes to assess progress:

- milestone achievement;
- an Earned Value Management System (EVMS);[265]
- computing-system development measures;
- technical reviews that follow systems engineering standards; and
- verification and validation of hardware and software progress.

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263 The AIR 6000 project has a highly complex and layered Performance Management Baseline for cost and schedule, which is derived from Lockheed Martin's Integrated Master Schedule, and the JSF Program Schedule. Department of Defence, Defence Materiel Organisation, *F-35 Joint Strike Fighter. DMO Schedule Compliance Risk Assessment Methodology (SCRAM). SCRAM review team report,* January 2012, p. 20.

The Lockheed Martin Integrated Master Schedule (IMS) is the prime contractor schedule underpinning the JSF Program. It incorporates all aspects of the JSF Air System, including development, aircraft production and support systems. It is the key schedule around which the US armed forces, international partners and FMS customers plan their acquisition.

264 Department of Defence, Defence Materiel Organisation, *F-35 Joint Strike Fighter. DMO Schedule Compliance Risk Assessment Methodology (SCRAM). SCRAM review team report,* January 2012, pp. 16, 17.

265 The EVMS is also referred to as a Cost and Schedule Control System (CS^2).

5.42 Of these five processes, EVMS is used as the predominant system for integrating all progress measurement processes to arrive at a holistic measure of an acquisition project's performance in terms of cost and schedule and technical achievement. The US Department of Defense guidelines on the use of EVMS represent a framework for an integrated management system that:

- plans the timely performance of work;
- budgets resources;
- accounts for costs and measures actual performance against plans; and
- replans resources needed to complete the contract when significant deviations from plans are identified.[266]

5.43 In carrying out this responsibility for the JSF Program, the JSF Program Office and the DCMA rely on Lockheed Martin's EVMS to measure and report cost and schedule performance, to quantify the accomplishment of work in earned value terms, and to provide a basis for authorising progress payments. Consequently, the EVMS needs to be accepted and validated as being consistent with EVMS guidelines adopted by the US Department of Defense.

5.44 The DCMA is the US Department of Defense agency responsible for monitoring the contractor's EVMS implementation. In October 2010, the DCMA withdrew the determination of compliance for Lockheed Martin's EVMS system, due to longstanding noncompliance issues with some specific guidelines that underpin a sound EVM system.[267]

5.45 At the time of ANAO fieldwork in the United States, in March 2012, the DCMA was conducting a recertification audit of Lockheed Martin's EVMS, and this was scheduled to be completed by June 2012.[268] At that time, 2 per cent of payments to Lockheed Martin were to be withheld for new F-35 LRIP contracts because of this issue. In June 2012, the ANAO was informed that the withheld payments were rising to 5 per cent, because issues of noncompliance with EVMS guidelines had persisted. In July 2012 it was DCMA's assessment

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266 US Department of Defense, Defense Contract Audit Agency, *DCAA Contract Audit Manual*, July 2011, Vol. 2, Section 11-201.

267 JSF Program Office, briefing to the ANAO, March 2012.

268 US Government Accountability Office, *Joint Strike Fighter: Restructuring places program on firmer footing, but progress still lags*, GAO-11-325, April 2011, pp. 11–12; US Defense Contract Management Agency, *Integrated Project Management Organization*, briefing to the ANAO, March 2012.

that Lockheed Martin's Fort Worth EVMS remained disapproved, and that Government officials could not fully rely on the EVMS cost and schedule data for management and decision-making purposes.

5.46 Central to the noncompliance issues is the need for the EVMS reports to provide accurate verifiable data required by the JSF Program Office at key decision points, without a need for supplementary annotations. The JSF Program Office is seeking to remove ambiguity from EVMS reports, so that it may resolve issues with higher confidence, through a better understanding of the cause and relationships between cost and schedule usage and the value of work accomplished. However, in spite of the EVMS noncompliance issues, data provided to the JSF Program Office is sufficient to illustrate the JSF SDD program's cost and schedule performance trends, as presented in Figure 5.2 below.

F-35 SDD phase cost and schedule performance indices

5.47 Since December 2001, Lockheed Martin has provided the DCMA with monthly EVMS reports that document contractor progress in terms of the value of work accomplished with respect to the SDD contract's cost and schedule budgets. The DCMA provides the JSF Program Office with Monthly Assessment Reports containing analysis and assessment of progress achieved by Lockheed Martin based on the EVMS data, and on verification activities conducted by DCMA personnel.

5.48 Amongst other things, EVMS data is used to produce cumulative cost-and-schedule trend information. Figure 5.2 shows the JSF Program's Cost Performance Index (CPI), which is derived from the ratio of the accomplished work in earned value terms (the earned value) and the actual costs of the work performed.[269] A CPI greater than 1 means the accomplished work is under budget, while a CPI of less than 1 means that the cost of completing the work is over budget.

5.49 Figure 5.2 also shows the Schedule Performance Index (SPI), which is derived from the ratio of earned value and the budgeted cost of work

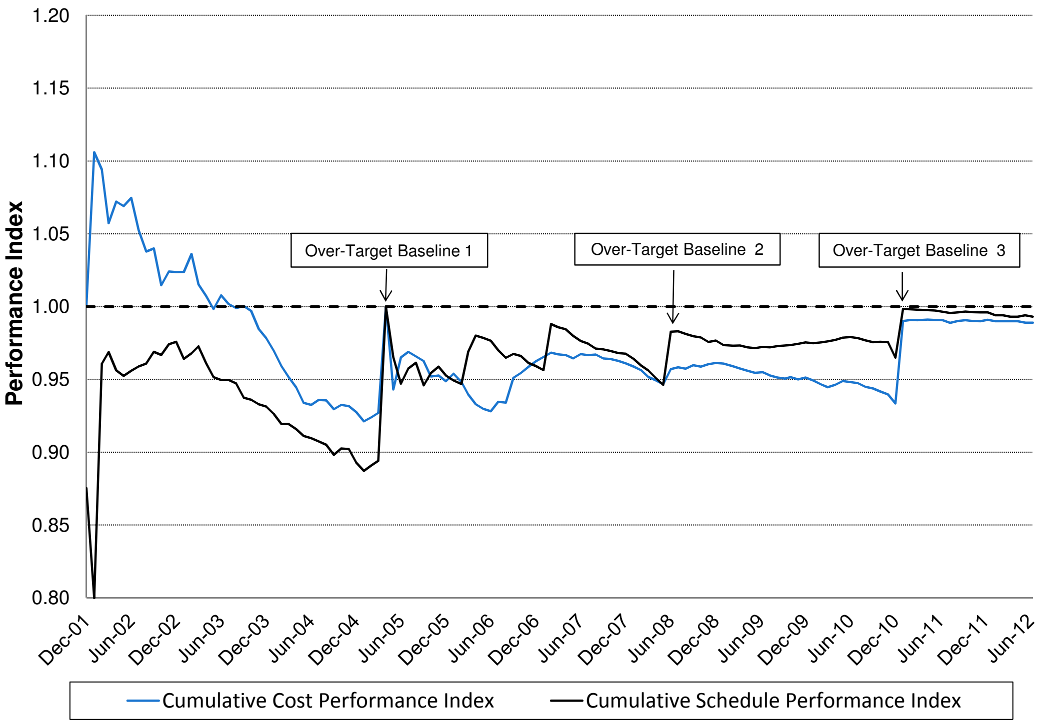
[269] In EVMS reports this ratio is referred to as the Budgeted Cost of Work Performed divided by Actual Cost of Work Performed.

scheduled (the planned value).[270] An SPI greater than 1 means that the work accomplished is ahead of schedule.

5.50 Figure 5.2 shows that during the first five years of the JSF Program's SDD phase, schedule performance largely fell short of the plan, and managerial interventions failed to reduce the declining cost and schedule performance. From mid-2008, the decline in schedule performance has largely been arrested. Since the January 2011 JSF Program restructure, cost-and-schedule performance indices have been between 0.98 and 1.0, or in other words, cost and schedule estimates were exceeded by less than two per cent. However, as at July 2012, the SDD phase's technical issues were yet to be fully resolved, and so there remains a risk that cost and schedule performance may again decline.

Figure 5.2

System Development and Demonstration phase, cost and schedule performance indices, December 2001–June 2012



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[270] The Budgeted Cost of Work Performed divided by Budgeted Cost of Work Scheduled.

5.51 Figure 5.2 is labelled with the periods where JSF Program performance declined to the extent that it was considered better to allow the contractors to implement, through EVMS revisions, a more realistic time-phased cost and schedule budget plan, than to continue with one that was unachievable. These periods are labelled Over-Target Baselines 1, 2 and 3. In those instances, the budget plans exceeded the SDD phase's Target Costs and Target Schedules and so required an 'Over Target' Baseline to be declared, which was fully defined in contractual terms, and approved by the US Department of Defense.

5.52 Table 5.1 lists the SDD phase's EVMS performance measurement baseline restructures, including the Over-Target Baselines.

Table 5.1

JSF Program SDD phase replans and restructures, 2001–12

Date	Type	Outline
17 March 2004	Rebaseline	SDD schedule extended by one year, LRIP postponed for one year, further efforts at weight reduction and improved performance required; total buy reduced by 409 to 2443.[271]
April 2005	Over-Target Baseline 1	Noted in *Selected Acquisition Report* to Congress.[272]
September 2007		Mid-Course Risk Reduction Plan adopted, as a result of schedule pressures, negative cost variances and contractor management-reserve shortfalls. LRIP quantity revised to 275, two development test aircraft cut, test flights reduced, and accelerated reduction in the prime contractor's development workforce, in order to replenish management reserves depleted by design changes and manufacturing problems.[273]
June 2008	Over-Target Baseline 2	An Over-Target Baseline and an Over-Target Schedule were incorporated into the Lockheed Martin SDD contract in June 2008 and fully defined in 2009.[274]

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[271] *Selected Acquisition Report (SAR): F-35 (JSF), as of December 30, 2003*, Washington DC, p. 4.

[272] *Selected Acquisition Report (SAR): F-35 (JSF), as of December 31, 2009*, Washington DC, p. 46.

[273] *Selected Acquisition Report (SAR): F-35 (JSF), as of December 30, 2007*, Washington DC, pp. 4, 36; US Government Accountability Office, *Joint Strike Fighter: accelerating procurement before completing development increases the government's financial risk*, GAO-09-303, March 2009, p. 7.

[274] *Selected Acquisition Report (SAR): F-35 (JSF), as of December 31, 2009*, Washington DC, p. 46.

<table>
<tr><th>Date</th><th>Type</th><th>Outline</th></tr>
<tr><td>Early 2010</td><td colspan="2">Critical breach of the Nunn-McCurdy Act (notified to Congress on 24 March 2010), causing revocation of the existing program baseline (see footnote 245).</td></tr>
<tr><td>24 February 2010</td><td>Restructure</td><td>More than $2.8 billion moved from procurement to development, fully funding SDD to the level of the current estimate; 122 fewer LRIP aircraft; 13-month schedule slip: SDD test schedule extended to March 2015, and Milestone C (Full-Rate Production) moved to April 2016; ninth LRIP lot added; up to three LRIP aircraft to be used in support of SDD testing.</td></tr>
<tr><td>January 2011</td><td>Restructure and Over-Target Baseline 3</td><td>Decisions arising from the Technical Baseline Review: including 124 fewer LRIP aircraft (for further details, see paragraph 5.31).[275]</td></tr>
<tr><td>January 2012</td><td>Restructure</td><td>179 fewer LRIP aircraft.</td></tr>
<tr><td>28 March 2012</td><td>Acquisition Program Baseline reapproved</td><td>Re-establishment of program baseline following 2010 Nunn-McCurdy breach and subsequent Over-Target Baseline and restructures. Full-Rate Production now set for 2019 and to conclude in 2037.</td></tr>
</table>

Source: ANAO analysis of successive Selected Acquisition Reports 2001–11 and *United States Department of Defense Fiscal Year 2013 Budget Request*, February 2012.

Acquisition program rebaseline, March 2012

5.53 In late March 2012, the US Department of Defense established a new Acquisition Program Baseline for the JSF Program, which projects a total F-35 SDD and production cost of US$395.7 billion (then-year dollars).[276] This restructure re-established the JSF Program's baseline following the 2010 Nunn-McCurdy breach, the Technical Baseline Review and subsequent program changes since 2010.

5.54 This acquisition baseline extends the SDD phase by three years, until the completion of Initial Operational Test and Evaluation, scheduled for February 2019, and this phase is now estimated to cost US$55.2 billion (then-year dollars)—$US31.8 billion for the F-35 airframe and mission systems development by Lockheed Martin, US$8.4 billion for the jet engine and F-35B

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275 US Defense Contract Management Agency, *Integrated Project Management Organization*, briefing to the ANAO, March 2012.

276 *Selected Acquisition Report (SAR): F-35, as of December 31, 2011*, Washington DC, p. 20.

fan development by Pratt & Whitney, and US$15 billion for US Government costs.[277]

5.55 The decision on Full-Rate Production of F-35 aircraft has been delayed by seven years from 2012 to 2019,[278] and the production phase has been extended by two years to 2037, and is now estimated to cost US$335.7 billion (then-year dollars).[279] This amount includes the procurement for the US Services of 2443 production F-35 aircraft, consisting of 307 Low-Rate Initial Production aircraft to be acquired by 2018, and 2136 Full-Rate Production aircraft to be acquired between the years 2019 to 2037.[280]

5.56 Overall, from the commencement of the SDD phase in October 2001 until March 2012, the JSF Program's SDD and production phase cost estimates have increased from US$233.0 billion to US$395.7 billion (then-year dollars), a rise of some 70 per cent. Over the same period, the total number of F-35 SDD and production aircraft to be produced for the US has decreased 14 per cent from 2866 to 2457. The estimated unit average then-year cost for these aircraft has grown 98.5 per cent, from US$69 million in 2001 to US$137 million in 2012.[281] The US Government is addressing this cost growth through the mechanisms outlined below.

Production and sustainment cost control

US Truth in Negotiations Act

5.57 The US Truth in Negotiations Act (TINA) was passed in 1961, and is an important factor in establishing the relationship between the US Government and its defense contractors. TINA requires every prime and subcontractor to submit cost or pricing data and certify that such data are current, complete and

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277 *Selected Acquisition Report (SAR): F-35, as of December 31, 2011*, Washington DC, p. 20.

278 US Government Accountability Office, *Joint Strike Fighter: DOD actions needed to further enhance restructuring and address affordability risks*, GAO-12-437, June 2012, pp. 5.

279 *Selected Acquisition Report (SAR): F-35, as of December 31, 2011*, Washington DC, p. 20.

280 US Government Accountability Office, *Joint Strike Fighter: DOD actions needed to further enhance restructuring and address affordability risks,* GAO-12-437, June 2012, pp. 4, 8, 44.

281 US Government Accountability Office, *Joint Strike Fighter: DOD actions needed to further enhance restructuring and address affordability risks,* GAO-12-437, June 2012, p. 5.

accurate, prior to award of any negotiated contract, subcontract or amendment, if the price exceeds US$700 000 and no exemption applies.[282]

5.58 The purpose of the TINA is to put the government on an equal footing with contractors when negotiating contracts requiring cost or pricing data. It also provides the government with a price-reduction remedy if a contractor did not submit accurate, complete, and current data for a contract, and the government relied on that defective data in determining the contract price. In these cases, the contractor is liable to pay a penalty equivalent to any loss incurred by the government, with interest.[283] The price-reduction remedy is enabled by the government's power to access a contractor's records in order to evaluate cost and price data that have been provided.[284]

Department of Defense cost initiatives

5.59 Since the passing of the US Weapon Systems Acquisition Reform Act of 2009, and under the budget pressure of the succeeding years, the US Department of Defense has been pursuing a focus towards delivering better value to the taxpayer through increased efficiency. This drive for 'Better Buying Power' concentrates on five areas:

- targeting affordability and controlling cost growth;
- stimulating productivity and innovation in industry;
- promoting real competition;
- improving tradecraft in services acquisition; and
- reducing non-productive processes and bureaucracy.[285]

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[282] 10 US Code §2306a, as implemented by Federal Acquisition Regulation, Subpart 15.4—Contract Pricing. Other sections of the US Code apply similar provisions to non-defence contractors. See also Tim A Di Guiseppe, *Understanding the Truth in Negotiations Act in federal procurement*, available from <http://www.calu.edu/business-community/government-agency-coordination-office/files/Understanding%20TINA.pdf> [accessed 18 May 2012].

[283] 10 US Code §2306a(f); US Department of Defense, Defense Contract Audit Agency, *DCAA Contract Audit Manual,* July 2011, Vol. 2, section 14-103.1.

[284] This role is performed by the Defense Contract Audit Agency; see paragraph 5.8.

[285] US Under Secretary of Defense for Acquisition, Technology, and Logistics, Memorandum for acquisition professionals: *Better Buying Power—Guidance for obtaining greater efficiency and productivity in defense spending*, 14 September 2010.

5.60 The renewed emphasis on controlling costs includes a proactive approach to establishing cost and price data, based on fair dealing established by the Truth in Negotiations Act. The new approach, which has been termed Will-Cost/Should-Cost Management, aims to control and lower prices before they have been agreed on:

- Will-Cost: decision-makers and Congress use independent cost estimates—forecasts of what a program will cost based upon reasonable extrapolations from historical experience—to support budgeting and programming; and
- Should-Cost: the manager of each major program is required to conduct a Should-Cost analysis justifying each element of program cost and showing how it is improving year by year or meeting other relevant benchmarks and/or value.

5.61 The US Under Secretary of Defense for Acquisition, Technology, and Logistics has announced that the JSF Program is implementing Will-Cost/Should-Cost Management:

> We will use this method, for example, to drive cost down in the Joint Strike Fighter (JSF) program, the Department's largest program and the backbone of tactical air power for the U.S. and many other countries in the future. This aircraft's ICE [independent cost estimate] (Will Cost) average unit price grew from $50 million Average Unit Procurement Cost (APUC) when the program began (in 2002 dollars, when the program was baselined) to $92 million in the most recent ICE. Accordingly, the JSF Program had a Nunn-McCurdy breach last year and had to be restructured by the Secretary of Defense. As a result of that restructuring, a Should Cost analysis is being done in association with the negotiation of the early lot production contracts. The Department is scrubbing costs with the aim of identifying unneeded cost and rewarding its elimination over time. The result should be a negotiated price substantially lower than the Will Cost ICE to which the Department has forecasted and budgeted. Secretary Gates indicated in his Efficiency Initiative that monies saved in this way could be retained by the Service that achieved the efficiency; in this case the Air Force, Navy, and Marine Corps could reallocate JSF funds to buy other capabilities.[286]

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[286] US Under Secretary of Defense for Acquisition, Technology, and Logistics, Memorandum for acquisition professionals: *Better Buying Power—Guidance for obtaining greater efficiency and productivity in defense spending*, 14 September 2010, p. 3.

5.62 In practical terms, a Should-Cost team review is a method of contract pricing that employs an integrated team of government procurement, contract administration, contract audit, and engineering representatives to conduct a coordinated, in-depth cost analysis at the contractor's plant. The purpose of a Should-Cost review is to:

- identify uneconomical or inefficient practices in the contractor's management and operations and to quantify the findings in terms of their impact on cost; and
- develop a realistic price objective which reflects reasonably achievable economies and efficiencies.

5.63 A Should-Cost team review represents an onsite proposal evaluation. It is a specialised approach to the establishment of a fair and reasonable price based on what a contract (normally a major production contract) should cost, in the environment and under the conditions predicted for contract performance.[287]

5.64 In recent evidence to Congress, the JSF Program Executive Officer described how the recent cost initiatives, and in particular Should-Cost reviews, were playing a role in establishing a contract price for the F-35 aircraft that will be produced during LRIP 5:

> The Office of the Secretary of Defense's (OSD) Director of Defense Pricing led an F-35 LRIP 5 'Should Cost' effort from the contractor proposal submittal in late April 2011 through early October 2011. Following an OSD Peer Review, LRIP Lot 5 negotiations commenced on December 9, 2010 and are heavily informed by the F-35 LRIP Lot 5 'Should Cost' conclusions which are based on actual experienced costs. Negotiations on the definitized contracts for Lot 5 are anticipated to conclude in late Spring [*that is, for Australia, in late Autumn 2012*].[288]

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[287] US Department of Defense, Defense Contract Audit Agency, *DCAA Contract Audit Manual,* July 2011, Vol. 2, sections 9-1301–9-1302.

[288] Department of Defense, Vice Admiral David J. Venlet, Program Executive Officer F-35, *Presentation to the Senate Armed Services Committee Subcommittee on Tactical Air and Land Forces: F-35 Joint Strike Fighter Program*, Washington DC, 8 May 2012, p. 13.

F-35A Unit Recurring Flyaway cost

5.65 The Unit Recurring Flyaway (URF) cost of an aircraft is the full cost of all fixed systems (that is, the baseline aircraft configuration, including airframe, engine and avionics). However, the URF cost is only one of five US Department of Defense cost categories listed below:

- *the development cost* — is the one-time cost to research, develop, design and test the new aircraft (that is, the cost of the SDD phase that may be apportioned to each new aircraft);
- *the nonrecurring cost* — is typically a fraction of the URF cost and covers the basic production 'start-up' costs apportioned to the purchase of a fleet of aircraft;
- *the unit procurement cost (also known as weapon system cost)* — is the URF cost plus the cost of support items such as technical data and publications, technical training and training equipment, maintenance support equipment and initial spares;
- *the program acquisition cost* — is the addition of the unit procurement costs, the development costs, and the costs of related military construction such as hangars, test and support facilities; and
- *the life-cycle cost* — is the program acquisition cost together with all of the projected lifetime logistic and operational costs—munitions and missiles; fuel, oil, and lubricants; spares (other than initial spares); replenishment; depot maintenance; system support and modifications; as well as the costs of hiring, training, supporting, and paying the personnel associated with the operating units.[289]

5.66 The F-35 development cost and URF cost are relatively well known to the AIR 6000 project. However, the other costs are contingent upon government approvals of the number and timing of F-35A acquisitions, sustainment arrangements and infrastructure investments.

5.67 As at June 2012, the JSF Program Office estimated the F-35A CTOL's URF to be US$131.4 million for Fiscal Year 2012, reducing to US$127.3 million

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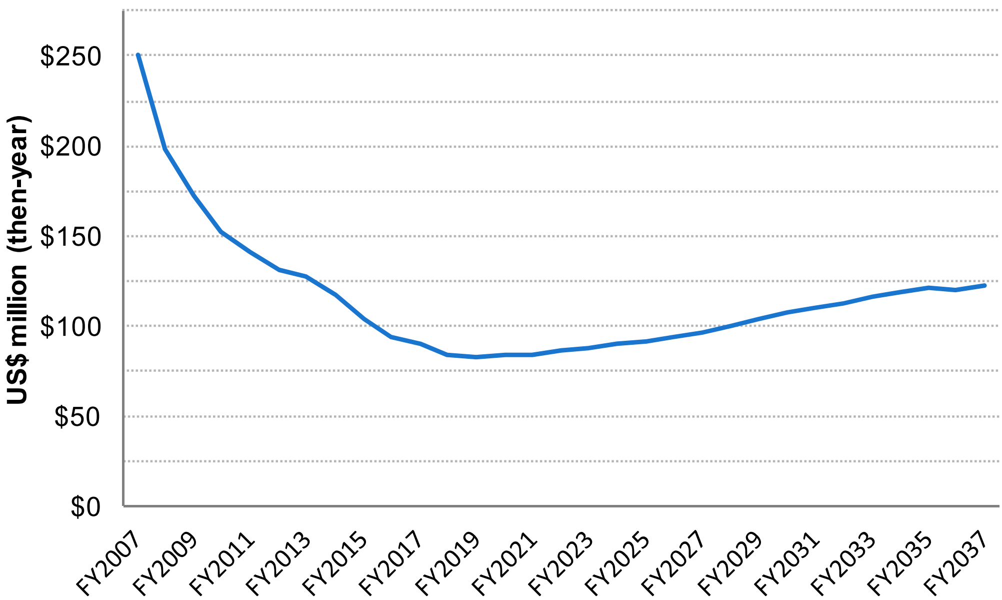
[289] US Department of Defense, Assistant Secretary of Defense (Program Analysis and Evaluation), *Cost analysis guidance and procedures*, DOD 5000.4-M, 1992, pp. 44–9.

in 2013, and reducing further to US$83.4 million in 2019. These reductions take into account microeconomic factors associated predominantly with increasing production volumes, as well as macroeconomic factors associated with cost inflation. The estimates indicate that after 2019, inflation will increase the URF cost of each F-35A by about US$2 million per year. The estimates are based on current expected orders from the United States and other nations.

5.68 Figure 5.3 shows the latest estimates by the JSF Program Office for the Unit Recurring Flyaway cost of F-35A aircraft out to Fiscal Year 2037.

Figure 5.3

Joint Strike Fighter Program Office estimate of F-35A Unit Recurring Flyaway cost, as at June 2012



Source: Joint Strike Fighter Program Office, June 2012.

5.69 The ANAO notes that these estimates are the best available to the ANAO at the time of the audit. They remain dependent upon expected orders from the United States and other nations, as well as continuing Will-Cost/Should-Cost management, as outlined in paragraphs 5.59 to 5.64 above.

Conclusion

5.70 The JSF Program is often acknowledged as the Pentagon's most expensive current weapons program. Since 2002, the JSF Program has encountered technical problems and funding reprogramming, which have resulted in the program progressing more slowly than originally planned. The JSF Program Office, other US Department of Defense authorities, and the US Government Accountability Office have conducted regular reviews and audits of the JSF Program, and these have revealed the original cost and schedule estimates to be unrealistic. The US Government has invested heavily in remediation programs to bring the cost and schedule variations under control.

5.71 Recent indications are that initiatives to improve performance are starting to show results, in terms of software development milestones being more closely adhered to, and planned flight test targets being reported as met or exceeded in 2011–12. However, a full assessment as to how effectively that progress can be maintained will be some years off. At the time of the audit, almost 80 per cent of the F-35 test and evaluation program was yet to be completed, so significant F-35 key performance parameters had not been fully validated as being achieved by F-35 aircraft. Although program cost reduction measures are being pursued by the US Department of Defense and its contractors, the cost targets remain challenging.

5.72 While the ANAO considers that Defence has gained reasonable assurance that adequate work has been undertaken to identify significant risks in the US JSF Program, and that measures have been progressively developed and implemented to mitigate them, significant risks still remain, including in relation to mission-system data processing, software development schedule adherence, Helmet Mounted Display performance, structural health monitoring and structural durability testing. These will require close management as the final stages of development of the F-35A aircraft unfold.

5.73 The successful coordination of this highly complex and costly procurement with the effective sustainment of the ageing F/A-18A/B fleet and the planned transition to an F-35-based air combat capability in the required timeframe, so that a capability gap does not arise between the withdrawal from service of the F/A-18A/B fleet and the achievement of full operational capability for the F-35, remains challenging. Following US and Australian Government decisions that have delayed earlier F-35A delivery intentions, the F/A-18A/B fleet's operational life is likely to be extended beyond the current Planned Withdrawal Date of 2020. Defence's capacity to accommodate any further delays in the production and/or acquisition of F-35s through a further extension to the life of the F/A-18A/B fleet, beyond the limited extension currently being considered, has limits, is likely to be costly, and has implications for capability. That said, decisions in relation to capability for the

ADF, including Australia's acquisition of F-35As, properly rest with the Australian Government, informed by advice from Defence.

Ian McPhee — Canberra ACT

Auditor-General — 27 September 2012

Appendices

Appendix 1: Defence Response to the Proposed Report

AUDIT-IN-CONFIDENCE

Australian Government
Department of Defence

Chief Audit Executive
Audit and Fraud Control Division
CP3-2-005
PO BOX 7912
CANBERRA BC ACT 2610
Telephone: 02 6266
Facsimile: 02 6266

GED
10 SEP 2012
2.20

AFCD/CAE/OUT/2012/371

Dr Tom Ioannou TJ 10/9
Acting Group Executive Director
Performance Audit Services
Australian National Audit Office
GPO Box 707
CANBERRA ACT 2601

Dear ~~Dr Ioannou~~ Tom

Australian National Audit Office (ANAO) Performance Audit of *Management of Australia's Air Combat Capability - Management of Australia's Air Combat Capability - F-35A Joint Strike Fighter Acquisition.*

I refer to your letter of 24 August 2012 which provided Defence with the Section 19 Report for the above mentioned audit, as well as the Section 19 Report on *F/A-18 Hornet and Super Hornet Fleet Upgrades and Sustainment*

Defence appreciates the opportunity to review and provide comment on the Section 19 Report. Defence's comments on the *F-35A Joint Strike Fighter Acquisition* Section 19 Report are contained at **Annexes A** and **B**. As requested, Defence's response to the *F/A-18 Hornet and Super Hornet Fleet Upgrades and Sustainment* Section 19 Report is provided in a separate correspondence (ref AFCD/CAE/OUT/2012/372). Noting connections between the two reports, the Agency Response for both Section 19 Reports is the same.

Defence welcomes the reports and believes that they present a balanced and detailed account that highlights the significant and continuing work that Defence undertakes in managing Air Combat Capability.

Should you have any queries, please do not hesitate to contact Ms Lynn Peever, A/Assistant Secretary Audit, on 02 6266 or myself directly on the number above.

Yours sincerely

GEOFFREY BROWN OAM
Chief Audit Executive
Audit & Fraud Control Division

6 September 12

Annexes:

A. Summary of Agency Response
B. Proposed Amendments and Editorials

AUDIT-IN-CONFIDENCE

Defending Australia and its National Interests

Appendix 2: JSF Program Office Response to the Proposed Report

GED
- 5 SEP 2012
10.50

F-35 JOINT PROGRAM OFFICE
200 12TH Street South, Suite 600
Arlington, Virginia 22202-5402

Dr. Tom Ioannou TI 5/9
Acting Group Executive Director
Performance Audit Services Group
GPO Box 707 CANBERRA ACT 2601
19 National Circuit BARTON ACT

Dear Dr. Ioannou,

I received your 27 August 2012 letter regarding the Australian National Audit Office's proposed report on *Management of Australia's Air Combat Capability-F-35A Joint Strike Fighter Acquisition*. I appreciate the opportunity to review and respond to the proposed report.

I find the F-35A extract of the proposed report to be a fair and balanced portrayal of the current state of the F-35 Joint Strike Fighter program. The professionalism demonstrated by your team during the research and writing of this report was exceptional, and I want to extend my thanks to them for their hard work.

I consider the partnership we share with the Australian Government and citizens to be of upmost importance to the success of the overall F-35 program. Again, thank you for the opportunity to comment and we look forward to future interactions as the F-35 matures to Full Operational Capability.

David J Venlet
DAVID J. VENLET
Vice Admiral, U.S. Navy
Program Executive Officer

Appendix 3: Lockheed Martin Response to the Proposed Report

18 SEP 2012
9.15

Lockheed Martin Aeronautics Company
P.O. Box 748 Mail Zone 1204 Fort Worth, TX 76101
Telephone 817-777-9193 Facsimile 817-763-7403

LOCKHEED MARTIN

Tom Burbage
Executive Vice President and General Manager
F-35 Joint Strike Fighter Program Integration

September 7, 2012

Ref: 2011/1022

Dr Tom Ioannou TI 18/9
Acting Group Executive Director
Performance Services Group

Management of Australia's Air Combat Capability

At the reference Lockheed Martin was provided a draft extract of an audit conducted on the Management of Australia's Combat Capability – F-35A Joint Strike Fighter Acquisition for comment.

Overall, Lockheed Martin considers the draft a valid representation of the JSF Program as at the time of audit, noting that there were significant sections not provided to us. A number of editorial comments have been passed direct to your office, which we believe will enhance the readability and accuracy of the report.

Lockheed Martin appreciates the opportunity to comment on the draft report and commends the work effort needed by the report auditors to comprehend such a complex and multifaceted project.

Sincerely,

Tom Burbage

Tom Burbage
Executive Vice President and
General Manager
F-35 JSF Program Integration

Appendix 4: Glossary of Terms

Airworthiness. Airworthiness is a concept, the application of which defines the condition of an aircraft and supplies the basis for judgement of the suitability for flight of that aircraft, in that it has been designed, constructed, maintained and is expected to be operated to approved standards and limitations, by competent and authorised individuals, who are acting as members of either an approved or authorised organisation and whose work is both certified as correct and accepted on behalf of the Australian Defence Force. ADF, *Technical airworthiness management manual*, Australian Air Publication 7001.053(AM1), 21 October 2010.

Australian Military Type Certificate (AMTC). A certificate issued by Chief of Air Force, as the ADF Airworthiness Authority, for an aircraft type entered on the register of State aircraft. The AMTC signifies that the particular aircraft type has been assessed (undergone type certification) by the ADF as airworthy and supportable in its intended ADF role/s. ADF, *Technical airworthiness management manual*, Australian Air Publication 7001.053(AM1), 21 October 2010.

Certification.

- The act of issuing a certificate that provides assurance that an entity, including product, service or organisation, complies with a stated specification, standard or other requirement. Defence Instruction (General) LOG 4–5–012, *Regulation of technical integrity of Australian Defence Force materiel*, September 2010.
- The end result of a process which formally examines and documents compliance of a product, against predefined standards, to the satisfaction of the certificating authority. ADF, *Technical airworthiness management manual*, Australian Air Publication 7001.053(AM1), 21 October 2010.

Certification basis.

- The suite of standards against which materiel is to be certified, derived from or judged to be equivalent to a subset of the materiel standards approved by a Technical Regulatory Authority (TRA). Defence Instruction (General) LOG 4–5–012, *Regulation of technical integrity of Australian Defence Force materiel*, September 2010.
- The set of standards which define the criteria against which the design of aircraft or aircraft-related equipment, or changes to that design, are assessed to determine their airworthiness. ADF, *Technical airworthiness management manual*, Australian Air Publication 7001.053(AM1), 21 October 2010.

Deeper Maintenance (DM). This level of maintenance includes tasks that are more complex than operational maintenance and normally require specialised equipment and technical skills and which relies on access to extensive support equipment and workshop facilities for successful conduct. ADF, *Technical airworthiness management manual*, Australian Air Publication 7001.053(AM1), 21 October 2010.

Design Acceptance. The process whereby a design or design change (that is, an output of the design process) involving aircraft or aircraft-related equipment is determined to be technically acceptable for ADF use based on a determination that the specified requirements and design standards are sufficient and applicable (to the ADF authorised configuration, maintenance policy and procedures, and operations) and that the quality of the design has been proven to the satisfaction of the responsible DAR. Generally, design quality is assured through approval of the design by an Authorised Engineering Organisation against the approved design requirements and standards plus an acceptable basis of design verification. ADF, *Technical airworthiness management manual*, Australian Air Publication 7001.053(AM1), 21 October 2010.

Design Acceptance Certification. The final act of the Design Acceptance process whereby a DAR provides a certified record of the technical acceptability of a change to aircraft or aircraft-related equipment Type Design. ADF, *Technical airworthiness management manual*, Australian Air Publication 7001.053(AM1), 21 October 2010.

Design Acceptance Representative (DAR). A Commonwealth employee with delegated authority from the Technical Airworthiness Regulator to perform Design Acceptance certification of changes to aircraft or aircraft-related equipment. ADF, *Technical airworthiness management manual*, Australian Air Publication 7001.053(AM1), 21 October 2010.

Fatigue. The cracking or failure of an aircraft structure by repeated loading over time.

Life of Type. The upper limit of service life (in AFHRS, landings or cycles) which has been qualified either by test or calculation, or by requirement. RAAF, *F/A-18 A/B Hornet aircraft structural integrity management plan*, 2011, vol. 2, Definitions.

Planned Withdrawal Date. The date which has been promulgated for removal of the aircraft type from service. RAAF, *F/A-18 A/B Hornet aircraft structural integrity management plan*, 2011, vol. 1, Definitions.

Safe life. The safe life of an item is the life at which the weakest example just retains the required standard of strength, deformation, stiffness or mechanical function, until it is withdrawn from service at the end of a specified life, or an equivalent life having taken into account the actual usage. The minimum standard of strength is 80 per cent of the design ultimate. (DEF STAN 00-970). RAAF, *F/A-18 A/B Hornet aircraft structural integrity management plan*, 2011, vol. 1, Definitions.

Service Release. The approval to release an incorporated design change for use in service, based on the condition that all implementing instructions relating to the design change have been issued to user organisations. Service Release is granted by either the Chief of Air Force (for major type-design changes) or the Senior Executive of an Authorised Engineering Organisation (for minor type-design changes). ADF, *Technical airworthiness management manual*, Australian Air Publication 7001.053(AM1), 21 October 2010.

Statement of Requirement (SOR). A document or documents defining the complete set of DAR requirements on a design agency to allow DAR acceptance of an aircraft or aircraft-related equipment design or design change. The SOR includes or references a Specification, which is the document defining the specific essential function and performance requirements for the product design or design change. ADF, *Technical airworthiness management manual*, Australian Air Publication 7001.053(AM1), 21 October 2010.

Supplemental Type Certificate (STC). A certificate issued by Chief of Air Force for an aircraft which undergoes a major design change or role change that is beyond the type design defined in the original AMTC, but is not substantial enough to require a complete reinvestigation of compliance of the aircraft with the applicable airworthiness standards (that is, it does not require a new AMTC). ADF, *Technical airworthiness management manual*, Australian Air Publication 7001.053(AM1), 21 October 2010.

Type Certification. The process of: (i) prescribing and revising minimum standards governing the design of aircraft, engines, propellers and other aircraft equipment as may be required in the interests of safety; and (ii) administering a program to determine compliance with those prescribed standards and maintain certification integrity with a higher level of oversight, specification and compliance than the normal Design Acceptance process requires. Successful type certification activity leads to the issue of an AMTC. ADF, *Technical airworthiness management manual*, Australian Air Publication 7001.053(AM1), 21 October 2010.

Appendix 5: The Establishment of AIR 6000

Original AIR 6000 process

1. While the United States and other countries in the late 1990s were developing their plans to manufacture a new fighter aircraft, Australia began to develop its own plans, in its case, to purchase a new fighter aircraft. Australia's plans to replace its air combat capability were announced in the Defence White Paper released on 6 December 2000:

> [T]he Government will examine options for acquiring new combat aircraft to follow the F/A-18, and potentially also the F-111. Provision has been made in the Defence Capability Plan for a project to acquire up to 100 new combat aircraft to replace both the F/A-18 and F-111 fleets. Acquisition is planned to start in 2006–07, with the first aircraft entering service in 2012. The Government has specifically made financial provision to allow acquisition of high-performance aircraft to provide the basis for the maintenance of Australia's critical air-combat edge well into the twenty-first century. Much work remains to be done over the next few years to define and refine our requirements, and to establish the optimum balance between capability and numbers. That time will also allow better evaluation of a number of competing aircraft types.[290]

2. In May 1999, project AIR 6000, New Air Combat Capability, had been established within Defence, with the first stages appearing in the Pink Book 1998–2003.[291] In an Additional Estimates hearing in February 2000, the broad time frame for AIR 6000 was described as follows:

> [T]he project concept development and definition planning has commenced. That commenced in the latter part of [1999]. The assessment of broad affordability and the effectiveness of any spectrum of future force mix options against the strategic requirements that might come out of the white paper will occur in the

[290] *Defence 2000: Our future defence force*, Defence White Paper, Canberra, 2000, p. 87. In 1997, the review of *Australia's strategic policy* had indicated that a replacement for the F/A-18 would need to be decided soon. *Australia's strategic policy*, Canberra, 1997, p. 61.

[291] The 'Pink Book' was the predecessor of the Defence Capability Plan, and contained a consolidated breakdown of major defence capital-equipment proposals. The first stages of AIR 6000 were listed as Capability Definition Study and Project Definition Study. *Defence new major capital equipment proposals 1998–2003*, Canberra, 1999, pp. 39–40 and 118.

> period from [2000] through to about 2002. You could expect some detailed project definition studies in the period 2002–04. We could expect to go to government for approval for major funding around 2005 and we could probably expect contracts for the initial phases of acquisition around 2007 to meet some sort of in-service date around 2012.[292]

3. Stage 1 of AIR 6000 produced a Feasibility Analysis, which the Defence Capability and Investment Committee considered in October 2000. The Feasibility Analysis, conducted internally, updated a 1997 Fighter Replacement Study which had established the Planned Withdrawal Date of the F/A-18 as 2012–15. The new study considered the supportability and maintainability of both the F/A-18 Hornet and the F-111, to ensure that the aircraft would continue to provide the desired capabilities and remain safe to operate until their respective Planned Withdrawal Dates. The study results provided reasonable confidence that Australia would be able to retain both types of aircraft as effective combat aircraft until their then Planned Withdrawal Dates of 2015 and 2020 respectively.[293]

4. Stage 2 of AIR 6000, an Impact Analysis, was to examine a range of platforms and weapon systems to provide a list of effective force-mix options that could replace the capabilities provided by the F/A-18 and F-111. The study was to be conducted over a two-year period, presenting a final report to the Defence Capability Committee in mid-2002.[294] The Acting Vice Chief of the Defence Force (VCDF) approved expenditure of $2 million for the Impact Analysis on 7 July 2000.[295]

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[292] Rear Admiral Chris Ritchie AM, RAN, Head, Capability Systems, statement to Senate Foreign Affairs, Defence and Trade Legislation Committee, Additional Estimates hearing, *Committee Hansard*, 9 February 2000, p. FAD&T 160.

[293] Department of Defence, Head Capability Analysis and Options, *New aerospace combat capability studies*, draft ministerial minute, June 2000. The *Defence capability plan 2001–2010*, released on 26 June 2001, also described AIR 6000 Stage 1 as complete, and summarised it as involving F/A-18 and F-111 Life of Type capability/cost assessments to validate the platforms' Planned Withdrawal Dates. *Defence capability plan 2001–2010*, Canberra, 2001, p. 57.

[294] Department of Defence, Head Capability Analysis and Options, *New aerospace combat capability studies*, draft ministerial minute, June 2000.

[295] Department of Defence, Head Capability Analysis and Options, *Funding of AIR 6000 New Aerospace Combat Capability Stage 2: impact analysis*, minute, 7 July 2000.

5. Stage 3 of AIR 6000, Options Definition, with the aim of selecting a preferred option, was to be conducted between 2002 and 2004, with contract signature for Phase 1 acquisition planned for 2007.[296]

6. As part of the initial processes of AIR 6000, in November 2001 Defence issued a Market Survey to seek technical and costing information on aircraft that might have the capabilities required by Australia. In December 2001 Defence also released a Request for Information, seeking additional information on nine potential air combat options.[297] Responses to the Request for Information were received in February 2002.[298] However, the United States Government would not allow aircraft-manufacturer Lockheed Martin to respond with information about the Joint Strike Fighter, because Australia was not a partner nation in the JSF Program.[299]

Joining the JSF Program

7. However, the formal process for deciding the best options for Australia was not completed as planned, as noted in a previous ANAO report:

> In early 2002 an opportunity existed for Australia to join the Joint Strike Fighter System Development and Demonstration (JSF SDD) program and Defence sought Ministerial approval to prepare a business case. In Jun 2002 the [National Security Committee of Cabinet] considered the business case and authorised Defence to enter into negotiations to enter the JSF partnership.
>
> In Oct 2002 following successful negotiations NSC approved entry by Australia into the JSF SDD program and at the same time formally terminated any further consideration of other combat platforms.

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296 Department of Defence, Head Capability Analysis and Options, *New aerospace combat capability studies*, draft ministerial minute, June 2000; *Defence capability plan 2001–2010*, Canberra, 2001, pp. 57–8.

297 ANAO Audit Report No.48 2008–09, *Planning and approval of defence major capital equipment projects*, pp. 88–9; question on notice: 'Defence: Joint Strike Fighter', *House of Representatives Hansard*, 11 November 2002, p. 8758.

298 Australian Defence Headquarters, Capability Systems, *Briefing on Australia's involvement in Joint Strike Fighter Program—Chronology of Australian involvement in Joint Strike Fighter Program*, 5 September 2002.

299 All the other contenders for AIR 6000 did provide responses. Defence, *Australian participation in the Systems Design and Development Phase of the US Joint Strike Fighter Program*, draft brief, [March 2002].

> Notwithstanding, ongoing monitoring of the wide option set was maintained by DSTO.[300]

8. By October 2001, when Australia was still pursuing the original AIR 6000 process, the United States had already commenced the SDD phase of the JSF Program, having signed a partnership MoU with the United Kingdom in January 2001. Six more partner nations—Canada, Denmark, the Netherlands, Norway, Italy and Turkey—signed the JSF SDD MoU between February and June 2002.

9. As for Australia, on 10 January 2002, the then Minister, Senator Robert Hill, during a visit to Washington DC, told media that Australia would be sending officials to the United States in the near future to discuss the value of joining the SDD phase. The *Australian Defence Business Review* reported that:

> Hill is understood to have undertaken a series of meetings with Pentagon officials and Lockheed Martin management to examine technology access issues, as well as likely dates for availability of the F-35A for the RAAF. Lockheed Martin and other competitors for the F/A-18 and F-111 capability replacement project have spent Xmas addressing what some in industry have described as a 'flaky' Air 6000 market survey, which is said to have had difficulty specifying exactly the types of threats and operating environments the new air capability would have to contend with. Defence's alleged vagueness in this regard, when combined with expectations of a reshuffling of national security priorities affected by new resource demands upon Defence to fund the war on terrorism, suggest big ticket projects such as Air 6000 and Sea 4000 may move to the right as a result of the current Defence Capability Plan review, thus falling into more appropriate time-scales for the F-35A. In this regard, Defence is looking closely at the viability of life extension programs for both the F/A-18 and F-111 fleets, including the possibility of an earlier 'stop-gap' acquisition (or lease) of a current off-the-shelf aircraft should the current fleets fall short of concurrency with a prospective F-35 introduction date.[301]

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[300] ANAO Audit Report No.48 2008–09, *Planning and approval of defence major capital equipment projects*, p. 89.

[301] 'RAAF to study Joint Strike Fighter', *Australian defence business review*, 28 January 2002, p. 26.

10. A short while later, *Flight International* reported that the Australian Government would decide whether to join the SDD phase in April 2002. The Minister was reported to have stated that even if Australia decided to invest in the development of the JSF, this did not necessarily mean that the JSF would be the aircraft that ultimately won what would be Australia's largest-ever military procurement.[302]

11. On 11 April 2002, Defence requested permission from the Minister to present a business case for joining the SDD phase of the JSF Program. Defence proposed three possible significant benefits from joining this phase:

- access to detailed information about JSF capabilities, cost and schedule;
- Australian industry participation in the largest military program in recent history and the foreseeable future, with over 4500 aircraft expected (with export) at a total value ofUS$375 billion, and a potential for contracts to the value of up to about $2 billion; and
- substantial cost savings in the event that JSF was ultimately selected for AIR 6000.[303]

12. The ministerial submission foreshadowed that Defence was considering narrowing the potential field of aircraft to three, including the JSF. It proposed that a business case would be presented to Cabinet to narrow the field of competition for AIR 6000, and to gain approval for MoU negotiations on joining the SDD phase. The information to be provided by the United States early in the negotiations would inform a robust view of the probability of ultimately selecting the JSF for AIR 6000. However, the submission also noted that:

> However it is portrayed, contenders for Air 6000 may consider Australia's participation in the SDD phase as tantamount to selection

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[302] 'Australia could join JSF Programme, but warns orders may not follow', *Flight international*, 26 February–4 March 2002, p. 20.

[303] Secretary of Defence and Chief of the Defence Force, *AIR 6000: Australian participation in the System Development and Demonstration (SDD) Phase of the United States Joint Strike Fighter (JSF) Program*, minute to the Minister for Defence, 11 April 2002, p. 1.

of JSF, and will view the opening of negotiation accordingly. Some competing companies have stated they would consider withdrawing from participating in Air 6000 if Australia joined the SDD phase as, in their opinion, such a sizeable investment would indicate that the JSF was Australia's preferred acquisition choice.[304]

13. Nonetheless, the submission suggested to the Minister that the AIR 6000 competitors should be informed that a business case for JSF SDD participation was being developed for government consideration, and that the future handling of the AIR 6000 project would be determined as part of the business case.[305]

14. The Minister responded to Defence that he had already publicly stated that Defence would be developing a business case to enter the JSF's SDD phase, although he stressed that Cabinet approval would be required to enter MoU negotiations. He also observed that, interestingly, no Australian industry had approached him arguing for the SDD investment in terms of industry growth potential.[306]

15. On 26 June 2002, shortly after prime ministerial meetings in Washington, the National Security Committee of Cabinet decided that Australia would commence negotiations with the United States to join the JSF Program, thus pre-empting any competition under the original AIR 6000 process.[307] At the time of joining the JSF Program, the then Minister for Defence announced that further consideration of other manned aircraft options for Australia would not be actively pursued,

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304 Secretary of Defence and Chief of the Defence Force, *AIR 6000: Australian participation in the System Development and Demonstration (SDD) Phase of the United States Joint Strike Fighter (JSF) Program*, minute to the Minister for Defence, 11 April 2002, p. 6.

305 Secretary of Defence and Chief of the Defence Force, *AIR 6000: Australian participation in the System Development and Demonstration (SDD) Phase of the United States Joint Strike Fighter (JSF) Program*, minute to the Minister for Defence, 11 April 2002, p. 7.

306 Secretary of Defence and Chief of the Defence Force, *AIR 6000: Australian participation in the System Development and Demonstration (SDD) Phase of the United States Joint Strike Fighter (JSF) Program*, minute to the Minister for Defence, 11 April 2002, p. 2.

307 Question without Notice: 'Defence: Equipment', *House of Representatives Hansard*, 27 June 2002, p. 4593; ANAO Audit Report No.48 2008–09, *Planning and Approval of Defence Major Capital Equipment Projects*, pp. 88–9.

and that a decision on acquisition of the JSF aircraft would be made in 2005–06.[308]

16. The AIR 6000 project was renamed as New Air Combat Capability, and a New Air Combat Capability Integrated Project Team was established within DMO, on 1 July 2002.

17. In October 2011, the process of the decision to join the SDD phase was discussed in a hearing of the Senate Foreign Affairs, Defence and Trade References Committee. Defence was asked if the normal procurement process for replacing the air combat fleet had been affected by urgency in obtaining a replacement. The Chief of Air Force replied that there was no other aeroplane on the drawing-board that was going to meet the imperative to operate the best air force in the region. The Chief of the Capability Development Group added that the 2002 decision:

> was not a selection of the aircraft to purchase. That did not come until about 2006, and that did go through the full first-pass process and then second-pass process. […] We were not locked in; we paid—I think—$150 million contribution over time to be a partner in the development, which gave us access to information to inform the decision process subsequently.[309]

18. In discussion with the Senate committee, the Chief of the Capability Development Group recognised that the decision to participate in the SDD phase gave an indication that Australia was considering ultimately purchasing the JSF. This response is in accordance with the Minister's 2002 statement that other options would no longer be actively pursued (see paragraph 15 above).[310]

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308 Senator the Hon. Robert Hill and the Hon. Ian MacFarlane, *Australia's future air combat capability*, transcript of joint press conference, 27 June 2002, pp. 3 and 5.

309 Senate Foreign Affairs, Defence and Trade References Committee, Inquiry into procurement procedures for Defence capital projects, *Committee Hansard*, 5 October 2011, p. 35.

310 Senate Foreign Affairs, Defence and Trade References Committee, Inquiry into procurement procedures for Defence capital projects, *Committee Hansard*, 5 October 2011, p. 35.

Appendix 6: The Fundamental Inputs to Capability

1. Capability, in the Australian Defence Force context, comprises the synergy realised by combining the eight 'Fundamental Inputs to Capability' (FIC) categorised and broadly defined in the following table.

Table A 1

The Fundamental Inputs to Capability (FIC)

Input	Key Provider
1. **Personnel.** All people within Defence, both military (permanent and Reserves) and civilian. The input incorporates recruiting, individual training and all conditions of service and employment, including entitlements, salaries and wages, superannuation and allowances;	**Capability Manager**
2. **Organisation.** Flexible functional groupings with an appropriate balance of competency, structure and command and control to accomplish their tasks. This input also includes critical organisations that directly support the ADF effort.	**Capability Manager**
3. **Collective training** A defined training regime undertaken by organisations that is validated against the preparedness requirements for operations, derived from government guidance. The regime is to include frequency and depth of competency in skills, with a particular emphasis on long-term readiness critical war-fighting skills.	**Capability Manager and Chief Joint Operations Command**
4. **Major Systems.** Systems that have a unit cost of A$1 million or more or have significant Defence policy or joint service implications designed to enhance Defence's ability to engage military power. Input includes, but is not limited to, ships, tanks, missile systems, armoured personnel carriers, major surveillance or electronic systems and aircraft.	**DMO**
5. **Supplies.** Supplies needed for Defence to operate, including stock holdings, provisioning lead times, serviceability and configuration status;	**DMO**
6. **Facilities and training areas.** Buildings, structures, property, plant, equipment, training areas, civil engineering works, through-life maintenance and utilities necessary to support capabilities, both at the home base and at a deployed location. Input may involve direct ownership or leasing.	**DMO** for equipment and systems, **Defence Support Group** for facilities
7. Support. Infrastructure and services from the wider national support base in Australia or offshore which are integral to the maintenance of Defence effort. The input is encompassing and could originate from civil/private industry/contractors, other government agencies and international support base agencies.	Suppliers to DMO for Mission and Support Systems
8. **Command and Management.** Written guidance such as regulations, instructions, publications, directions, doctrine, tactical level procedures and preparedness documents required for Defence to support decision making, administration and operations. Input also includes funding not readily attributable to any other FIC element (e.g. discretionary funding).	**Capability Manager,** for regulations and service-specific command and management, **DMO** for system acquisition and logistics management

Source: ANAO, adapted from Defence Materiel Organisation, *DMO Acquisition and Sustainment Manual*, 2007, pp. 74–5.

2. The current scope of AIR 6000 Phase 2A/B specifically excludes the items listed in Table A2.

Table A 2

Exclusions to the NACC Program

Excluded items
1. **Weapon war stocks:**
War stocks of JSF weapons will be acquired by DMO Explosive Ordnance Division via separate projects identified in the Defence Capability Plan 2009–19: —AIR 6000 Phase 3 – War Reserve Weapons (all except the air-to-air missile and maritime strike); —AIR 6000 Phase 5 – Future Air-to-Air Missile (both beyond and within visual range); and —JP3023 Phase 1 – Maritime Strike (development and acquisition of an air-launched stand-off maritime strike capability).
2. **Fundamental Inputs to Capability (FIC):**
Provision of non Project specific FIC elements including: —personnel; —collective training to achieve Integrated Training Center entry standards; and —command and management of the delivered capability.
3. **Upgrades:**
NACC will not cover: —upgrades to existing air combat platforms; —upgrades to existing non-air combat platforms; —upgrades to simulation or training devices for the above-listed platforms; or —upgrades to JSF beyond Block 4 configuration.
4. **Facilities:**
NACC will not cover infrastructure upgrades at main and forward operating bases unless primarily related to the introduction into service of the JSF Air System.

Source: Defence Materiel Organisation, New Air Combat Capability Integrated Project Team, *Acquisition project management plan*, version 1.0a, 5 December 2011, p. 33.

Appendix 7: F-35 Design Approval, Acceptance and Type Certification

1. This appendix expands upon the consideration of the processes described in paragraphs 3.69 to 3.73.

Design approval

2. The JSF Program Office has three distinct levels of certification for the F-35 JSF aircraft and support systems:

(b) Safety of Flight (SOF), which certifies that the vehicle is ready for flight within its design envelope, and supports Development Test & Evaluation;

(c) Intermediate Airworthiness (IA), which supports the release of Low-Rate Initial Production (LRIP) aircraft and the commencement of Operational Test & Evaluation (OT&E) ; and

(d) Full Airworthiness, which supports the Milestone C decision by the US Defense Acquisition Board (DAB) for Full-Rate Production (FRP).

3. The US Air Force plans to certify the JSF Air System using a tailored version of the US Department of Defense's Airworthiness Certification Criteria.[311] In addition to this airworthiness certification, the JSF Program Office will also be required to certify the F-35 aircraft and support systems in accordance with applicable statutory and regulatory requirements.[312] Requirements relevant to Australia have been documented in the NACC Airworthiness Management Plan and Functional Performance Specification.[313]

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[311] Department of Defense Handbook, *Airworthiness certification criteria*, 26 September 2005, MIL-HDBK-516B.

[312] This is outlined in Department of Defense Handbook, *Operational safety, suitability & effectiveness for the aeronautical enterprise*, 28 March 2003, MIL-HDBK-514.

[313] Defence Materiel Organisation, New Air Combat Capability Integrated Project Team, *NACC acceptance into service plan*, version 3.0b, December 2009, pp. 31–2.

Design acceptance

4. Design Acceptance Certification is a prerequisite to the issue of an Australian Military Type Certificate and Service Release. It is therefore the key component of an aircraft's acceptance-into-service process.

5. The NACC IPT's Design Acceptance Representative is responsible for managing the Design Acceptance process, including the progressive review of design activities and associated milestones, culminating in the Design Acceptance Certification of the F-35 system. The Design Acceptance Representative is required by the ADF Technical Airworthiness Regulations to manage the Design Acceptance process in accordance with an approved Project Design Acceptance Strategy, using approved Aerospace Systems Division and NACC IPT procedures implemented by competent personnel using an approved Engineering Management System.[314]

6. Overall Design Acceptance Certification is based on a review of all design and development milestone results. However, the NACC IPT's Design Acceptance Representative is not required to review the technical integrity of all aircraft design decisions, calculations and design outputs. The design agencies, by virtue of the requirements imposed by the JSF Program Office in their contracts, certify their own designs.

7. In accordance with ADF Technical Airworthiness Regulations, the NACC IPT's Design Acceptance Representative may certify Design Acceptance once he/she is satisfied that the approved design has been produced against an approved specification; that the design has been verified as meeting the specification by the Original Equipment Manufacturers (OEMs) and the JSF Program Office; and that the US Air Force has issued a type certificate following its independent review of the design documentation delivered by the JSF Program Office.

8. Once all design and development milestones are successfully completed and reviewed for technical integrity, the Design Acceptance Representative is responsible for applying to the Director General

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[314] Annex A to TAREG 2, in Australian Defence Force, *Technical airworthiness management manual*, Australian Air Publication 7001.053(AM1), 21 October 2010, Section 2, Chapter 1, p. 2A-1.

Technical Airworthiness (DGTA), who is the ADF Technical Airworthiness Regulator, for a recommendation to the ADF Airworthiness Authority concerning the granting of an Australian Military Type Certificate.

Australian Military Type Certificate and Service Release program

9. Before type acceptance of Australian aircraft can occur, the NACC IPT will provide DGTA staff with a type-certification Accomplishment Summary, which will include the F-35 Statement of Operating Intent, Design Approval Certificate, Design Acceptance Certification, Type Record, Safety Case Report, and an index to Instructions for Continuing Airworthiness. DGTA staff will then seek a recommendation from the Director General Technical Airworthiness to the Airworthiness Board, concerning the issue of an appropriate airworthiness instrument. At different phases of the program, the NACC IPT will seek the following airworthiness instruments:

- an Airworthiness Directive, to cover Australian aircraft operations in the USA during 2014–19;
- a Special Flight Permit, to cover first aircraft ferries and the Operational Test and Evaluation (OT&E) program in Australia in 2017–18; and finally
- an Australian Military Type Certificate and Service Release, to be sought following the completion of Australian OT&E.

10. The project's acceptance strategy and engineering-management system record the engineering decisions made in the exercise of engineering authority. Consequently, the strategy and engineering records should satisfy the key prerequisites for Design Acceptance, and assist the NACC IPT's Design Acceptance Representative to establish whether the F-35 is technically acceptable for ADF use.

11. Military type certification and Service Release will need to occur when the new air combat capability is scheduled for acceptance into service. This process is assisted by the NACC IPT having its Statement of Work and System Specification approved by the project's Defence stakeholders, as well as having an approved design-acceptance strategy and other key plans (including Airworthiness, Test and Evaluation, Configuration, and Systems Engineering Management plans) endorsed by the Chief Engineer of DMO's Aerospace Systems Division, the Director General Technical Airworthiness and other stakeholders.

Aircraft Certificate of Airworthiness

12. In addition to the aircraft type-certification process, each individual aircraft must receive a Certificate of Airworthiness. The NACC IPT's Design Acceptance Representative is responsible for issuing Certificates of Airworthiness for each F-35 aircraft based upon the Type Certificate and individual Certificates of Conformance submitted by the JSF Program Office. The JSF Program Office has a memorandum of agreement in place with the US Defense Contract Management Agency (DCMA) for DCMA to perform production-acceptance activities for F-35 Air System products on behalf of all partner nations.

F-35 airworthiness certification

13. US Air Force and US Navy airworthiness authorities have both provided data requirements for F-35 flight certification, and the JSF Program Office coordinates the consolidated requirements of the US Services and partner nations as one program.

14. The first Military Flight Release for the F-35A was issued by the USAF in February 2012, enabling the beginning of local area operations at the F-35 Integrated Training Center at Eglin Air Force Base in Florida.[315]

[315] F-35 Lightning II Joint Strike Fighter Program Office, *Air Force issues flight release for Eglin AFB F-35A*, media release, 28 February 2012; Dave Majumdar, *Eglin pilots should take to air in F-35 next week: USAF*, DefenseNews, 28 February 2012.

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